SAN FRANCISCO BAY
BIRD OBSERVATORY

Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2015

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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 2015 breeding season, we monitored Snowy Plover numbers, nesting and fledging success, use of experimental habitat enhancement sites, and potential predators. We also participated in the second year of a reproductive success pilot study initiated by the Institute for Wildlife Studies (IWS).

As part of the Pacific Coast breeding season window survey (May 17-23), we counted 195 adult Snowy Plovers in the San Francisco Bay. Over the course of the breeding season (March-September), we documented 304 plover nests in all of Recovery Unit 3. In the South Bay, we determined the fate of 298 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 60%. Remaining nests failed due to predation (33%), abandonment (4%), flooding (1%) and for unknown reasons (1%). We summarize 2015 nesting activity by pond complex or management unit below:

On Refuge property, we determined the fate of 16 nests in the Alviso Complex (ponds A3N, A13, and A16) and 83 nests in the Ravenswood Complex (ponds RSF2, R1, R2, R3, R4, and R5). Apparent nest success was 56% and 71% in the Alviso and Ravenswood complexes, respectively. One nest was found in Crittenden Marsh West (non-Refuge property) in Mountain View, yielding an apparent nest success of 0%. This was the second season that Mountain View pond A2E and Crittenden Marsh West (CM-W) and East (CM-E) were monitored for breeding Snowy Plovers. High water levels at Crittenden Marsh throughout the season resulted in minimal available nesting habitat compared to the 2014 breeding season. Pond A3N, located nearby and drier than in previous years, held 11 nests with a nest success rate of 45%. A3N likely replaced Crittenden Marsh as nesting habitat in the area.

Also on Refuge property, we located 22 nests in the Warm Springs complex in Fremont. Apparent nest success was 64% in Warm Springs.

In addition to confirmed nests on Refuge property, three broods from unknown nests were reported. At pond M13, Cargill representatives reported two separate sightings of an adult and two chicks; at NPP1, SFBBO biologists reported a group of two adults and two chicks.

We found 58% of Snowy Plover nests in Recovery Unit 3 at CDFW's Eden Landing Ecological Reserve (Eden Landing). We determined the fate of 175 nests and found that apparent nest success was 54%, while 36% of nests throughout Eden Landing were lost to predation.

EBRPD reported one Snowy Plover nest on the California Least Tern (*Sterna antillarum browni*) island at Hayward Shoreline, which hatched (D. Riensche, pers. comm.). No nests were reported at the Oliver Brother's North salt ponds at the Hayward Shoreline Interpretive Center (Ann Graham, pers. comm.).

CDFW biologists found and monitored 6 Snowy Plover nests at the Napa-Sonoma Marshes Wildlife Area (ponds 7/7A and Napa Plant Site) in the North Bay, of which 4 hatched (K. Taylor, pers. comm.). Monitoring efforts at the Hamilton Wetlands Restoration site in Novato were conducted by Avocet Research Associates. Nesting attempts reportedly occurred during the 2014 breeding season, but it was concluded that there was no nesting activity during the 2015 breeding season after the levee in the area was breached (J. Evans, pers. comm.). At the Montezuma Wetlands in Solano Count, a breeding window survey and incidental Snowy Plover information was collected by Eco bridges Consulting. One nest was confirmed, several more were suspected, and at least three fledglings were confirmed (Anne Wallace, pers. comm).

In 2015, SFBBO participated in the second year of a pilot study initiated by the Institute for Wildlife Studies (IWS) which investigated alternative methods of calculating reproductive success. As part of this study, we banded 116 Snowy Plover chicks and 40 adults from nests that successfully hatched within predetermined study ponds. From band re-sighting surveys, we determined that at least 38 of these 116 chicks survived to fledging (31 days post-hatching) as of December 31, 2015. Our apparent fledging success was 33%.

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.

From 2008-2014, SFBBO and the Refuge conducted a pilot Snowy Plover habitat enhancement study at Eden Landing using 1-ha oyster shell pilot plots. The study indicated that oyster shell habitat enhancement increased plover nest abundance and nest success within treatment areas. With these findings as support, 22.26 hectares of oyster shell were spread as a large scale habitat enhancement project in September of 2014 at Eden Landing pond E14. During the 2015 breeding season, the oyster shell enhancement plots were used extensively by Snowy Plovers, containing a total of 64 nests over the course of the season.

In future years, we recommend that the South Bay Salt Pond Restoration Project (the Project) carefully plan Phase II 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 Snowy Plovers from using ponds where construction activities are taking place, as long as sufficient alternate habitat is available.

As more areas are opened to tidal action or converted to ponds with islands, we recommend that the Project and local land managers take great care in maintaining adequate Snowy Plover nesting habitat to preserve and increase the number of nesting Snowy Plovers in the South Bay. Management actions currently undertaken along these lines should be continued in future seasons, including management of multiple ponds at shallow depth during the winter and large scale shell enhancement at appropriate nesting ponds. With the completion of Phase I Project restoration in Eden Landing, we recommend that new or existing levee trails in close proximity to Snowy Plover nesting ponds be kept closed to the public during the breeding season to minimize impacts from human disturbance. We also propose continued adaptive management and/or enhancement of Snowy Plover nesting sites. The Project and other restoration projects will affect Snowy Plovers in multiple ways, and managers and researchers should continue to study and monitor the Snowy Plovers in the South Bay to reduce impacts and improve recovery efforts 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 2006). 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 (USFWS) listed the Pacific Coast Western Snowy Plover population as federally threatened in 1993 (USFWS 1993). They are listed as a species of special concern in California (CDFW 1998).

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). Snowy Plovers in this Recovery Unit nest almost exclusively in dry salt panne habitat provided by former salt evaporation ponds, as well as on pond berms and levees. 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 Snowy Plovers and determining nest fates since 2003.

From 2003-2015, 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, trespass, construction activities and other human activities.

In 2013, the Institute for Wildlife Studies (IWS) proposed a study to investigate an alternative method of measuring Snowy Plover reproductive success. While current methods require individually marking and resighting a large portion of the population, this approach instead involves marking and resighting a targeted sample of the population. All chicks from a brood and the associated adult male are included in the sample population. This effort would utilize predictive statistical models to more accurately assess plover recovery via the number of fledglings per male. This new approach aims to alleviate many of the current issues associated with high intensity color band marking and resighting methods, which include limited band combinations, staffing and funding resources, and impacts to breeding birds. SFBBO participated in the pilot year of this study in the South Bay during the 2014 breeding season and continued through the 2015 breeding season.

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 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 Project initiated a large-scale oyster shell habitat enhancement project, informed by the previous pilot studies from 2008-2014, on Eden Landing pond E14. Enhancements were made in September and October 2014 after the breeding season was complete. In February, prior to the start of the 2015 breeding season, seven hunting blinds and numerous perches within the pond were removed; historical structures within the pond that could not be removed were treated with Nixalite. This pond was uniquely monitored during the 2015 nesting season to measure the effect of treatment types (Enhancement and Non-Shelled) on nest success, chick success, brood behavior, and a variety of microhabitat characteristics including salinity, moisture, and invertebrate abundance.

In this report, we summarize results from the 2015 breeding season, including data on Snowy Plover nest distribution and plover habitat use, nest (hatching) success, fledging success,

habitat enhancement studies, and avian predator abundance and distribution. 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. CDFW biologists surveyed and contributed nesting information for one site in the North San Francisco Bay this year (North Bay; Figure 2). Additionally, SFBBO volunteers monitored lower priority sites with potential Snowy Plover habitat in the South Bay. 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). Many of the ponds used by Snowy Plovers are currently managed as seasonal ponds, or are dried down for the purpose of creating nesting habitat. For this study, we divided the Refuge into seven geographic locations: Warm Springs (Figure 3), Alviso (Figure 4), Mountain View (Figure 4), Ravenswood (Figure 5), Coyote Hills, Dumbarton, and Mowry (Figure 1). Alviso ponds A2E and A3N are owned and managed by the Refuge while Crittenden Marsh is co-owned by several agencies, including Midpeninsula Regional Open Space District and the National Aeronautics and Space Administration, Ames Research Center (NASA). We coordinated our weekly surveys with their NEPA compliance representatives and staff biologists. This area is collectively termed Mountain View for the purposes of this report.

CDFW owns and manages Eden Landing (formerly known as Baumberg), which includes approximately 6,400 acres of former salt ponds, marsh, and tidal habitat (Figure 6). CDFW also owns and manages the Napa-Sonoma Marshes Wildlife Area (NSMWA), 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 is located in Novato at the former Hamilton Army Airfield and is owned by the State Coastal Conservancy. Prior to levee breach early in the 2015 breeding

season, this area provided Snowy Plover foraging and nesting habitat on a dry area within the tidal restoration site. As a result of the breach, much of the former nesting habitat is now tidal; however, there remains a portion of suitable nesting habitat in the North Seasonal Wetlands. No nesting activity was observed during the 2015 breeding season.

Nesting Snowy Plovers were detected and anecdotally documented among breeding Least Terns within the Montezuma Wetlands Restoration Project footprint in Solano County, CA by contracted biologists. This year, Snowy Plover breeding window surveys were performed here, and adult numbers for the survey window are included in this report. Further nesting information is not included due to inconsistent survey methods.

Snowy Plover Surveys

Snowy Plovers in the San Francisco Bay nest predominantly on dry ponds, berms, and levees. 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, 2015, 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 all Snowy Plovers present, identified the sex and age class of each individual using plumage characteristics (Page et al. 1991), and marked the approximate location of sightings on a geo-referenced map. We also recorded the color-band status, and combination if appropriate, of any banded plover sighted.

In total, SFBBO and Refuge biologists and interns surveyed 17 Refuge ponds, 1 Mountain View site and 19 Eden Landing ponds weekly (**Table 1**, Table 2). SFBBO plover volunteers surveyed the HARD ponds monthly. Rather than visit monthly, SFBBO volunteers periodically scouted some areas of the Napa-Sonoma Marshes Wildlife Area (NSMWA) and some low-priority Eden Landing ponds to check for possible nesting activity during the season (Table 3). CDFW biologists increased their nest monitoring efforts at NSMWA in 2015 due to construction on pond 7/7A. SFBBO staff biologists also surveyed the Coyote Hills, Dumbarton, and Mowry salt pond complexes twice in the Spring quarter and once in the Summer quarter as part of SFBBO's waterbird surveys (see Washburn and Heyse 2015 for methods); it is important to note that the waterbird survey methods are designed to document waterbird abundance and distribution rather than Snowy Plover nesting activity, so they may not adequately detect Snowy Plovers or nests. However, limited breeding habitat is available in these areas.

From May 17-23, we participated in the Pacific Coast Snowy Plover breeding window survey. This survey was coordinated by the USFWS as part of an annual, regional effort to census all coastal-breeding Snowy Plovers during the same week. In Recovery Unit 3, the survey covered

Refuge, Eden Landing, NSMWA, and HARD ponds, and we used the same methods for sighting and counting Snowy Plovers as described above. Nesting Snowy Plovers were also surveyed using the same method in the Montezuma Wetlands Restoration Project footprint in Solano County, and these data are included in the 2015 breeding window survey.

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 or Garmin® eTrex Venture HC). Volunteers located 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 leave 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), or IWS survey pond (see *IWS Reproductive Success Study* 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. Apparent nest density was calculated by dividing the number of nests found on a given pond by the pond area determined that week through habitat availability surveys (see methods section below).

Chick Color Banding

Beginning in 2008 and continuing through the 2015 breeding season, SFBBO and Refuge biologists banded Snowy Plover chicks to study their movements and to estimate fledging success rates in the South Bay. Chick banding was limited by time, resource, and staff availability. To band chicks, biologists checked nests daily, starting four days before the estimated hatch date. Due to the precocial nature of chicks, arrival at nests was timed to allow complete hatching of chicks prior to their movement away from the nest; this is typically a several hour window. We banded each chick with a unique four-color combination by placing two bands on each leg below the tibiotarsal joint. Each combination consisted of three darvic (XCLA Darvic Leg Bands I/D 3.1mm n.d.) or acetal (XCLA Acetal Leg Bands I/D 3.1mm n.d.) color

bands and one silver U.S. Fish and Wildlife Service band. All bands were then wrapped in colored auto pin-striping tape. Darvic color bands are becoming increasingly unavailable so acetal bands were used as an alternative whenever needed.

We defined a fledged chick as one that survived to 31 days of age, at which point it is 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 significant limitations (see *Discussion* for further explanation).

IWS Reproductive Success Study

In 2013, IWS initiated a study to measure the reproductive success of Snowy Plovers by banding and monitoring a sample of the breeding population, rather than using the traditional method of banding the entire population. SFBBO participated in this study during the 2014 and 2015 breeding seasons (Hudgens et al. 2014) at five of the most historically productive ponds for breeding Snowy Plovers (E14, E6B, and E8 at Eden Landing; RSF2 and R1 at the Refuge). The study design for the 2015 breeding season was altered from 2014, and instead treated an entire pond as a study plot rather than a smaller measured area within the pond. In addition to this change, R1 was omitted from the study during the 2015 season due to high water levels which limited habitat availability for most of the season. Target numbers of banded broods, including both chicks and associated adult males, were determined at each study pond.

Adult males were caught at the nest site using noose mats, typically when chicks had just recently hatched and were still in the nest bowl. We used the same chick banding approach as stated above. All chicks banded by SFBBO in 2015 were used for the IWS reproductive success study.

Oyster Shell Habitat Pilot Studies

From 2008 to 2010 we placed oyster shell treatments on the ponds at Eden Landing using a randomized block design in order to evaluate the effects of oyster shell enhancements on breeding Snowy Plovers. 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). Shell plots and respective control plots were monitored from 2009 to 2014. Drake's Bay Oyster Farm donated the oyster shells, and SFBBO staff, volunteers, and the California Conservation Corps spread the shells by hand.

E14 Large Scale Enhancement

With support from the findings from our 2008-2014 pilot study, we began a large scale habitat enhancement project in September 2014 at Eden Landing pond E14, where 20.23 hectares were treated with oyster shells at the previously tested density. Two distinct plots were created within the pond – a western plot totaling 6.47 hectares and an eastern plot totaling

13.76 hectares (both termed Enhancement in this report). We designed a spatial configuration in which the shell blocks alternated with the control blocks in order to avoid clustering treatments in one region of the pond, as well as to address pre-existing variation in habitat quality for breeding Snowy Plovers.

We measured several parameters that would reflect breeding success during the first season of large scale enhancement at this pond. Nest surveys were performed to document adult activity and nest success, and brood surveys were performed to measure fledging success and brood behavior. In addition to the regular predator surveys, trail cameras were deployed at individual plover nests to document predation events and predator activity. Soil samples were collected at predetermined randomized points to measure abiotic factors including salinity, pH, moisture, and temperature of soils within each treatment type. We also sampled the potential prey population by using a sticky trap design to measure invertebrate abundance and diversity. We designed several analytical methods using these data in order to measure the effect of treatment types (Enhancement and Non-Shelled) on breeding success (Tokatlian et al. 2015).

Apparent Estimates.

We compared apparent nest success and apparent nest densities in 1-ha shell plots (Pilot), control plots, and all other Eden Landing nesting areas (Non-Shelled) from 2009-2015 (Table 11). Nests in E14 1-ha shell plots and control plots are not treated independently in 2015 as they were impacted by large scale enhancement, and were omitted from this analysis. This season we conducted weekly habitat availability surveys. This allowed us to measure nest densities more accurately than in past years, when the entire pond area was used regardless of water levels.

Nest Survival Models.

Previous analyses performed from 2009 through 2013 showed that rates of daily nest survival were consistently higher in the pilot shell plots than outside the pilot shell plots over the five year period. In light of these findings, we elected not to run logistic exposure models in 2015. Weekly nest survival models were performed for nests in pond E14, across the treatment types.

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 Snowy Plovers (Tables 1-2). Likewise, volunteers conducted monthly avian predator surveys at ponds surveyed monthly for Snowy Plovers. We defined avian predators as any species that could potentially prey on a Snowy Plover nest, chick, or adult. Raptor species included American Kestrels (*Falco sparverius*), Bald Eagles (*Haliaeetus leucocephalus*), Barn Owls (*Tyto alba*), Burrowing Owls (*Athene cunicularia*), Cooper's Hawks (*Accipiter cooperii*), Golden Eagles (*Aquila chrysaetos*), Merlins (*F. columbarius*), Northern Harriers (*Circus cyaneus*), Peregrine Falcons (*F. peregrines*), Red-Tailed Hawks (*Buteo jamaicensis*), and White-Tailed Kites (*Elanus leucurus*); gull species included California Gulls (*Larus californicus*), Herring Gulls (*Larus*

argentatus smithsonianus), Ring-Billed Gulls (*Larus delawarensis*), and Western Gulls (*Larus occidentalis*); Corvid species included American Crows (*Corvus brachyrhynchos*) and Common Ravens (*C. corax*); other species included Great Blue Herons (*Ardea herodias*), Great Egrets (*A. alba*), Snowy Egrets (*Egretta thula*), and Loggerhead Shrikes (*Lanius ludovicianus*). 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. Observed mammalian predators included grey fox (*Urocyon cinereoargenteus)*, red fox (*Vulpes vulpes*), skunks (*Spilogale gracilis*, *Mephitis mephitis*), and domestic cats (*Felis catus*). Among all predators, we considered raptors, gulls, corvids, and mammals to be the most critical potential predators to Snowy Plover adults, eggs, and chicks due to consistent previous documentation of effects.

We conducted avian predator surveys following plover surveys, so human disturbance may have affected detection rates of some species. Observers walked or drove slowly on levees 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. 2004), 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.

Habitat Availability

The South San Francisco Bay salt ponds are extremely dynamic by nature, with constantly changing habitat based on precipitation, management, and other factors. In order to better measure the available potential nesting habitat over the course of the season, habitat availability surveys were conducted during the 2015 breeding season.

Prior to the season, maps for each pond were overlaid with a grid composed of 50m x 50m squares. During each survey, the approximate outline of water within each pond was marked on the corresponding map. When maps were later analyzed, squares with greater than 50% water cover were considered unavailable for breeding, while squares with less than 50% water cover were considered available for breeding. Habitat availability surveys were conducted on the same day as each breeding survey, allowing for accurate assessment of habitat availability based on the date that nests were observed and checked.

Though the habitat availability maps are an estimate and no doubt incorporate some measure of error, they provide a much more accurate measure of potentially available nesting habitat over time compared to previous methods. As such, reported apparent nest densities in this report represent a much closer approximation of the actual nest densities than past reports.

RESULTS

Snowy Plover Surveys

South Bay Overall.
During the 2015 Pacific Coast breeding season window survey (May 17-23), we counted 195 adult Snowy Plovers in the Bay (Table 4). We observed a mean of 260 birds per week from March 2 through August 31 in the entire South Bay. We consistently observed the greatest numbers of Snowy Plovers at Eden Landing (Table 4, Figure 7). We documented Snowy Plover nesting activity at 25 South Bay ponds (Figure 9, Figure 10).

Refuge.
We documented a mean of 107 Snowy Plovers per week from March 2 through August 31 on Refuge property. We observed an average of 65 Snowy Plovers per week in the Ravenswood complex (Figure 7b). We observed an average of 29 Snowy Plovers per week in the Warm Springs complex, 13 Snowy Plovers per week in the Alviso complex, and only 0.3 Snowy Plovers per week at Pond A2E and Crittenden Marsh (East and West). The Dumbarton ponds, which were only surveyed five times during the season after a brood was sighted on NPP1, yielded an average of 0.4 Snowy Plovers per week.

Eden Landing.
We observed the most Snowy Plovers throughout the season at Eden Landing (Figure 7), with a mean of 152 birds observed per week from March 2 through August 31. This was higher than in 2014 when we observed a mean of 131 birds per week during the same time period. Pond E14 supported large numbers of Snowy Plovers during the breeding season this year, averaging 82 birds per week. In March, we observed large flocks at E14, averaging 139 Snowy Plovers per week for the month, while in August, we observed large flocks at E6B, averaging 137 Snowy Plovers per week for the month (Figure 7c). In both cases, many of these birds may have been staging (for migration), arriving for the breeding season (in March) or early arrival wintering birds (in August).

Nest Abundance and Success

South Bay Overall.
In 2015, we determined the fate of 298 Snowy Plover nests in the South Bay. Of these, 178 nests hatched (apparent nest success = 60%), 97 nests were depredated (33%), 13 were abandoned (4%), two were flooded (1%) and eight failed from unknown causes (3%, Table5, Figure 10). We found the highest number of nests ever documented in the South Bay in 2015 (previous high of 243 nests in 2010). The predation rate was lower in 2015 than in 2014, providing evidence that high nest numbers were not entirely due to renesting attempts (Figure 10). Consistent with findings from previous years, predation serves as the most significant cause of nest failure.

Refuge.
In 2015, SFBBO determined the fate of 121 Snowy Plover nests on Refuge property (Table 5). We determined the fate of 22 nests in the Warm Springs complex (all at A22), 14 of which hatched (64%), seven were depredated (32%), and the fate of one nest was unknown. We determined the fate of 16 nests in the Alviso Complex (in ponds A3N, A13, and A16 Table5). Out of these nests, nine hatched (56%) and seven was depredated (44%). Adjacent to Refuge property, one nest was found in Crittenden Marsh West in Mountain View, which was depredated. We determined the fate of 83 nests in the Ravenswood Complex. Of these, 59 hatched (71%) and 19 were depredated (23%), three were abandoned (4%) and two failed from unknown causes (2%). We found the most nests in the Ravenswood complex on pond R4 (30 nests; Table5).

Zero nests were found in Alviso ponds A12 and New Chicago Marsh (NCM) or in Mountain View Ponds A2E and CM-E (Table 5). NCM water levels were kept high for water quality purposes, resulting in little exposure of dry salt panned habitat. A2E water levels are generally kept at higher levels to provide foraging habitat for terns and larger shorebirds, while Crittenden Marsh was flooded for the entire season.

Eden Landing.
We determined the fate of 175 Snowy Plover nests at Eden Landing. Of these, 95 hatched (54%), 63 were depredated (36%), ten were abandoned (6%), two were flooded (1%), and the fate of five nests was unknown (3%) (Table5). Pond E14 had the most nests (98 nests), followed by pond E8 (25 nests) and pond E6B (15 nests; Table5). E14 alone comprised 56% of the nests found in Eden Landing and 33% of the nests found in the entire South Bay in 2015. As compared to the previous two seasons, construction activity was minimal at Eden Landing, resulting in no effect on breeding activity. The Eden Landing complex hosted 59% of all the nests found in RU3 (Figure 10).

Hayward Shoreline.
EBRPD reported one Snowy Plover nest on the California Least Tern Island at HARD, which successfully hatched (D. Riensche, pers. comm.; Table5). No nests were detected this season at the Oliver Brothers North Salt ponds at Hayward Regional Shoreline (pers comm).

Napa-Sonoma Marshes Wildlife Area.
CDFW biologists found and determined the fate of 6 nests in the Green Island Unit and pond 7/7A, 4 of which were successful (66%; K. Taylor, pers. comm.; Table5).

Montezuma Wetlands.
U.S. Geological Survey (USGS) biologists reported Snowy Plovers nesting among California Least Tern colonies in the Montezuma Wetlands, Solano County. This habitat is characterized as dredged sediment substrate within the Montezuma Wetlands Restoration Project footprint. In 2015, the plover breeding window survey as well as incidental Snowy Plover nesting

information was collected by contracted biologists during their Least Tern surveys. Anecdotal information shows a peak number of 13 Snowy Plover adults at one location on July 11, with an average of 3 Snowy Plovers seen per site visit. One nest was confirmed during the season, with several others suspected. Chicks were occasionally seen on tern surveys throughout the season, and at least three fledglings were visually confirmed (Anne Wallace, pers. comm). However, nest and fledgling success rates cannot be determined without more detailed monitoring.

Hamilton Wetland Restoration Area.
Monitoring efforts at the Hamilton Wetland Restoration site were conducted by contracted biologists with Avocet Research Associates. No nesting activity was observed during broad monthly surveys of the wetlands (J. Evens, pers. comm).

Newark Cargill Evaporation Ponds.
Cargill representatives reported two separate sightings of two adults and two chicks at pond M13 adjacent to the Newark Plant Site on June 22 and 24, respectively. Another group of two adults and two chicks was reported on pond NPP1 in the Newark Ponds on June 25. SFBBO biologists began monitoring NPP1 immediately after being informed of the brood. The brood was resighted once, but was not seen again after July 9. Surveys at NPP1 continued through the end of the breeding season, during which time no other plover sightings were recorded. As this data was obtained opportunistically, nest and fledging success rates can't be determined without more detailed monitoring.

Breeding Chronology
We calculated apparent nest densities this season by using weekly information from habitat availability surveys, rather than the total area of potentially available habitat at each pond. We calculated weekly densities per pond, and then averaged them. This provides more accurate nesting densities in South Bay ponds as water levels changed throughout the season. Overall, average apparent nest density in the South Bay (across all ponds with dry panne) was 0.063 nests per hectare. We documented the highest apparent nest density in pond E12 at 0.39 nests/ha (Table 7), though we note that the available nesting habitat in this pond is provided by a handful of nesting islands, and averaged 11.5 ha throughout the season. The next highest apparent nest density in Eden Landing was at pond E14 at 0.324 nests/ha (Table 7). Pond E14 had an average of 240 ha of available habitat throughout the season, and is more representative of the dry panne habitat that Snowy Plovers rely on for nesting. The third highest apparent nest density in RU3 was in pond RSF2 at 0.132 nests/ha (Table 6). All nests in RSF2 this year were found in the panne habitat in the Cell 3; all available habitat including nesting islands was included in our nesting density calculations for this pond.

Weekly habitat availability information for CM-W was not available in order to calculate nesting density. The total area was used to calculate nesting density.

From early May through early July, we recorded high nest initiation rates at a consistent pace. During the week of May 3, 21 nests were initiated, with another 22 nests initiated during the week of May 24 (Figure 12). In June, 21 nests were initiated during the week of June 14, followed the next week by another 20 initiated (Figure 12). The week of July 5 saw the last large amount of nests initiated at 19, after which the number of nests initiated dropped off steeply through the end of the season in August (Figure 12).

The number of active nests followed a slightly different trend than in past years, staying at a consistent level for most of the season with one major peak, rather than two distinct peaks with lower numbers in between. An early high of 70 nests was seen during the week of April 12 and remained around that number through the week of May 17 (77). From May 17 to June 14, the number of nests spiked dramatically, reaching 99 nests, and gradually declined to 86 nests during the week of July 12. After this point the number of nests declined until the end of the season in late August (Figure 14).

Chick Fledging Success

As part of our involvement with the IWS reproductive success study, we banded 116 Snowy Plover chicks in 2015 and determined that at least 39 chicks fledged (34%,
Table 8). While most fledgling sightings were recorded during the breeding season, several came during post breeding season band resighting surveys. Another fledged chick was reported from the Monterey Bay area, more than two months after the end of the breeding season. This illustrates the difficulty in re-sighting banded chicks within the ponds, and as such these estimates should be viewed with caution.

IWS Reproductive Success Study

All chicks banded during the 2015 breeding season were banded as part of the IWS reproductive success study (Table 9). We also banded 37 adult Snowy Plovers to aid in our tracking of brood units. The highest apparent fledge success rate was documented at E14, where 59 chicks were banded and 26 were confirmed fledged (44%; Table 9). Nineteen chicks were banded at pond E8, and eight were confirmed fledged (42%). 30 chicks were banded at pond RSF2 and five were confirmed fledged (17%). Eight chicks were banded in the E6B pond, with zero confirmed fledged (Table 9).

We reached or exceeded our target sample size of 15-20 banded broods in E14 (25), 10-15 banded broods in E8 and E6B combined (12), and 10-15 banded broods in RSF2 (11). SFBBO nesting surveys covered brood resight information at ponds E8, E6B, and RSF2, while a brood survey specifically targeted broods and associated adults at E14. Nest surveys at ponds E8, E6B, and RSF2 began at the start of the season, and brood surveys at pond E14 began after the first nest hatched. Surveys were typically conducted for several hours per pond. Each study pond was surveyed once a week throughout the season and until 30 days after the last nest hatched within that plot (Hudgens et al. 2015).

Preliminary results from this season suggest that there are two limiting factors for chick survival. Survival rates were lower for chicks during their first week after hatching compared to the remaining weeks before fledge age. Survival rates were also lower during the first half of the season compared to the second half of the season. Models also showed slightly lower survival rates of all age classes and equally throughout the season in the Ravenswood study areas compared to Eden Landing areas. We stress that these results are preliminary and require further analysis, however researchers confidently state that detection probabilities were low during weekly surveys, and that there were a high proportion of temporary, nonbreeding males at Eden Landing sites during the 2015 season. (*See* Hudgens et al. 2015 *for more detailed results*).

Oyster Shell Habitat Enhancements

During the first season of large scale enhancement at pond E14, we documented a total of 64 nests in the Enhancement plots, 14 nests in the Pilot plots, and 20 nests in the Non-Shelled areas. Data from large Enhancement plots and Pilot plots were combined and collectively termed "Enhancement" for analysis. Nest success rates were similar in Enhancement and Non-Shelled areas (58% and 60%), and a linear regression model (IBM SPSS Statistics 22) found that nest success was not significantly predicted by several measured variables including treatment type and distance to the nearest nest. The average nest density during peak breeding months was calculated at 1.7 ± 0.6 nests/ha in Enhancement areas and 0.1 ± 0.1 nests/ha in Non-Shelled areas. Higher nest density in Enhancement areas may have increased conflict between males with broods; two documented chick mortalities may have been the result of this increased aggression.

We did not detect any significant relationships or predictive power between chick success or brood behavior between treatment types. Common ravens were the most common predator documented via nest cameras (10 documented nest depredations); in addition, one nest was depredated by a peregrine falcon immediately after hatching. We found no significant distributions of biotic or abiotic factors between the treatment types. For more detailed information regarding these study results, refer to Tokatlian et al. 2015.

Apparent Estimates.

From 2009-2015, we documented higher apparent nest densities in the original 1-ha pilot shell plots compared to control plots (Table 11). In 2015, we found a total of 19 nests in the pilot shell plots and four nests in the control plots (Table 11). Apparent nest densities were 1.58 nests/ha in the pilot shell plots, 0.33 nests/ha in the control plots, and 0.12 nests/ha in all other areas of Eden Landing combined (Table 11). In 2014 we redefined the "all other ELER" category to include consistently monitored plover nesting ponds (E11, E16B, E15B, E15B, E12, E13, E14, E6A, E6B, E8 and E6) for more accuracy when calculating apparent densities. Apparent nest densities, hatch rates, and depredation rates from previous years were recalculated using these new parameters (Table 11). Due to the installation of large oyster shell enhancement plots that covered much of E14, nests from this pond were not included in Table 11 for the 2015

calculation. Apparent nest success (defined as the percentage of nests that successfully hatched at least one egg out of the total nests monitored) inside the plots was 37% while apparent nest success was 75% in control plots and 29% in all other areas of Eden Landing (Table 11). In 2015, apparent depredation rates were higher in pilot shell plots (42%) than in control plots (25%), and 57% in the rest of Eden Landing. The small sample size in control plots limits the applicability of these data.

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 avian predators in all areas of the Refuge (Figure 21-24). Raptors and corvids were also present in many areas. In Ravenswood, we observed Red-Tailed Hawks and Peregrine Falcons perched on the PG&E towers and available perches on the pond bottoms, while corvids were often spotted walking on pond bottoms (Figure 21a). In Alviso, Common Ravens, Peregrine Falcons, and Red-Tailed Hawks were commonly sighted throughout much of the complex, especially at ponds A3N and A13 (Figure 22a). Gulls were often seen roosting and feeding in large flocks on pond A16 nesting islands and ponds A12-A13 (Figure 22b). At Warm Springs (ponds A22 and A23), we primarily observed Common Ravens and Red-Tailed Hawks (Figure23a), often perched on PG&E towers or in the adjacent vernal pool and grassland habitat.

Mountain View.
As with other ponds in the South Bay, the most abundant critical potential avian predators at pond A2E and Crittenden Marsh were California Gulls (Figure 24b). Red-tailed Hawks were often sighted perched on PG&E towers near CMW, and Common Ravens were often seen flying over CME and A2E(Figure 24a).

Eden Landing.
The most abundant critical potential avian predators at Eden Landing were California Gulls and unidentified gulls (Figures 25-27). Common ravens were often seen flying over and walking through ponds E8, E13, and E14 (Figures 26a-27a). Northern harriers were often observed hunting over E6B, E8, E13, and E14 (Figures 26a-27a). Peregrine falcons were frequently observed perched and hunting in ponds E13, E14, and E16B (Figures 26a-27a.)

In Eden Landing pond E9, a peregrine falcon nest was located in a blind within 200m of E14. Two juveniles fledged from the nest by early June. Throughout the 2015 breeding season, we regularly observed multiple falcons perched, actively hunting or consuming prey on ponds E12-14. Peregrines were observed taking an adult plover on one occasion and chicks on two occasions. The remains of other shorebirds were often found on the E14 pond bottom near active plover nests and broods.

Hayward Shoreline.
We observed low numbers of avian predators at Hayward Shoreline including California Gulls and Common Ravens (Figure 28).

Napa-Sonoma Marshes Wildlife Area.
We observed Ring-Billed Gulls, Common Ravens, Red-Tailed Hawks and Bald Eagles at the Napa-Sonoma Marshes Wildlife Area (Figure 29).

Mammalian Predators

We observed Gray Fox (*Urocyon cinereoargenteus)*, Red Fox *(Vulpes vulpes*), skunks (*Spilogale gracilis*, *Mephitis mephitis*), and domestic cats (*Felis catus*) around plover nesting ponds. Mammalian predator trapping and removal was coordinated by USDA and the Refuge throughout the season.

In past years, biologists have seen cats jumping over the Eden Landing predator fence north of E6A into the Ecological Reserve. In the Mountain View area, a group of Google employees that run GCats Rescue are known to feed feral cats at numerous stations near sensitive bird habitat adjacent to Crittenden Marsh. Feral cats are documented 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. At Eden Landing, we found the remnants of fireworks that had been shot off, graffiti in restricted areas, and on one occasion, a trespasser fishing in a restricted area. On Refuge property, we found drones on several occasions on ponds R4 and R5. All of these actions would have disturbed Snowy Plovers in adjacent areas.

DISCUSSION

Snowy Plover Surveys

We counted 195 Snowy Plovers in the Bay during the May breeding window survey. This number was higher than the 2014 and 2012 count, but lower than the 2013, 2011 and 2010 counts. 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 do not provide an exact number of breeding Snowy Plovers in the San Francisco Bay. Although we have greatly increased our efforts to color band Snowy Plovers over the last two seasons, these banded birds are still a small sample of the plover population in the South Bay. Combined with the challenges faced to survey all suitable nesting habitat over multiple days under existing staffing/resource levels, more precise estimates of the number of Snowy Plovers nesting in Recovery Unit 3 are not currently available. We are currently investigating alternative mark-recapture studies involving additional banding effort and/or other, more intensive methods to provide this information in the future (see also *Chick Fledging Success* below).

Nest Abundance and Success

In 2015, we found 304 nests in RU3, the most nests documented in the history of the recovery unit (previous high of 252 nests in 2010). Our larger, more skilled field crew likely increased detection of both successful and unsuccessful nests throughout the course of the season. This was especially true at IWS ponds, where field staff spent a large amount of time checking nests, cameras, and participating in banding. Increased banding efforts over the past two seasons allowed for the documentation of two renesting attempts over the course of the season, both after successful and unsuccessful previous 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. Issues traditionally associated with inaccurate nest counts, such as renesting after depredated nests (Warriner et al. 1986) and undetected unsuccessful nests, likely occurred during 2015. We currently lack estimates of re-nesting probability for Snowy Plovers in this Recovery Unit, which would aid in statistical determination of the number of nests initiated during the season. Unsuccessful nests are less likely to be found than successful nests, creating bias in apparent nest numbers, apparent nest success and apparent nest densities. However, we believe that these issues were less of a factor during this season.

Apparent nest success estimates ranged widely by pond and pond complex, with an overall average depredation rate of 33% (97/298) in RU3. At Eden Landing, E8 had the highest nest depredation rate at 48% (12/25), E14 was close to the RU3 average at 32% (31/98), and E6C had no nests depredated (8). At the Ravenswood complex, R3 had the highest nest depredation rate at 36% (4/11), RSF2 was lower at 28% (8/29), while R1 had a much lower nest depredation rate of 13% (1/8). At the Alviso and Warm Springs complexes, A3N had the highest depredation rate at 55% (6/11), A22 was close to the RU3 average depredation rate at 32% (7/22), and A13 had no nests depredated (4) (Table 5). Lower overall nest depredation rates may contribute to population growth within RU3; 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 2015, Snowy Plovers nested on ten Refuge ponds. We found 22 nests at Warm Springs, all located at pond A22. Nest depredation rates were much lower this season (32%) compared to previous seasons (67% in 2011, 100% in 2013, 72% in 2014). There are several potential causes for these high depredation rates. In the nearby Mowry ponds M1/M2, M3, and M4/M5, approximately 9,887 adult breeding California Gulls were counted (Figure 1; Washburn et al 2015). Warm Springs is also located near Newby Island Landfill, a potentially important source of food for gulls in the South bay. However, analysis of abatement efforts at Newby Island from 2008-2015 show that the number of gulls at the landfill has been significantly reduced compared to pre-abatement (Washburn & Heyse, 2016). As in past years, we observed large flocks of corvids perched on PG&E towers and foraging in the vernal pool grasslands to the northwest of the Snowy Plover nesting ponds. It is likely that corvids and raptors played a large

role in high depredation rates in prior years, though further monitoring is needed to confirm this.

In Alviso, we observed Snowy Plovers nesting on ponds A3N and A13 when pond water levels dropped and suitable nesting habitat became available. This marked the first year that A3N was used for plover nesting, as there is traditionally minimal available habitat. Due to construction activities in adjacent pond A3W, water levels in this complex were much lower, creating a significant amount of dry pond habitat for plover nesting. Eleven nests were found at A3N, though their depredation rate (55%) was relatively high compared to other ponds. There are many power towers suitable for predator perching within and around the pond, and both red-tailed hawks and peregrine falcons were consistently observed hunting in the area.

One nest was found this year on an island in A16, though it was depredated shortly after initiation. This pond hosted six nests in 2013, during which time it was kept dry for construction activities to build waterbird nesting islands. As with other constructed islands elsewhere in the South Bay, Snowy Plovers have subsequently shown only moderate affinity for nesting on these areas. Water levels were kept high in New Chicago Marsh to provide habitat for endangered salt marsh harvest mice (*Reithrodontomys raviventris*); zero Snowy Plover nests were found here due to a lack of dry nesting habitat.

Ravenswood pond R1, which held the largest amount of plover nests in the complex during the 2014 season (16), was flooded for much of this season resulting in a greatly reduced number of nests (8) in the pond (Table 5). R1 water levels were managed higher than usual for ducks during the winter (C. Strong, pers. comm.), therefore the pond did not evaporate until late in the season. As a result, it is likely that some Snowy Plovers nested instead at nearby available habitat in ponds R4 and RSF2. R4 hosted the most plover nests in the Ravenswood complex in 2015 (30), with a 77% rate of hatch success (Table 5). RSF2 saw a large upswing in the number of nests (29) and lower rate of nest depredation (28%) compared to the previous two seasons (2013: 6, 50%; 2014: 10, 70%) (Table 5, Figure 19). Nests were found on R5 (4) for the first time since 2012, all of which hatched (Table 5, Figure 19). These annual shifts in nesting habitat use suggest that Snowy Plovers can rapidly adapt to a changing landscape. This will be necessary for future plover recovery, as Phase 2 of the SBSPRP proposes to create tidal marsh habitat in R4 while maintaining R3 for breeding plover habitat. Phase 2 actions will effectively reduce Snowy Plover habitat in the Ravenswood complex overall. Supporting breeding Snowy Plovers during restoration actions at Ravenswood can be facilitated by careful water level management and habitat improvement at ponds R1, R3, and RSF2 during the breeding season. Doing so will support Snowy Plover use of the complex in the future.

Use of other seasonal ponds by breeding Snowy Plovers may help to offset the impact of changing habitat, particularly the overall reduction in available breeding habitat. If managed specifically for plover use, they may serve as transitional habitat during Phase 2 of the Project when some ponds will be breached and henceforth unavailable. Areas that may serve this function include Crittenden Marsh, pond A13, and pond A3N. Each of these ponds present a

set of challenges that could limit plover nest success, including public disturbance, high predator presence, and limited water management capabilities. However, with appropriate actions these issues may be mitigated enough to provide successful habitat options.

At Eden Landing, Snowy Plovers nested on thirteen ponds, with the majority of nesting occurring at pond E14 (98 nests, 56% of all nests in the complex). The high number of nests at E14 was likely related to the oyster shell habitat enhancement completed in November 2014. Ponds E12 and E13 were used relatively little compared to prior seasons, with only 6 and 2 nests, respectively (Table 5). During the 2014 breeding season, the first year of test operations for enhanced management of the reconfigured ponds E12 and E13, 14 nests were found on the internal drivable gravel levee and smaller berms which were not necessarily intended for shorebird nesting. All such nests were depredated prior to hatching. During the 2015 breeding season, however, only two nests were found in these areas at E12, with one successfully hatching. This sharp decline in use reflects previous anecdotal trends of plover habitat use, in which Snowy Plovers are initially attracted to new substrates and habitats. However, nesting density declines in subsequent years if depredation rates are high during the first year of use. In addition, five nests in E12 and one nest in E13 were found on nesting islands. Of these, only one located in E12 hatched, while the other 5 were depredated. These findings support previous trends of the limited plover use of nesting islands. In the South Bay, Snowy Plovers primarily select nesting habitat on large pond bottoms rather than nesting islands. The larger size of dry pond bottoms may provide greater crypsis for incubating adults and may increase flushing opportunities from approaching predators, whereas the small size and isolation of nesting islands may reduce the ability of nesting Snowy Plovers to evade predator detection.

Pond E8 supported the second largest amount of nests at Eden Landing, with a total of 25 nests (Table 5). The nest depredation rate was relatively high at 48%. Aside from E14 and E8, nests were relatively scattered throughout Eden Landing. Pond E6C in Eden Landing was regularly monitored for Snowy Plover nest activity beginning in mid-July after a brood was reported by SFBBO staff. Eight nests were found in E6C, all of which successfully hatched. Additional plover broods were also seen during nesting surveys, indicating that there may have been successful nests on the pond that had hatched prior to the beginning of monitoring. This pond was flooded in the beginning of the season and water levels changed with seasonal evaporation, thus limiting the amount of nesting activity missed. E6C will be monitored as needed in future breeding seasons.

Based on the amount of breeding activity at Eden Landing this season and in previous years, it is likely to remain critical breeding habitat for the future. Ponds E8 and E14 support the majority of nests, but monitoring shows that Snowy Plovers will use a multitude of ponds that are available nearby (Figure 20). To ensure that Snowy Plovers don't become too concentrated in any given area, at least several other Eden Landing ponds should continue to be drawn-down and managed for breeding Snowy Plovers each year. These areas should be supported by removing tall and dense vegetation, treating or removing large cracks in the ground, and most importantly, controlling for predators. This past season's findings suggest that high predator

presence at Eden Landing will continue to limit population growth at the reserve, and subsequently for all of Recovery Unit 3, if not adequately addressed.

Construction activities for Phase I of the SBSPRP continued through mid-May of the 2015 breeding season. Construction during the season was limited in size and scope, resulting in minimal potential for disturbance to nesting Snowy Plovers. SFBBO was contracted by Ducks Unlimited to monitor for breeding Snowy Plovers within construction areas during the nesting season. No significant impacts arose from construction activity in 2015.

This marks the seventh year that the number and fate of nests were documented for the North Bay ponds. For the second year, pond restoration and construction activity required CDFW biologists to monitor ponds 7/7A more intensely than previous seasons. This may have increased the detection rate of nests within the area. The 2015 breeding season also marked the first year since 2011 in which plover nests were found at the Green Island Unit.

Additional Nesting Areas.
Montezuma wetlands, an in-progress restoration site located in Solano County, contain some suitable plover nesting habitat. Eco Bridges Consulting, on-site biologists contracted to perform California Least Tern monitoring, agreed to perform the breeding window survey using proper survey methods this season, which had not been previously done. With confirmed plover breeding activity at this location indicating that there were at least several successful nests (Anne Wallace, pers. comm.), it is important that SFBBO continue to establish more consistent methods of Snowy Plover monitoring during future breeding seasons.

As there is no consistent snowy plover monitoring on a large portion of Cargill operated ponds, it is unknown how much nesting activity may occur on these ponds. Considering that there are occasional sightings of plover broods on these ponds, including two this season at M13, it is possible that there is additional nesting activity that goes undetected each year.

Nesting Behavior

Use of trail cameras at selected nests in pond E14 allowed for close examination of plover nesting behavior, including incubation, hatching, male and female nest attendance, and brooding. Two unusual events were documented with trail cameras during the season that warrant further discussion. In one incident, cameras documented a hatchling dying in the nest from natural causes not long after hatching. After it died, the male moved the hatchling to a location away from the nest, and then resumed brooding the two remaining hatchlings before eventually moving the brood away from the nest site. When banders arrived at this nest the following morning and prior to reviewing the camera footage, the third chick's location or status was unknown.

Trail cameras also captured another intriguing post-hatch event. In this case, a female was brooding chicks in the nest bowl that had recently hatched. While she was brooding, a male appeared on camera and copulated with the female. The polyandrous behavior of Western Snowy Plovers has been well documented, as females will often abandon their broods several days after hatch and renest shortly thereafter (Warriner et al. 1986). However, to the best of our knowledge, this is the first time that copulation associated with female renesting has been observed at an active nest site, particularly while the female is preoccupied with brooding.

Chick Fledging Success

We believe that relying on banding and re-sighting plover chicks in the 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 Snowy Plovers is characterized by uneven topography/substrate, and spans a large and complex network of ponds, sloughs, and channels. When combined with heat waves and long scoping distances, this creates very difficult conditions for locating broods. When broods are observed, the ability to effectively re-sight color combinations is often quite limited. In one case, a fledgling was confirmed at Sunset Beach in Monterey Bay over two months after the end of the season; it had not been sighted in the South Bay since one week after its hatch date at RSF2. This suggests that current survey methods used in RU3, particularly at larger ponds with widely varying habitat, are inadequate to accurately document brood activity, apart from opportunistic events. Considerable effort and planning are also needed to band Snowy Plovers in 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. Getting to hatching nests in time is further complicated by the sheer size of the ponds. This past season, Snowy Plovers nested on ponds totaling over 2100 hectares, with individual ponds ranging in size from 12-183 ha. Often, ponds are only accessible by kayak, and furthermore, the pond bottom can be difficult to traverse due to soft mud and a multitude of deep and wide channels. 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 will also require considerable resources to implement. Regardless of the methods used, all must carefully balance the need for more intensive monitoring with the potential impacts caused by increased researcher disturbance to Snowy Plovers.

IWS Reproductive Success Study

Preliminary results from this season's data suggest that there are two limiting factors for chick survival – chick age until fledging (first week versus remaining weeks) and inter-season time (first versus second half of the season). Clearly, chicks are most vulnerable during their first week after hatching and will benefit from management actions like habitat enhancement, predator control, and nest site protection. The arrival of migrating shorebirds in the South Bay may account for higher survival rates during the second half of the season, as they may be easier sources of food for predators and reduce predation pressure on plover chicks. Lower

survival rates at Ravenswood study sites compared to Eden Landing sites also follow our recommendations to continue supporting nesting Snowy Plovers in Eden Landing ponds.

This was the second and final year of SFBBO's involvement in the study. Humboldt State University (HSU) and Point Blue Conservation Science (PBCS) also participated this season at coastal breeding sites. We hope that this study will provide a set of observational tools that can be reliably used to estimate chick fledging success, and in particular, in identifying techniques that are efficient in the San Francisco Bay Area.

Oyster Shell Habitat Enhancements

Apparent Estimates.
In 2015, as in previous years of study, we documented higher apparent nest densities in shell plots (1.58 nests/ha) compared to control plots (0.33 nests/ha). Apparent nest success was higher in shell plots (37%) than other areas of Eden Landing (29%) this season (Figure 15). Density and success of nests in individual shell plots over the years may be influenced by a variety of factors, including but not limited to the brightness and quality of the shells varying on the plots. Shells in some areas were completely covered in sediment if, for example, the pond was flooded over the winter (E14 plot 2; E16B plot 2; E6B plots 2 and 3; E8 plots 2 and 4;), while shells in other areas remained mostly white (E14 plots 1 and 3; E16B plots 1 and 3; E6B plots 1 and 4; E8 plots 1 and 3). Therefore, there may have been differences in the camouflage benefits provided by shells. Apparent nest densities were much higher in the large scale Enhancement plots in E14 compared to Non-Shelled areas (1.7 nests/ha and 0.1 nests/ha respectively). This drastic difference in nest density provides further evidence that oyster shell enhancements provide a desirable nesting environment for Snowy Plovers.

Large Scale Enhancement Study.
Implementation of habitat enhancements at Eden Landing pond E14 allowed us to further test the efficacy of this method. Our pilot study using 1-ha plots gave promising indication that oyster shells provide beneficial cover for nesting Snowy Plovers and suggest further breeding benefits on a larger scale. Our analyses show that large scale enhancement had no significant effect on nest survival, chick survival, or chick behavior during development. However, we strongly caution that many of our statistical models had low power due to small sample sizes, and we strongly recommend the continuation of this monitoring effort for an additional year. This will not only strengthen our statistical analyses, but it will document whether Snowy Plovers follow similar nesting patterns of decreasing use of enhanced areas over time. This information will ultimately inform species and Project management, and will impact the targeted use of available resources.

Data from the 2015 breeding season suggest that large scale oyster shell enhancements have the potential to greatly increase nest density, however some problems may result. For instance, concentrated nesting may lead to increased predation if predators learn to cue in on nests in shell plots as Page et al. (1983) found with Snowy Plovers at Mono Lake. During this

season, both Common Ravens and Peregrine Falcons were consistently seen hunting in pond E14. Both nest camera footage and in-person accounts of depredation events suggest that increased predator presence is likely to occur with increased nest density. However, fledge rates for E14 were higher compared to other ponds that were part of the IWS program, indicating that large scale shell enhancements may also increase chick survival. If confirmed, this would constitute a significant development towards reaching population goals for the Project and RU3.

In addition, increased density occasionally resulted in territorial aggression between broods, which could result in adult and/or chick mortality. Two documented chick mortalities in E14 may have resulted from this increased aggression. On April 29, one unbanded chick was found dead on the pond bottom and in an area where a young brood was previously seen near aggressive adults. It was estimated to be three to four days old. One day prior to finding the dead chick, a male was seen in this location vocalizing and searching as if looking for a chick.

On April 27, the three-chick brood from an E14 nest was seen roughly 350m from the nest site where they were banded. Two chicks were foraging and brooding normally with the male while the third chick (ON:RB) was immobile on the pond bottom nearby. ON:RB was not brooded as frequently as the other two. A biologist briefly walked out to inspect ON:RB which was peeping weakly, appeared weak, but had no obvious injuries. After leaving the area to observe again, the male and two healthy chicks began moving on, leaving ON:RB at the same location. ON:RB was collected at 11:00 to be taken to Monterey Bay Aquarium (MBA) rehabilitation facilities. During transit, it was peeping weakly while its head often rolled back, crop bulging out. It was immobile and dead upon arrival, and was given to MBA biologists for testing. The diagnosis made by the pathologist was acute, multifocal severe hemorrhages on the liver, most likely due to trauma. Potential for aggression between males and broods must be taken into account when considering use of this habitat enhancement method. For detailed analysis of the E14 habitat enhancement study, see Tokatlian et al. 2015.

Additional Considerations.
Nesting locations in general may be attributed to habitat availability as a result of water level management and habitat conversion during tidal restoration projects. Accurately documenting inter-seasonal changes in breeding habitat availability is imperative as restoration Project activities continue. Calculating nesting densities using entire pond areas instead of the actual physically available area will obfuscate nesting projections needed to support breeding Snowy Plovers in a changing landscape. We recommend continuing our weekly habitat availability surveys, or designing another method that will accomplish similar results.

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 breeding numbers within a smaller habitat footprint. Shell plots are one way to achieve the higher nest densities needed to reach the Recovery Unit goal of 500 breeding birds. Oyster shells are no longer available from Drake's Bay Oyster Company, Marin County.

Therefore, it may be useful to investigate the feasibility of oyster shell collection programs from local restaurants, in addition to investigating the effectiveness of alternative materials used for habitat enhancement. Treating nesting areas with gravel, wood debris or bivalve shells may provide similar beneficial functions, however these materials should be tested through a pilot study before applying them on a larger scale. Additional strategies for supporting Snowy Plover recovery are the expansion of predator management/deterrence programs, and improvement of water control at designated ponds to ensure that dry, open panne habitat is available for nesting with nearby wet areas for foraging.

Avian Predators

Both Peregrine Falcons and Common Ravens were considered to be the main predators affecting plover recovery in Recovery Unit 3 during the 2015 breeding season. This is in contrast to past years, when California gulls were assumed the main predators. From 2009-2011, California gulls were the predator most consistently recorded depredating nests (using remote cameras), and the only predator documented in all three seasons (Demers and Robinson-Nilsen 2012). During this season, however, trail cameras deployed at nests in pond E14 did not document any California gull activity. Rather, they documented ten egg depredation events by common ravens, and in several instances where trail cameras malfunctioned, it is likely that at least several more nests were depredated in the same manner by ravens. Trail cameras also captured one incident of newly hatched chicks being taken directly out of the nest by peregrine falcons.

Peregrine Falcon populations continue to recover throughout North America, coinciding with declining environmental levels of Dichlorodiphenyldichloroethylene (DDE) and enactment of the Endangered Species Act (Cade 1988). While most of Coastal California has not yet experienced complete recovery, urban populations have recovered significantly (Kaufmann et al. 2004), including the South Bay, where they pose an especially significant threat to Snowy Plovers at Eden Landing. The nesting pair in an E9 hunting blind located approximately 200 meters from E14 fledged two juveniles by early June. The adults, and later also 2 fledglings, were consistently seen perched in and hunting over E14 and other sensitive plover nesting areas in Eden Landing. Whenever possible, biologists flushed Peregrine Falcons away from sensitive plover habitat and investigated prey remains for evidence of plover predation; however, no plover remains were found. On two separate occasions, however, Peregrine Falcons were visually observed depredating Snowy Plovers. In one instance, a biologist observed a chick depredated while running on pond E14 with the associated male. On the other occasion, a biologist observed an adult male plover depredated by an adult Peregrine and subsequently given to a juvenile Peregrine to eat.

SFBBO biologists accompanied predator specialists from the United States Department of Agriculture (USDA) in June and July, and attempted to haze the individual Peregrine Falcons without negatively impacting nesting Snowy Plovers. In an effort to proactively deter Peregrine

Falcon activity during the plover breeding season, we plan to continue removing or altering blinds and perches before the 2016 nesting season begins.

We frequently observed both Red-tailed Hawks and Common Ravens perched in the transmission towers within ponds at all three Refuge complexes. The Refuge coordinated with Pacific Gas and Electric (PG&E) to remove eight Common Raven nests and one Red-tailed Hawk nests in towers over sensitive habitat in 2015 (Strong and Sainz 2015). In addition, six California Gull nests were removed from boardwalks located adjacent to sensitive habitat. The Refuge will continue to coordinate the removal of nests from towers and boardwalks with PG&E annually.

The total number of California Gulls nesting in the South Bay was 47,806 breeding birds in 2015, a decline of over 5,000 from the 53,026 breeding birds recorded in 2014 (Washburn and Heyse 2015, Tokatlian et al. 2014). Three of the largest gull colonies (Alviso A9/A10/A14 colony, Coyote Hills N6/N7 colony, and Mowry M4/M5 colony) are particularly close to Snowy Plover nesting areas. Contrary to 2009-11, when gulls were identified as a major predator to nesting Snowy Plovers (Robinsen-Nilsen et al. 2011), gulls did not appear to have the same effect on nest success in 2015. This may be linked to the fact that their population appeared to decline by approximately 9.8% from 2014 to 2015. Since 2011, SFBBO and Refuge biologists have coordinated a non-lethal gull hazing program and successfully prevented gulls from nesting in areas identified as sensitive plover habitat (C. Strong, pers. comm.). This year marked the second season that hazing methods included the use of a high powered laser directed at roosting gulls flocks. This method produced mixed results, and should be reviewed further to determine appropriateness for gull hazing (V. Hayes, pers. comm.). Continued California Gull hazing and tracking is essential to prevent gulls from nesting in sensitive areas in future years.

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 in ponds with Snowy Plover nests. On one occasion, a harrier was observed kleptoparasitizing a White-Tailed Kite that had caught a Snowy Plover. Past research in the Sacramento Valley has found that harriers will often kleptoparasitize smaller raptors found within their territory (Temeles 1990). The Harrier then took the plover to the adjacent marsh to eat. 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.

Mammalian Predators

During the 2015 breeding season, red foxes continued to use a den located in the Saltworks area of E13. On numerous occasions early in the season, fox pups were observed playing near the den entrance. As the pups grew older, they were observed hunting throughout ponds E12-

14, particularly during the early morning hours when biologists arrived on site. It is possible that two nests were depredated by these foxes. One was located in the Saltworks approximately 115 meters away from the den, while the other was located approximately 150 meters away on the E12/13 levee. In both cases, foxes were suspected due to the close proximity to the den site. The substrate on dry ponds and levees do not allow for easy identification of predators via tracks.

Though Snowy Plover nest predation pressure remained this season, we continue to decide against the use of single nest exclosures. The execution of exclosures in dry pond habitat is cumbersome, and the potential for adult injury or fatality are arguably too substantial (Dave Lauten, pers. comm.). Using exclosures in barren dry pond habitat also results in conspicuous signs in the substrate (footprints) which does not weather away as it would on sandy beach habitat. This would make nests easier to find for predators, and risk adult plover loss (Caitlin Robinson-Nilsen, pers. comm.). Furthermore, exclosures improve rates of nest success but are ineffective in supporting chick survival or fledge success. Due to resource limitations, we chose to focus on alternative methods of predator control with help from USDA predator specialists.

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, contain constructed nesting islands. Islands are intended to provide waterbird nesting and roosting habitat. One of the Project's long-term 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 2015, SFBBO biologists monitored E12, E13 and E14 and communicated real-time locations of plover nests, broods, and adults to construction crews and to agency personnel. We have found that weekly meetings and daily, on-the-ground communications are essential in minimizing the threat to nests and broods from construction activities, as well as 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. As Phase II of the Project proposes to enhance some ponds (R3) for plover nesting habitat while breaching others (R4) in the same complex, we advocate for nesting habitat enhancement to occur prior to breaching. This will help to ensure that there is high quality nesting habitat available to Snowy Plovers when overall habitat availability decreases. During construction, we strongly urge managers to provide nesting habitat in areas adjacent to those ponds being drained for construction (for example, R1 and R2). While this will not entirely prevent plover nesting in the dry construction ponds, it may reduce the number of nests in

them. Furthermore, managers should begin this approach in January or February in order to allow pond bottoms enough time to dry and become available by the start of breeding season.

We suggest that construction activities on Snowy Plover nesting ponds occur outside of the breeding season whenever possible, and that actions be taken before the nesting season begins in order to deter Snowy Plovers from nesting on ponds where heavy equipment will be operating. 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. Some methods used to deter plover nesting, such as kites and reflective tape, have not proved effective in the past and should not be relied on as potential strategies.

This year, 36% of Snowy Plover nests in the South Bay were found within Eden Landing ponds E12-E14, and similar to last year, construction activity was limited to four independent locations along perimeter levees. SFBBO provided safety buffer locations and monitoring support during these events. Though impacts were limited, we nevertheless approached construction monitoring with the same standards and guidelines as in previous years, establishing safety buffers and clearing all impacted areas before work began on a daily basis. This type of monitoring is very resource intensive. In future years, we recommend focusing construction in small, localized footprints and outside of the breeding season to reduce potential impacts on Snowy Plover breeding.

The largest impact that the Project will have on South Bay Snowy Plovers is the long-term reduction of nesting habitat as dry 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 ponds opened to tidal action or converted historically hosted large numbers of Snowy Plovers (A8, E12-13 and E8A; Figure 14, Figure 17, Figure 18, and Figure 19). Losing the potential breeding habitat in these nesting ponds may reduce the number of Snowy Plovers nesting in the San Francisco Bay Area, although this has not yet happened. Nest numbers in 2015 reached an all-time high for the Recovery Unit. These elevated nests numbers were likely the result of two main factors as we previously discussed (E14 habitat enhancement and experienced field staff). Snowy Plovers in the San Francisco Bay prefer to nest in dry ponds or on large, open salt panne areas located near foraging habitat. While we have found seven nests on RSF2 islands, seven nests on E12 and E13 islands, and two on A16 islands since their operation as managed ponds, it is unknown how many pairs the created islands in these ponds will support in the future.

The USFWS (in cooperation with USGS and the US Army Corps of Engineers) implemented a social attraction effort on islands in ponds RSF2 and A16 over the 2014-15 winter season involving decoys and audio equipment. This project targeted Caspian Terns as part of a long-standing mitigation measure, but also included Snowy Plover social attraction on one island at each pond in order to maximize the ecological benefits on these breeding ponds. Six decoys of Snowy Plovers were placed on each island, and calls played over the course of the season.

SFBBO monitored these ponds as part of normal breeding surveys during the 2015 breeding season. No Snowy Plovers were observed on either island during the season, though one nest was initiated on an adjacent island in A16. As such, the efficacy of social attraction for plover nesting should be reviewed for future breeding seasons.

Another goal of the SBSPR Project is to increase public access in certain areas. Currently, most Snowy Plover nesting areas in the South Bay are closed to the public. At coastal breeding sites, human disturbance is a significant cause for abandonment of nest sites and lower overall nest success (Lafferty et al. 2006). 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. Research at coastal sites has also shown that human disturbance not only effects nest success, but can directly impact chick survival (Ruhlen et al. 2002). Installing fencing or barriers that limit pedestrians and cyclists from entering sensitive nesting areas is a necessary measure to reduce human disturbance, and should be implemented in future projects. Managers should consider low fencing (such as is present at RSF2) and smaller diameter chick fencing to keep Snowy Plover chicks off of 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 ponds should include projects that address the following topics:

1. Long term use of E14 large scale enhancement by breeding and wintering Snowy Plovers.
2. 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 needed to inform the recovery goal of 500 birds in Recovery Unit 3.
3. Nest success of Snowy Plovers on islands in managed ponds, and methods to improve nesting success on islands.
4. The effects of avian predator management on Snowy Plover breeding success.
5. Potential impacts of human disturbance from recreational trail use at Eden Landing and RSF2 as well as other sites.
6. Impacts of Peregrine Falcon, Common Raven, and California Gulls on nesting Snowy Plovers.
7. Northern Harrier territory size and habitat use and impacts on nesting Snowy Plovers, especially as tidal marsh nesting habitat increases for harriers.

8. Snowy Plover use of the ponds for foraging and roosting during the non-breeding season.
9. Snowy Plover foraging habitat use (borrow ditches, open channel, muted tidal, shallow pools, dry substrate) and invertebrate prey availability within the salt ponds.
10. Snowy Plover nesting habitat selection (use versus availability).

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 Snowy 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 Snowy 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 Snowy Plovers.
3. Monthly surveys should continue to include scouting components to visit areas that are not usually used by Snowy Plovers, including Frank's Dump locations in Hayward, Crown Beach in Alameda, and Bayfront habitat in Foster City and Redwood City. As the amount of pond habitat decreases, Snowy Plovers may use historical or new areas for nesting within the South Bay.
4. SFBBO, along with the Refuge, should continue to coordinate monitoring efforts in lower priority sites where Snowy Plovers have been seen breeding throughout RU3, including Cargill managed ponds PP1 and others as habitat is available.
5. SFBBO should continue to monitor the large scale oyster shell habitat enhancement at E14, and apply these findings to future enhancement opportunities, such as R3.
6. 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 should be placed in public areas to provide information on Snowy Plover habitat needs, disturbances, and conservation issues.
    b. Volunteer docents could be stationed at public areas adjacent to nesting sites, and trained to give guided plover surveys. This would create public awareness and support for Snowy Plovers, thereby reducing the human disturbance.

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, 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 occur 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 occurs adjacent to or within a Snowy Plover nesting area, then weekly meetings should be coordinated with all parties involved to ensure that all parties understand their roles in regards to minimizing impacts to listed species.
4. The predator management and gull hazing programs should continue in 2016 in the South Bay, with additional resources devoted to increase efficacy.
5. Managers should explore using alternative habitat enhancement materials or methods (oyster shell or other) as a tool for Snowy Plover recovery, and spread them in areas that will not be flooded.
6. Water levels in pond A23 should continue to 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. As designated breeding plover habitat, Cell 3 in RSF2 requires some modest enhancement in order to reach its full potential. Implementation of large scale oyster shell enhancement plots at RSF2 to cover more of the pond area may facilitate increased nest density, and could also reduce depredation risk for young broods.
9. If the Ravenswood ponds R1 and R2 are to support more Snowy Plovers in the future, these ponds should be drained before the breeding season begins, to expose panne habitat for nests. Also, replacing or improving water control structures in ponds R3 would allow for better water management. Water levels in the borrow ditches should be higher in order to keep interior channels full. This may enhance foraging habitat, and potentially, the numbers of Snowy Plovers using the complex. More water control structures could be added to the entire Ravenswood pond system to improve water management. Removal of remnant salt production structures used as predator perches would be beneficial for adult and chick survival.
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. Structures should be removed or treated with a bird deterrent such as Nixalite to discourage predator perching.
11. Law enforcement patrols 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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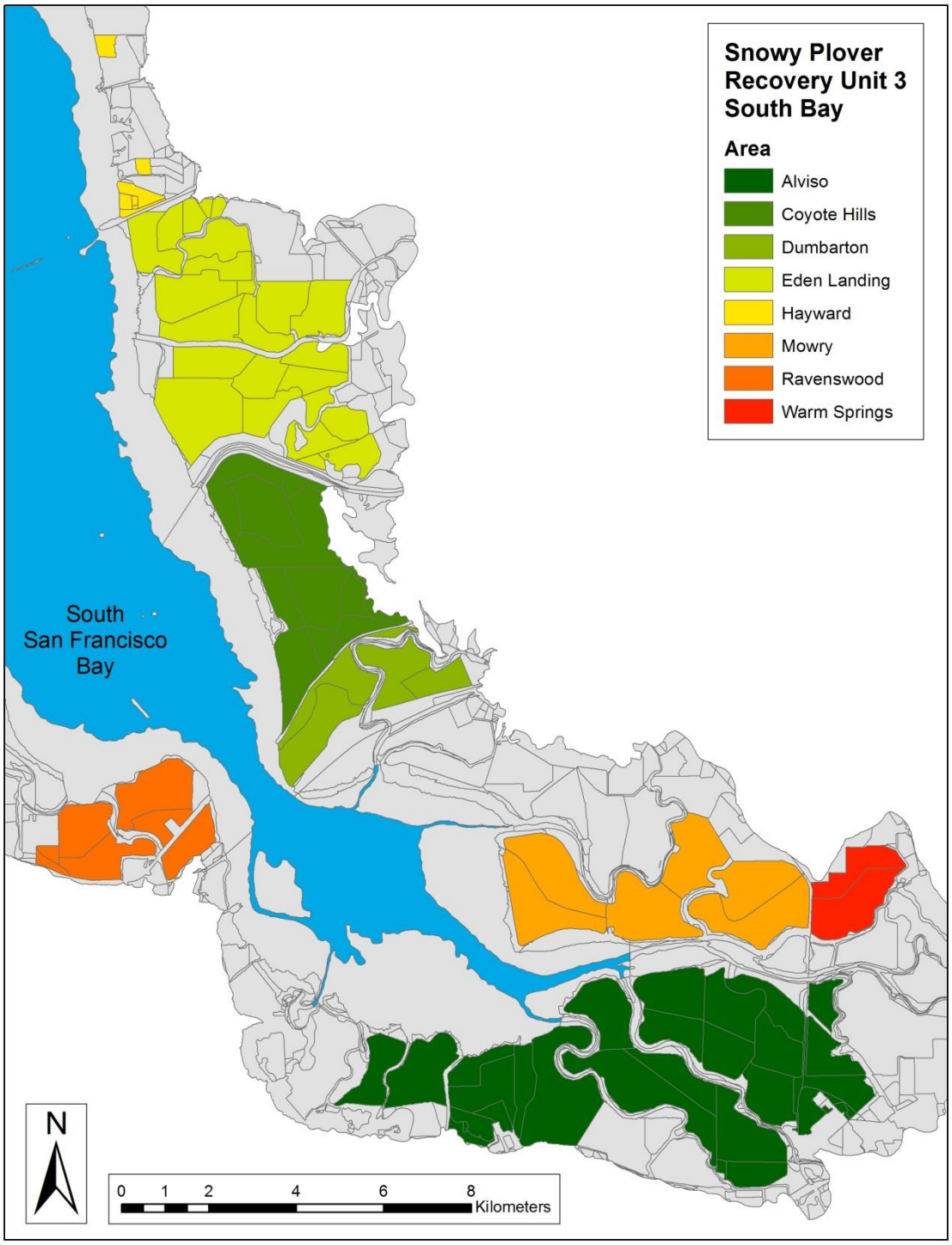

Figure 1. The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's Eden Landing Ecological Reserve, East Bay Regional Park District and Hayward Area Recreation and Park District lands in the South San Francisco Bay, California.

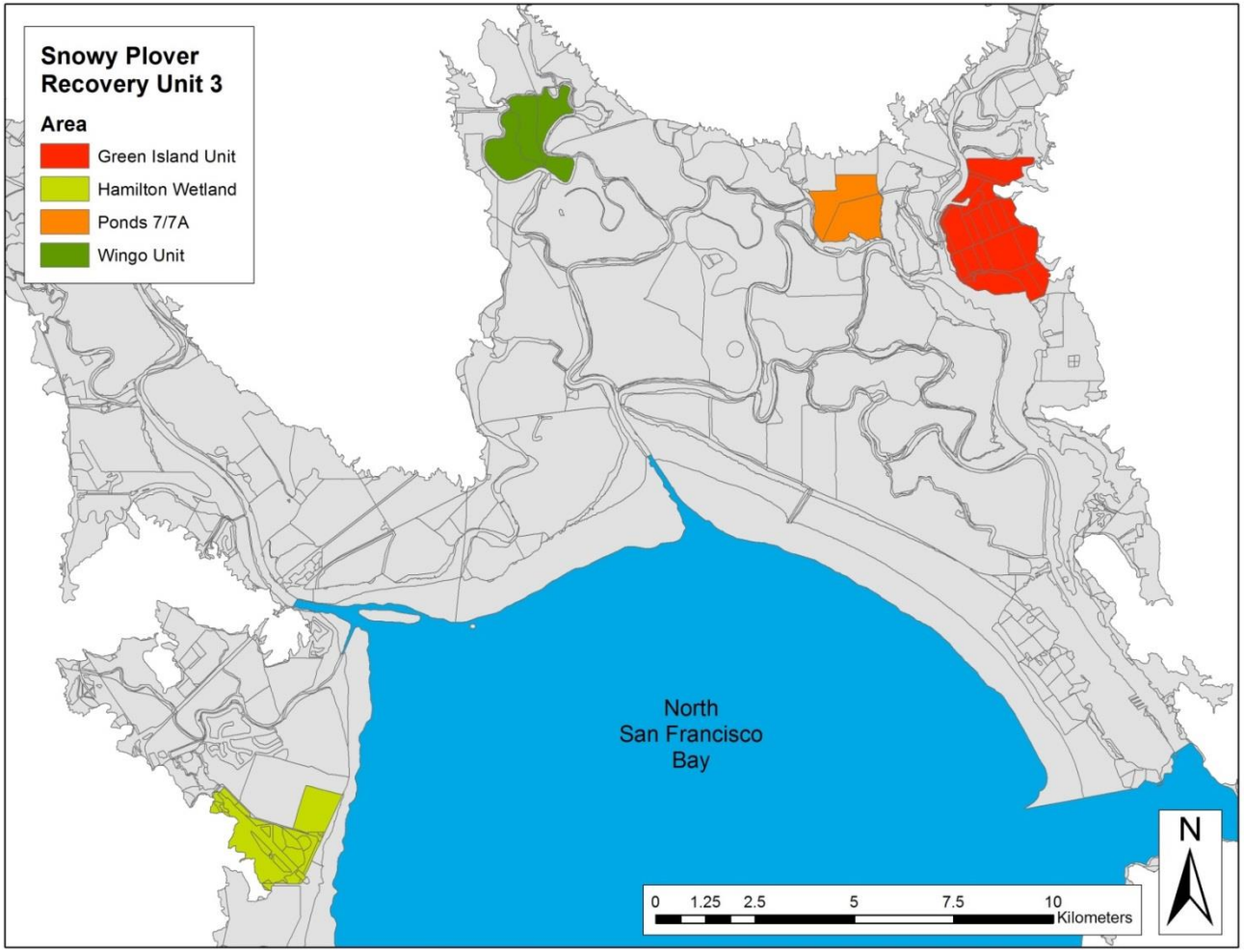

Figure 2. Snowy Plover nesting areas in the CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site), North San Francisco Bay, California.

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Figure 3. 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. Ponds in the Refuge's Alviso Complex, including Mountain View, 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. 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. 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.

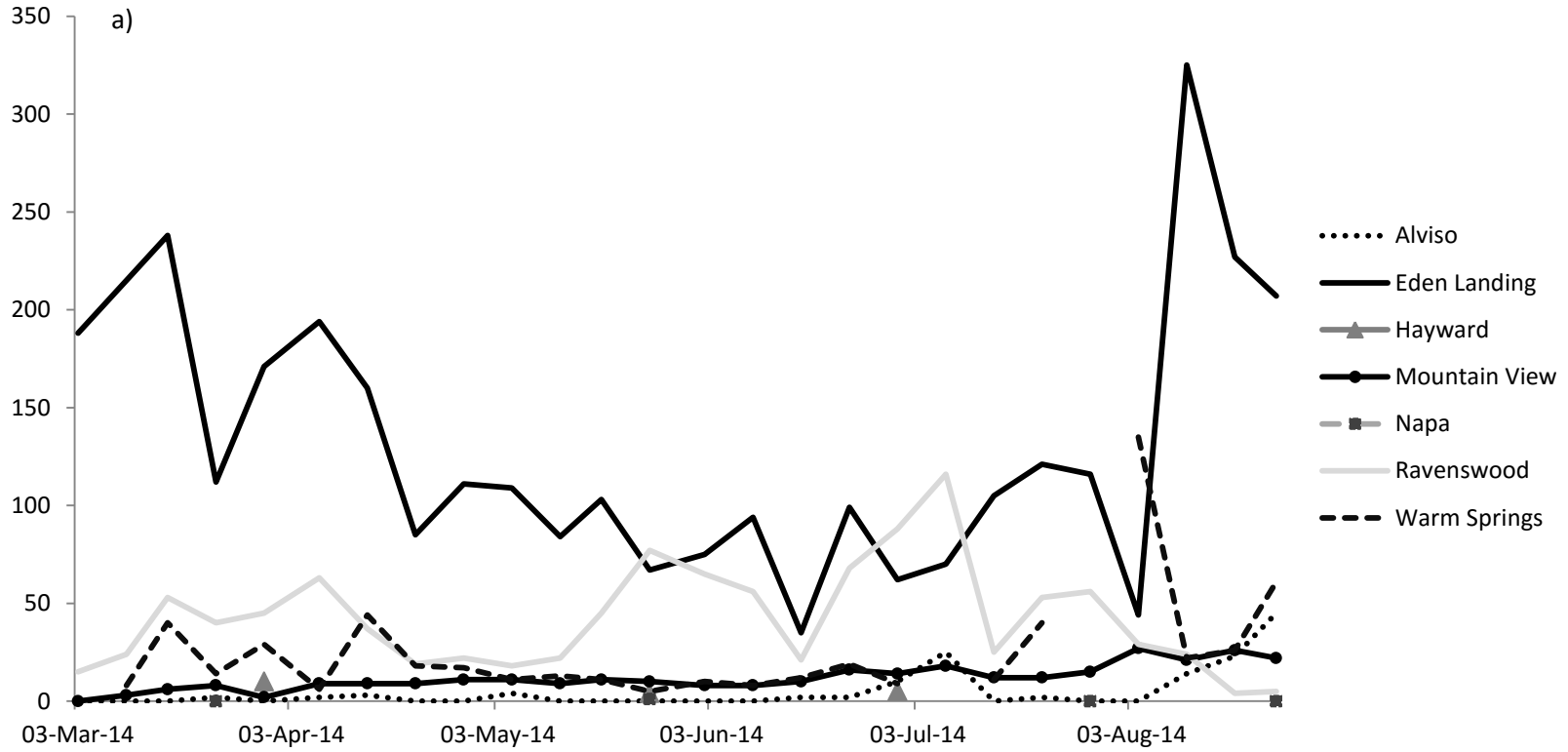

Figure 7a. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2015. Data are presented here for all locations monitored. Note the high number of Snowy Plovers observed in late March and August are presumed to be migrating and not breeding in the San Francisco Bay.

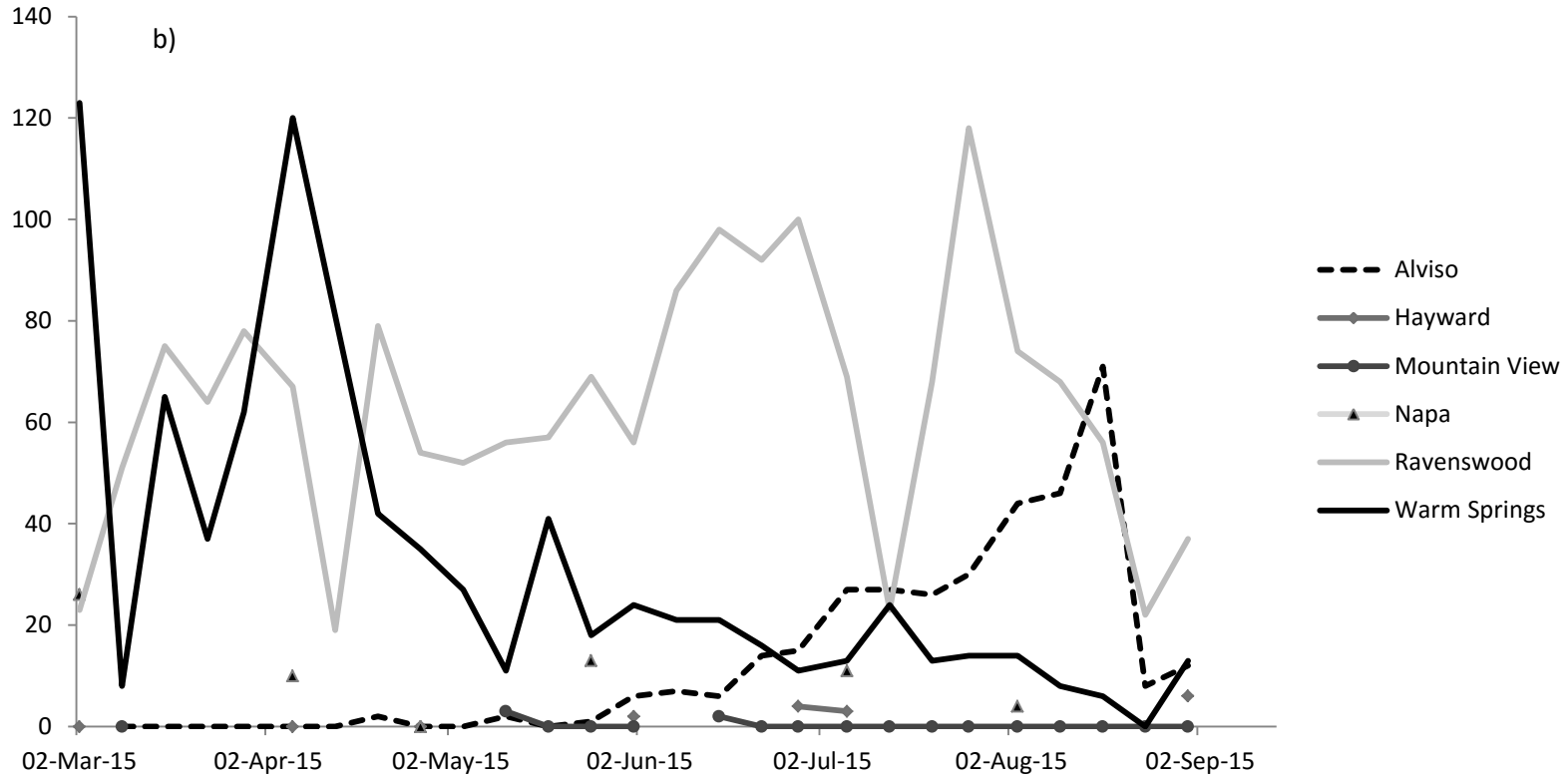

Figure 8b. Counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2015. To facilitate interpretation, data are presented for all locations monitored excluding Eden Landing. Note the high number of Snowy Plovers observed in late March and August are presumed to be migrating and not breeding in the San Francisco Bay.

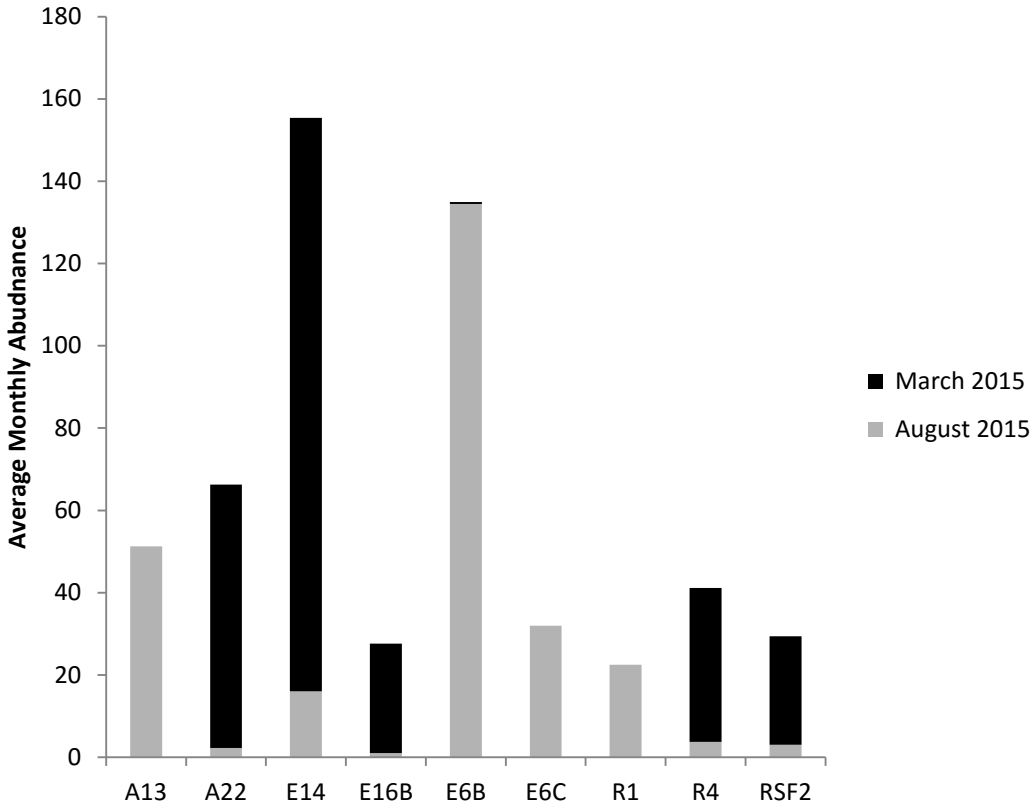

Figure 7c. Abundance of adult plovers at significant ponds during March and August, 2015. The purpose of this figure is to show that ponds are used by plovers in varying intensity during the beginning and end of the breeding season.

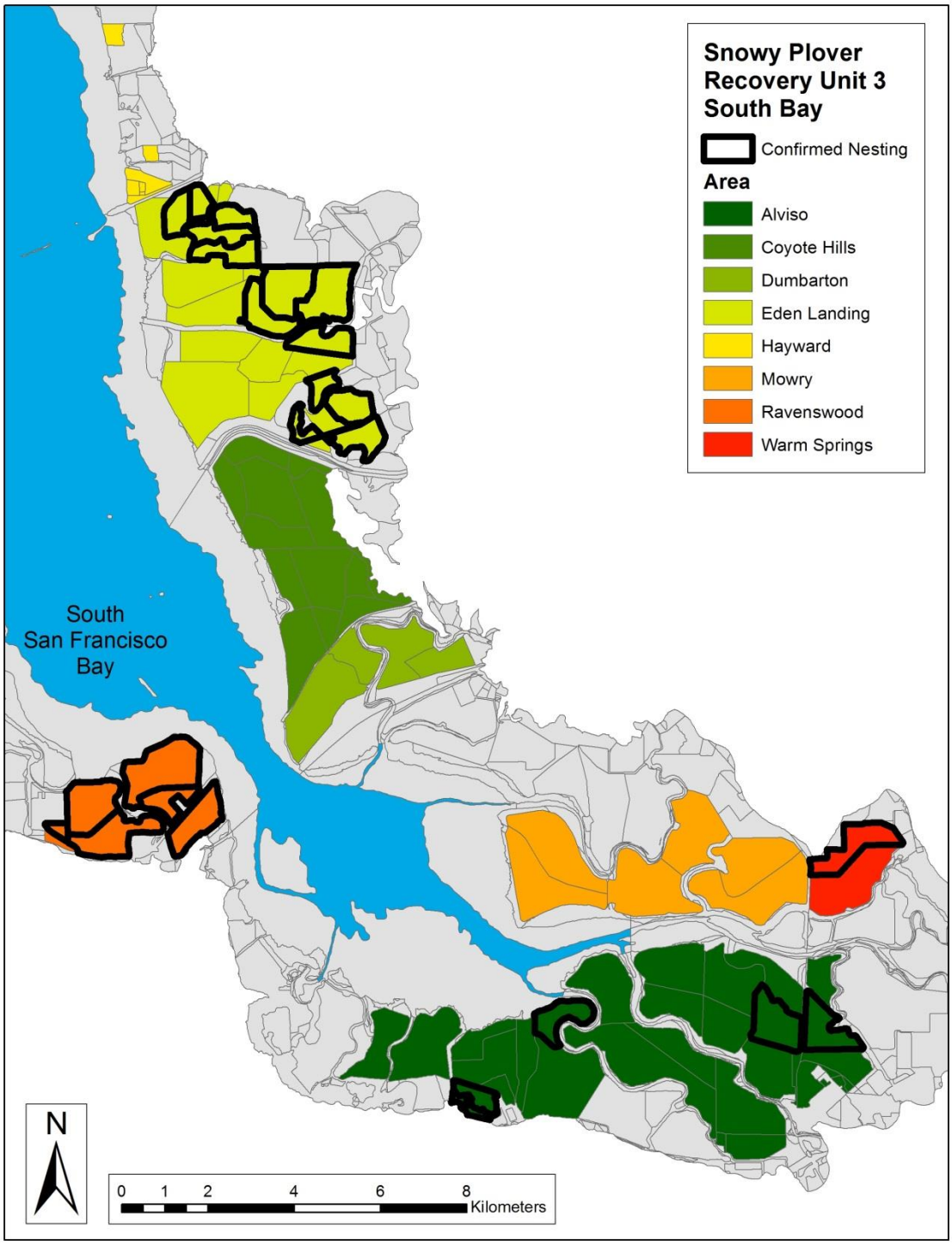

Figure 9. Areas (black outline) with documented Snowy Plover nesting activity during the 2015 breeding season, South San Francisco Bay, California.

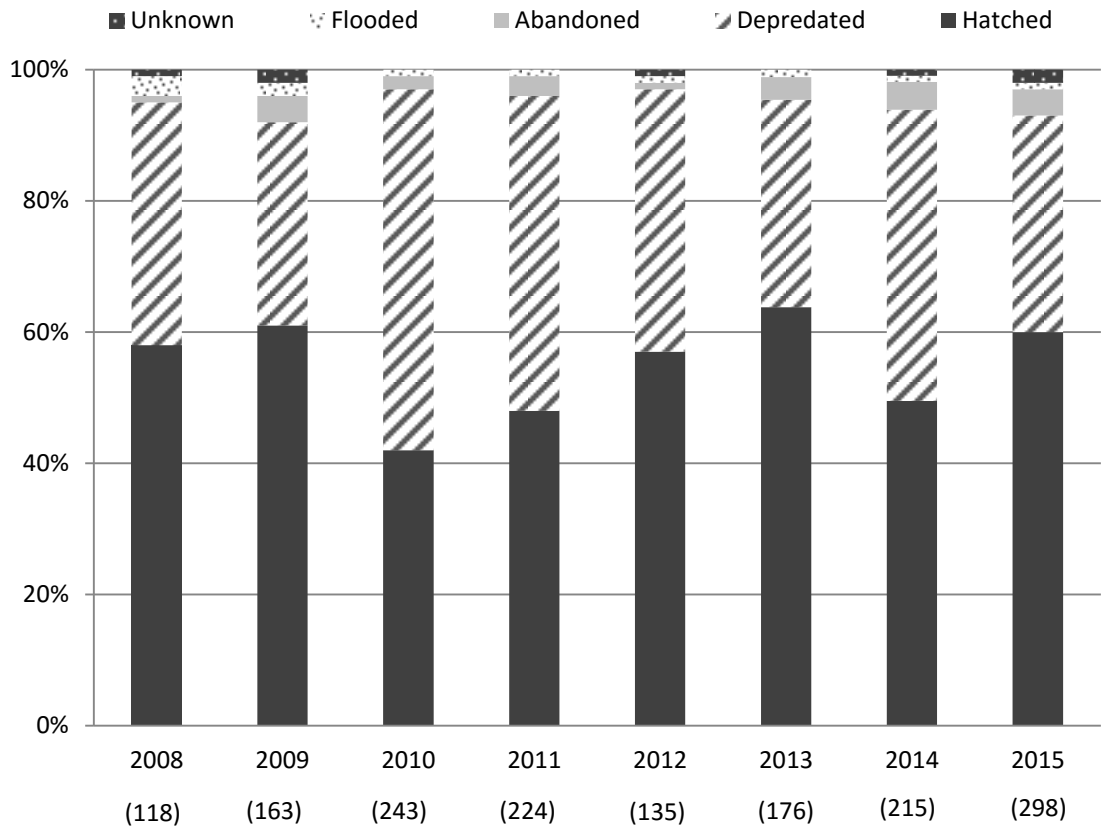

Figure 10. Annual apparent Snowy Plover nest fates in the South San Francisco Bay, California, 2008-2015. The number of nests monitored is indicated in parentheses beneath the year.

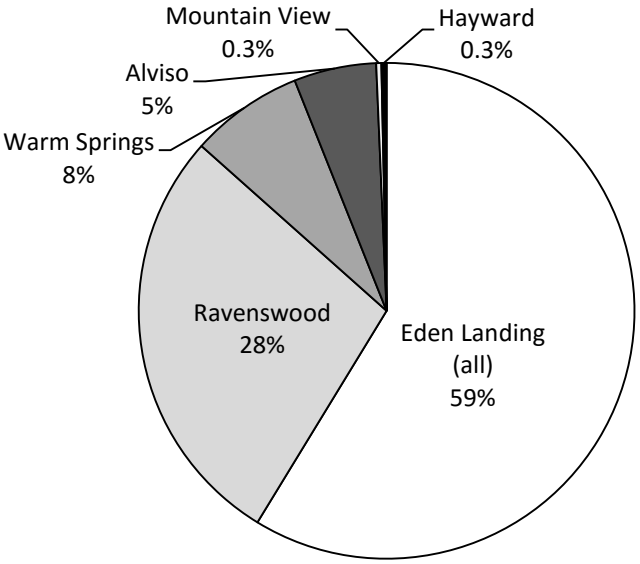

Figure 11. The proportion of Snowy Plover nests found in each pond complex in the South San Francisco Bay, California, 2015.

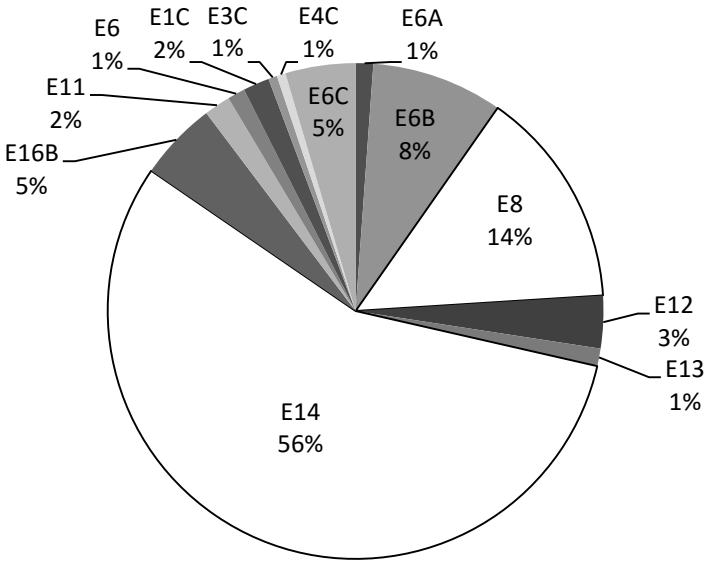

Figure 12 a. The proportion of Snowy Plover nests found in each pond at Eden Landing Ecological Reserve in Hayward, California, 2015. Note that 56% of Eden Landing nests were found in pond E14.

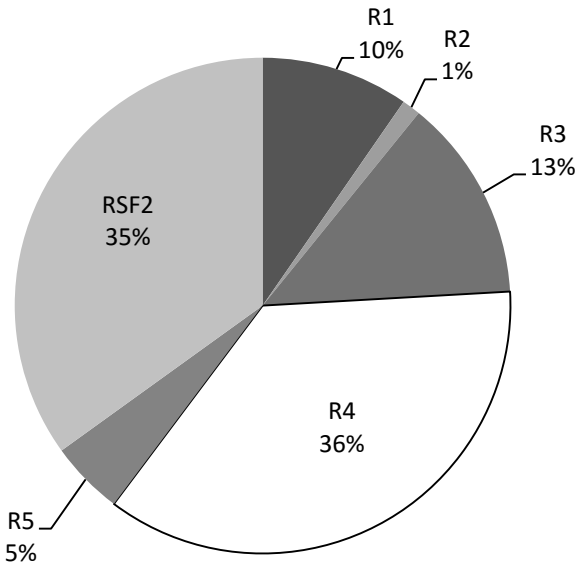

Figure 13 b. The proportion of Snowy Plover nests found in each pond at the Ravenswood Complex, Menlo Park, California, 2015.

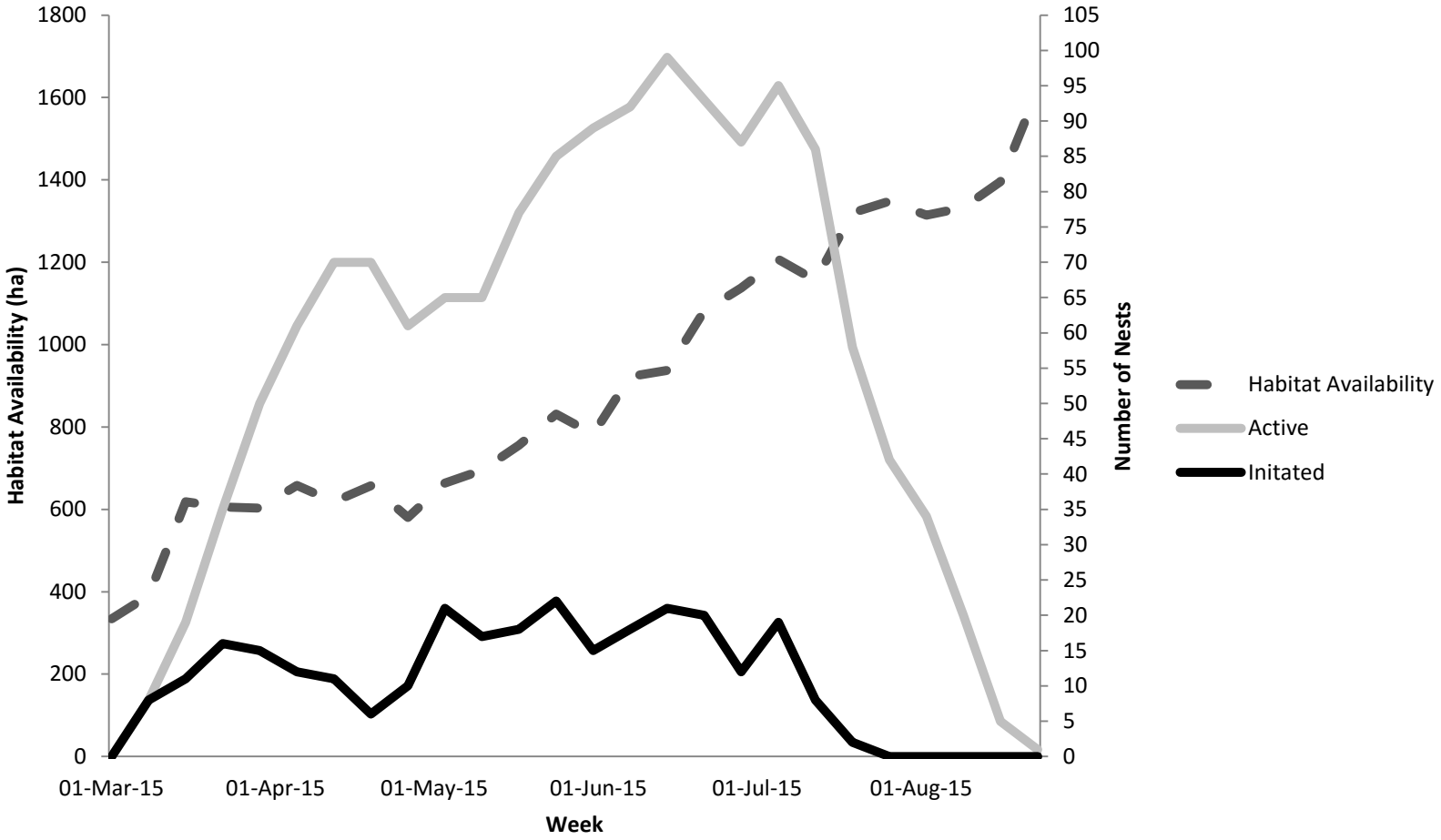

Figure 14. The weekly number of initiated and active Snowy Plover nests and estimated habitat availability in the South San Francisco Bay, California, 2015.

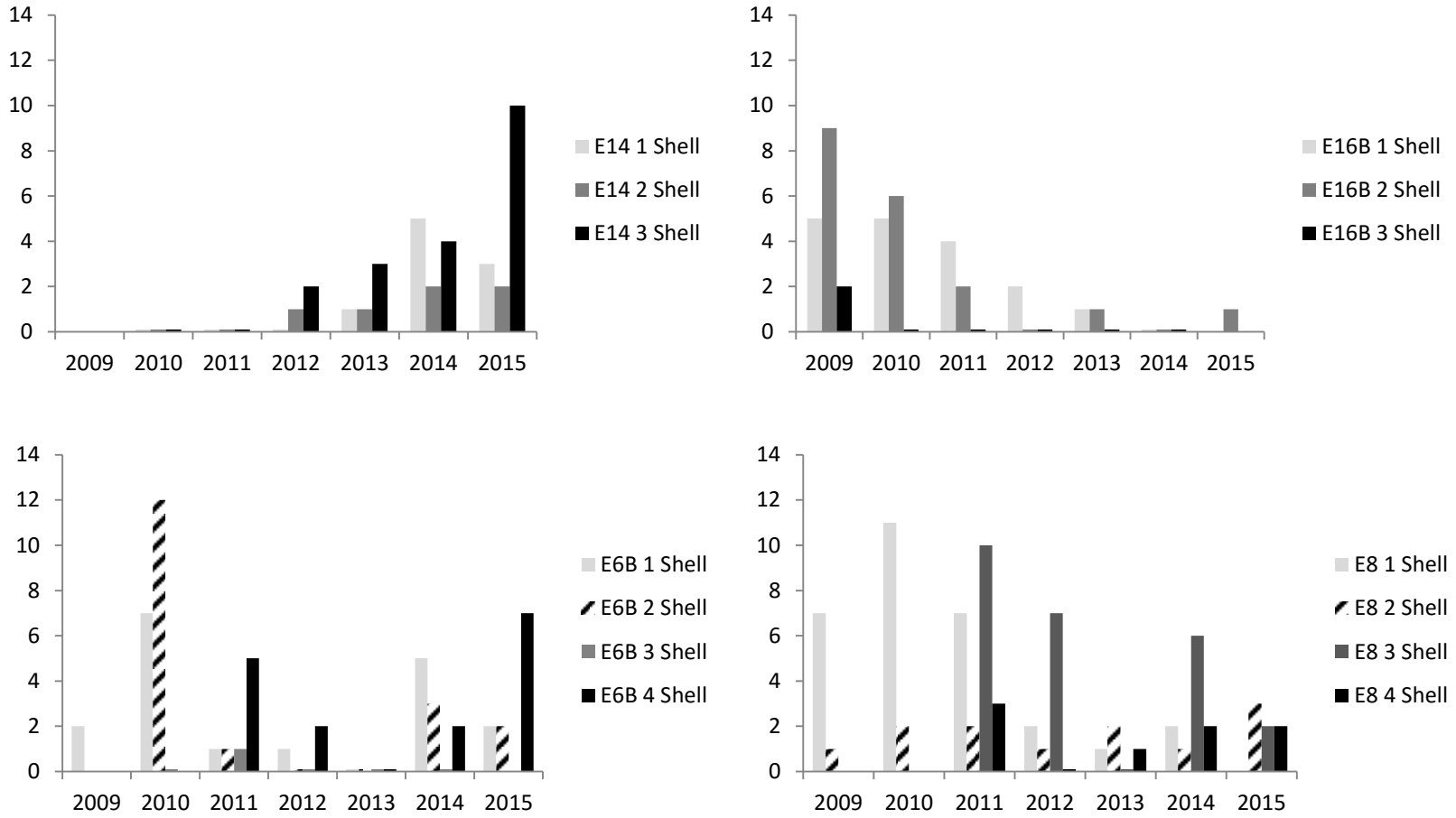

Figure 15. The number of Snowy Plover nests in each shell plot at Eden Landing Ecological Reserve, South San Francisco Bay, California, 2008-2015. Miniscule numbers were used to represent "0" nest values versus "null" values on each graph in order to signify years in which plots were not yet established. Shell plots considered to be in good condition are E16B-1 and 3, E6B-1 and 4, and E8-1 and 3. Shell plots considered to be in poor condition are E16B-2, E6B-2 and 3, and E8-2 and 4. Note that E14 shell plots are now surrounded by a new large shell plot, and thus no longer serve the same function in 2015.

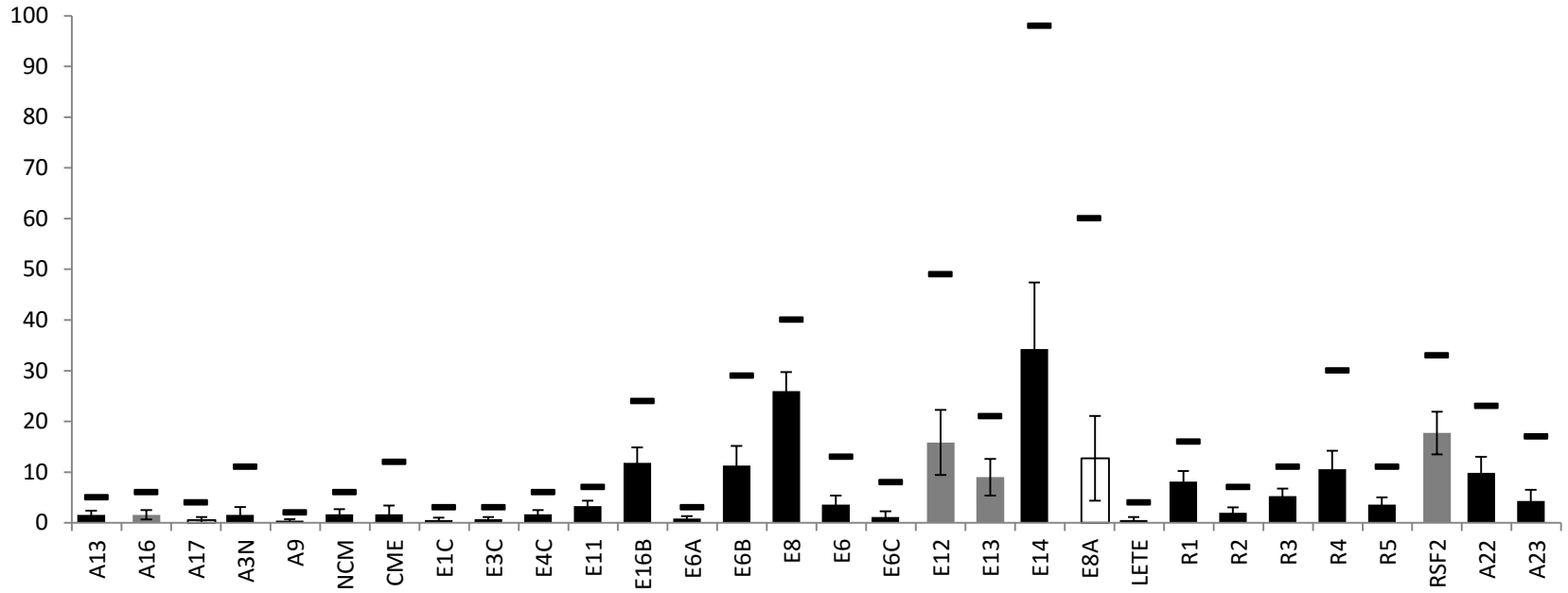

Figure 16. Average number of Snowy Plover nests initiated by pond in South San Francisco Bay, California from 2009-2015. Data are shown as mean + 1SD. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included 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 habitat available to Snowy Plovers will be reduced, black bars denote ponds that will not be directly affected by Phase 1 actions, and black dashes denote the maximum number of nests at each pond across all years. Note that "NCM" = New Chicago Marsh, "Hayward" = Hayward Least Tern Island, and "OBN" = Oliver Brothers North, Hayward; refer to Figs. 3-6 for other pond names and locations.

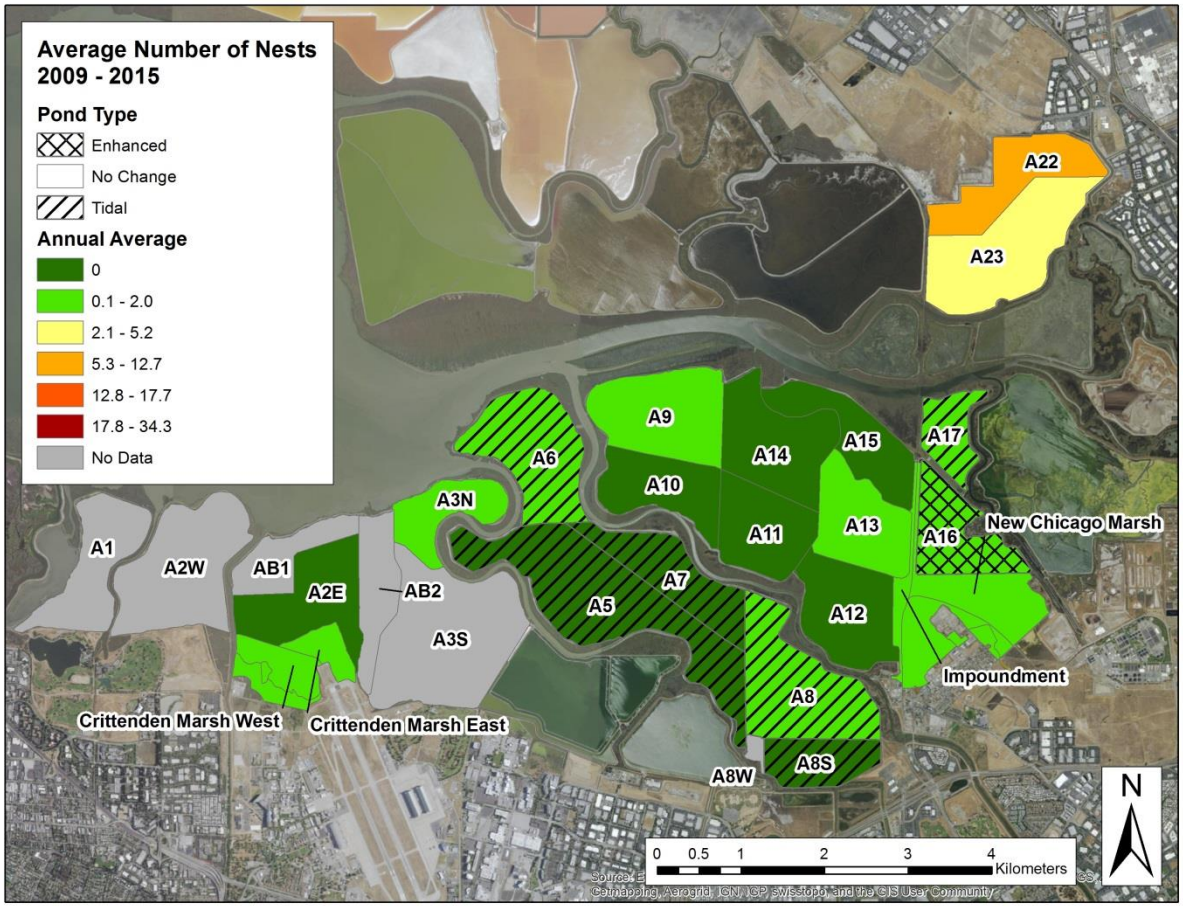

Figure 17. Average number of Snowy Plover nests initiated by pond in the Alviso Complex, South San Francisco Bay, California from 2009-2015. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. Diagonal lines denote ponds that have been returned to tidal (or muted tidal) influence, hatch lines denote ponds that are (or will be) enhanced for multiple species and the amount of habitat available to Snowy Plovers may be reduced (not A16), 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. 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.

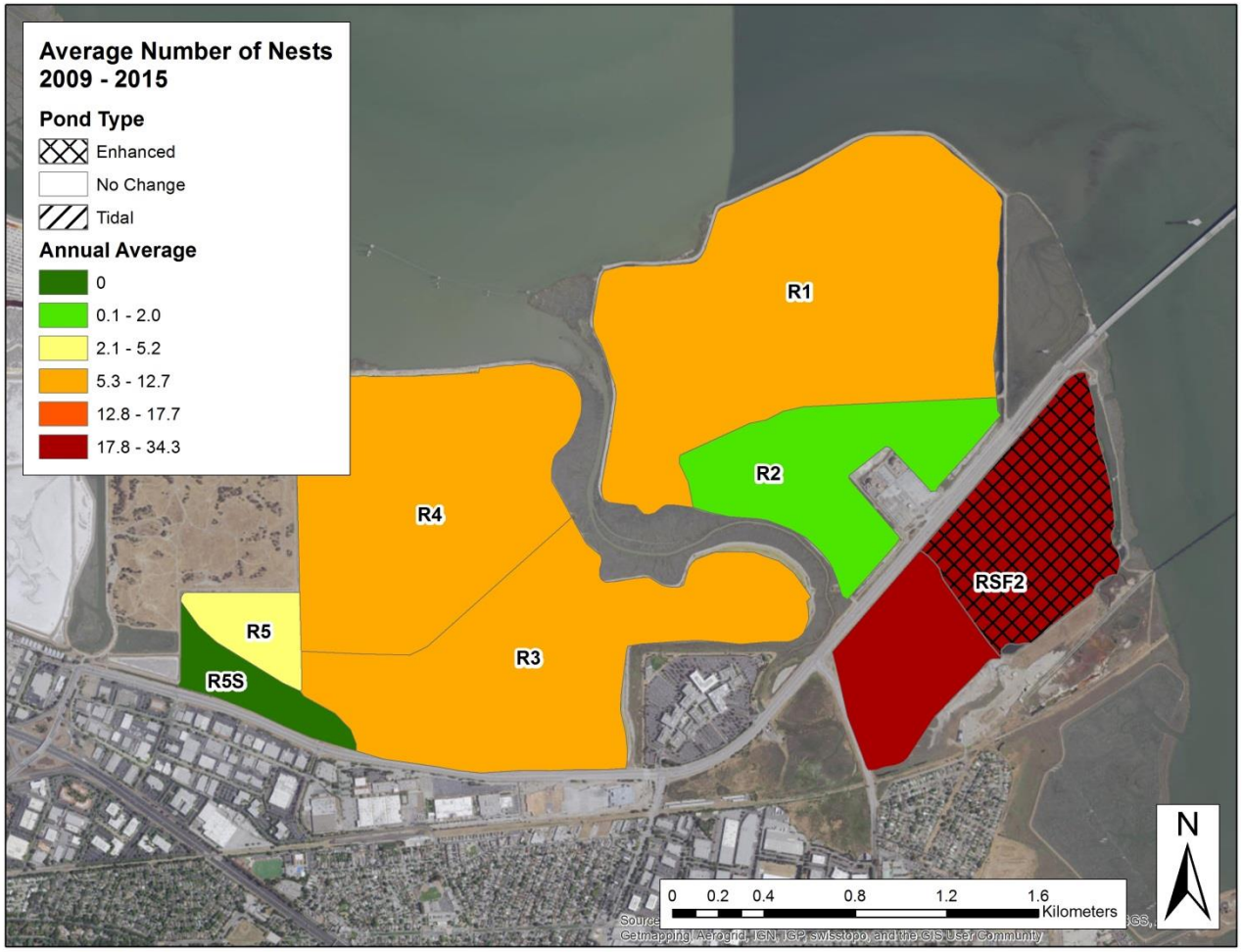

Figure 18. Average number of Snowy Plover nests initiated by pond in the Ravenswood Complex, South San Francisco Bay, California from 2009-2015. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. Crossed hatch lines denote ponds that have been enhanced for multiple species and the amount of habitat available to Snowy Plovers is reduced compared to recent years, 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.

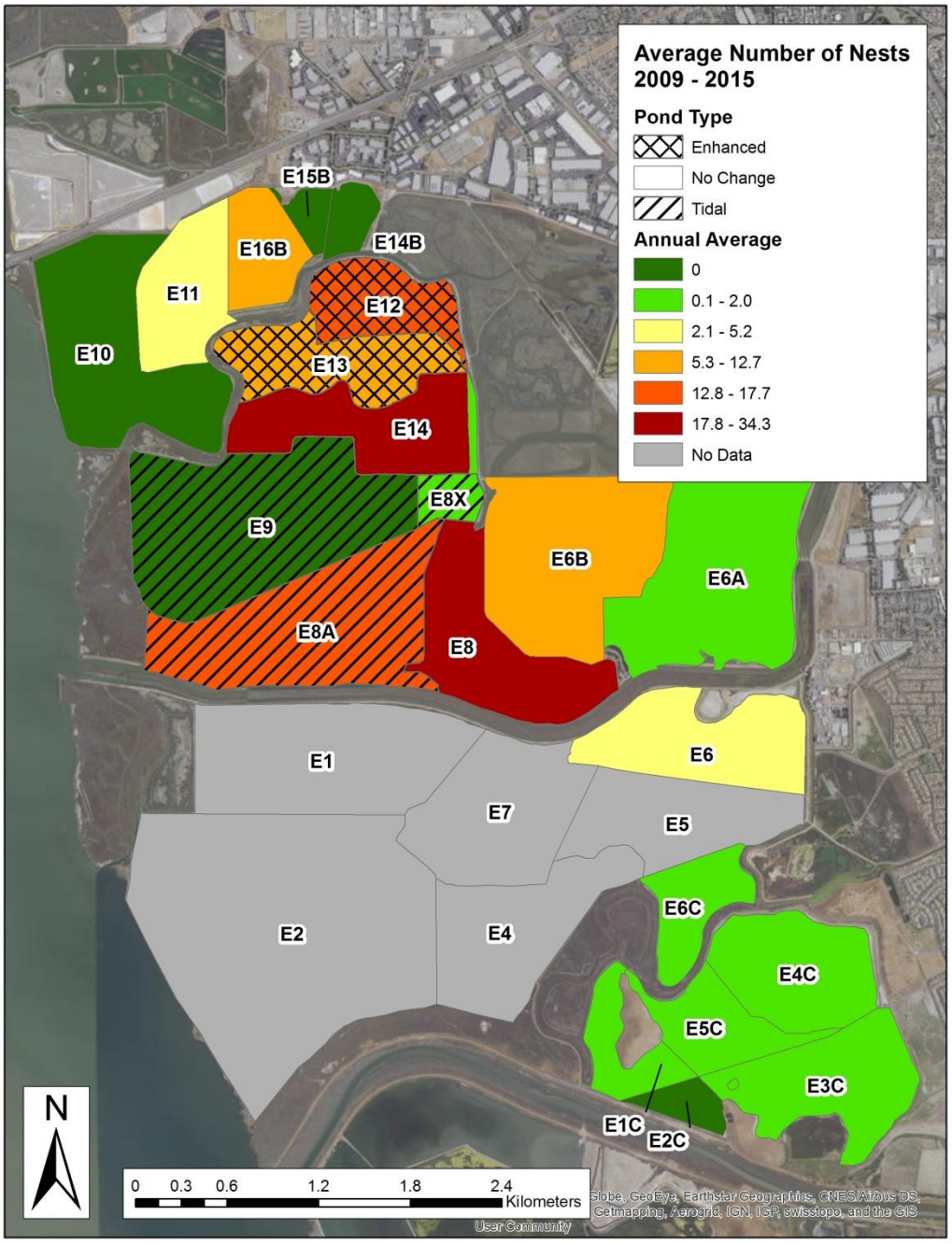

Figure 19. Average number of Snowy Plover nests initiated by pond in the Eden Landing Ecological Reserve, South San Francisco Bay, California from 2009-2015. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds 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 habitat 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. Note that pond E3C is owned by Cargill and managed largely as open water.

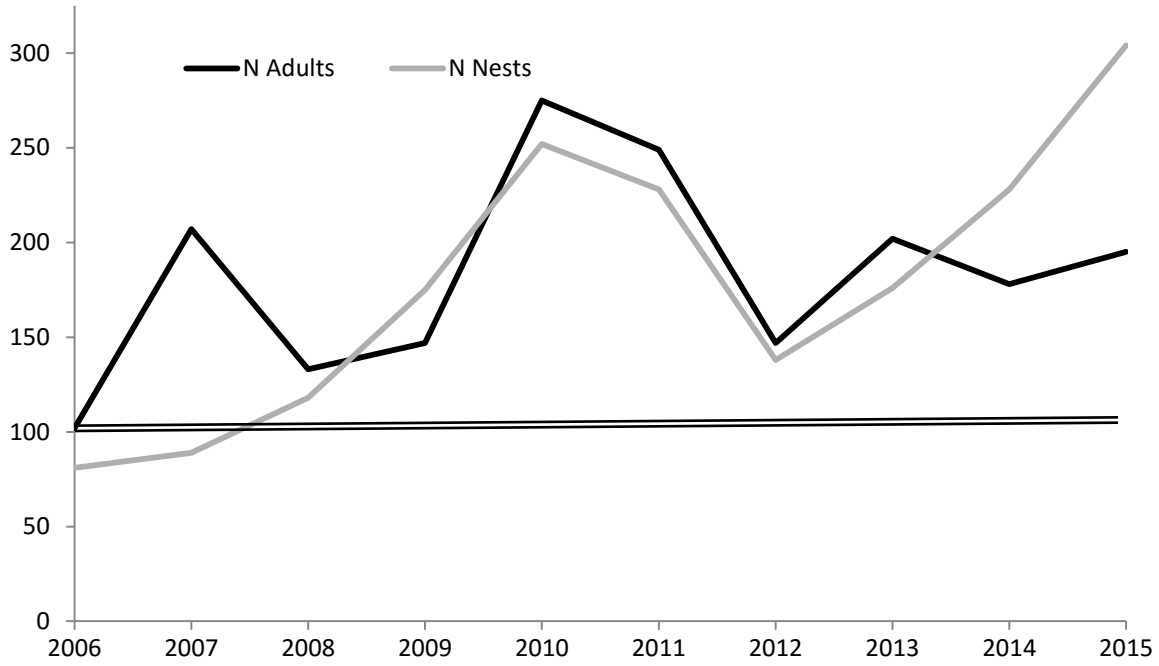

Figure 18. The total number of Snowy Plover adults counted during the breeding window survey and the total number of Snowy Plover nests counted during the season in all regularly monitored Recovery Unit 3 (RU3) areas, San Francisco Bay, from 2006-2015. The double line indicates the South Bay Salt Pond Restoration Project NEPA/CEQA baseline of 113 breeding adults in RU3, established from the average number of breeding birds from 2004-2006.

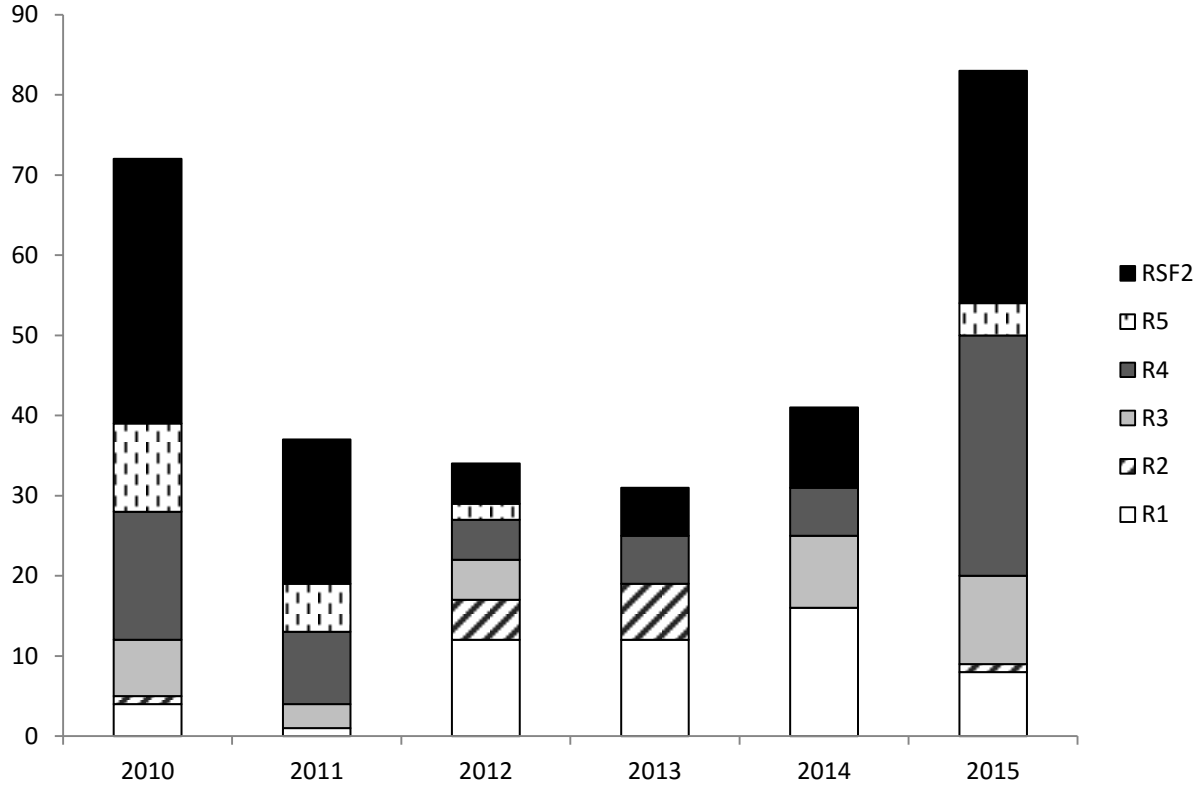

Figure 19. The number of snowy plover nests in the Ravenswood complex (ponds R1-5, RSF2) in Don Edwards National Wildlife Refuge, South San Francisco Bay, California, from 2010-2015. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years.

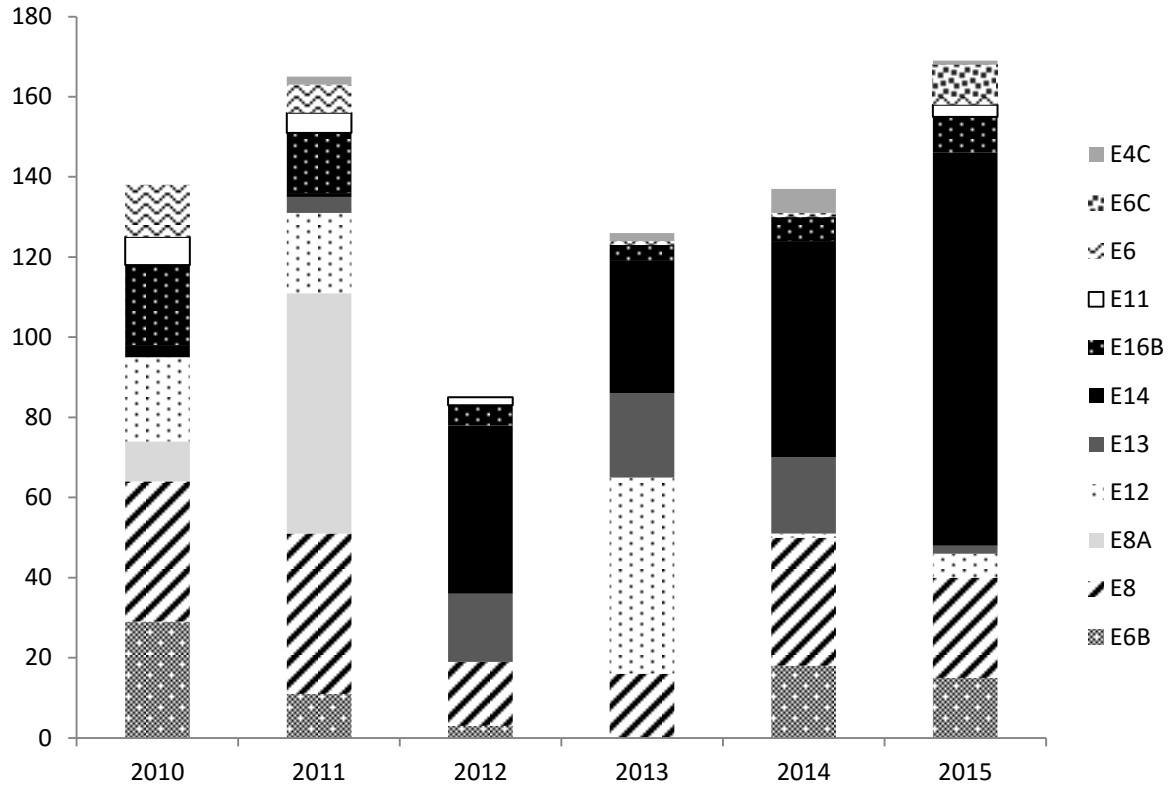

Figure 20. The number of Snowy Plover nests in Eden Landing Ecological Reserve, South San Francisco Bay, California, from 2010-2015. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years. It also shows an apparent positive trend in number of nests from 2012-2015. Following the 2011 breach of pond E8A, a reduction in total number of nests at Eden Landing was observed. The positive trend observed has restored the total number of nests at Eden Landing to pre-breach numbers.

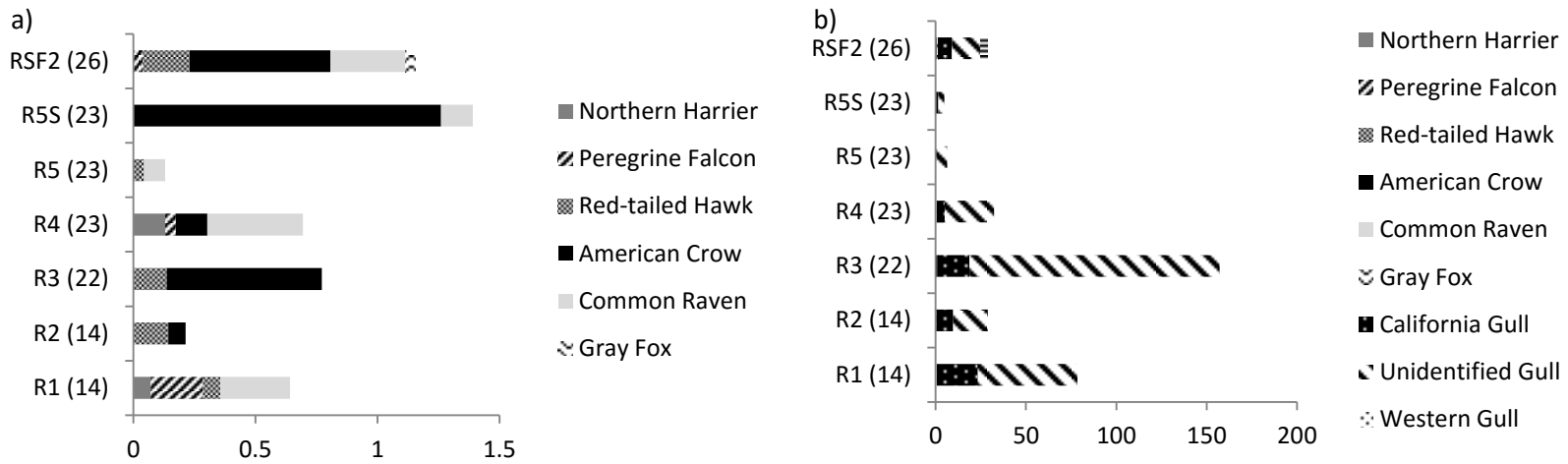

Figure 21. The average number of critical predators, a)excluding gull species, and b)including gull species, observed per survey at the Ravenswood Complex, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

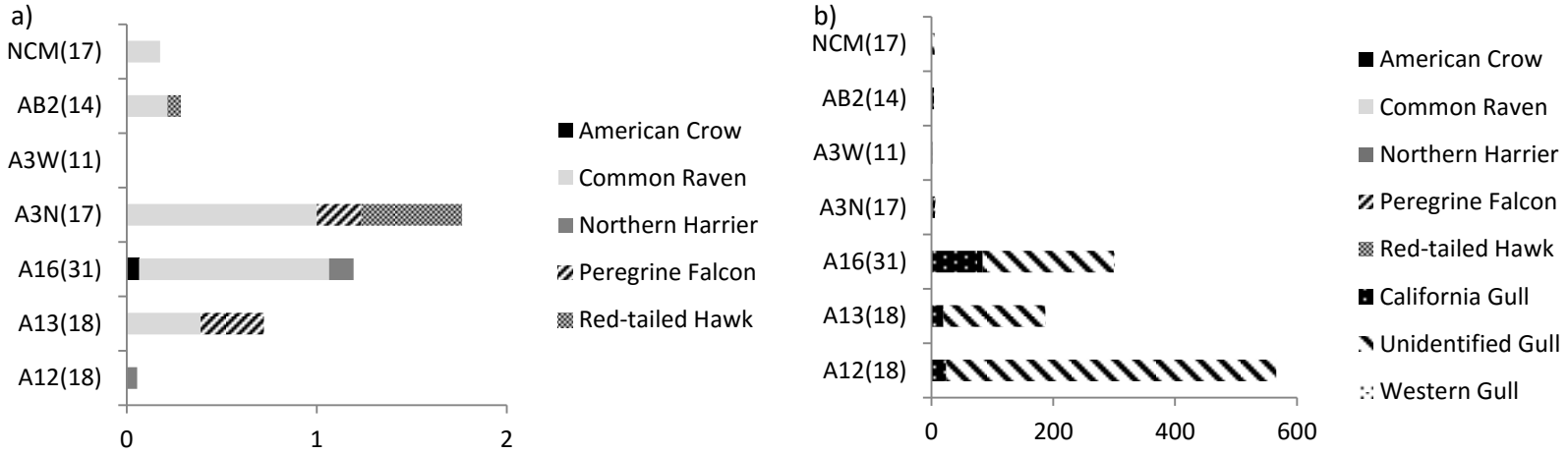

Figure 22. The average number of critical predators, a) excluding gull species and b) including gull species, observed per survey at the Alviso Complex, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

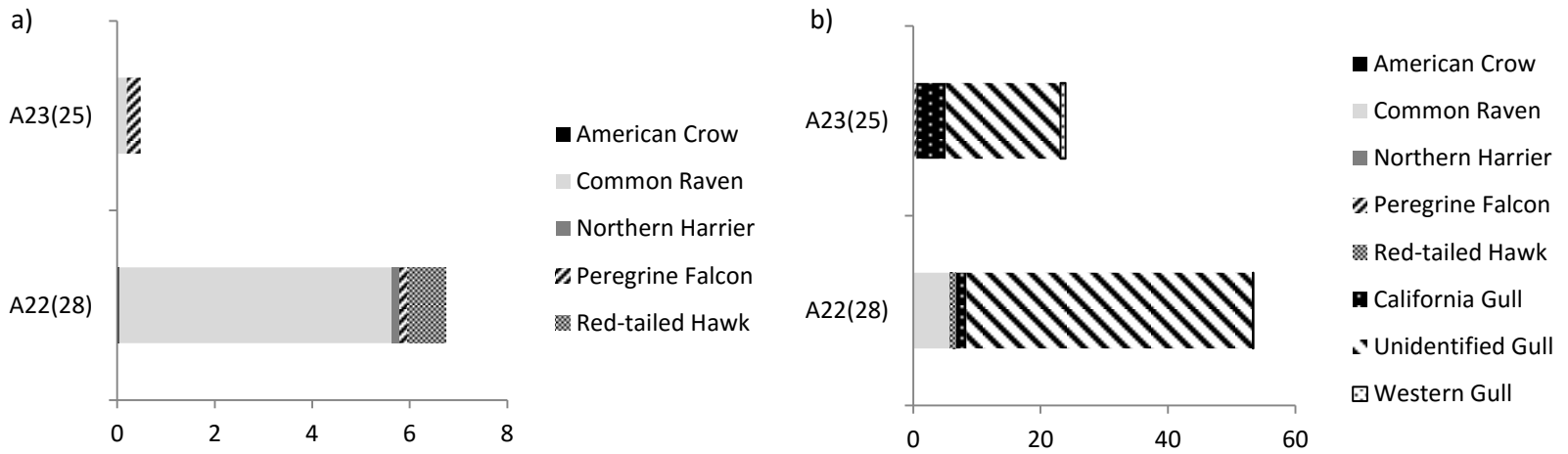

Figure 23. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at Warm Springs, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

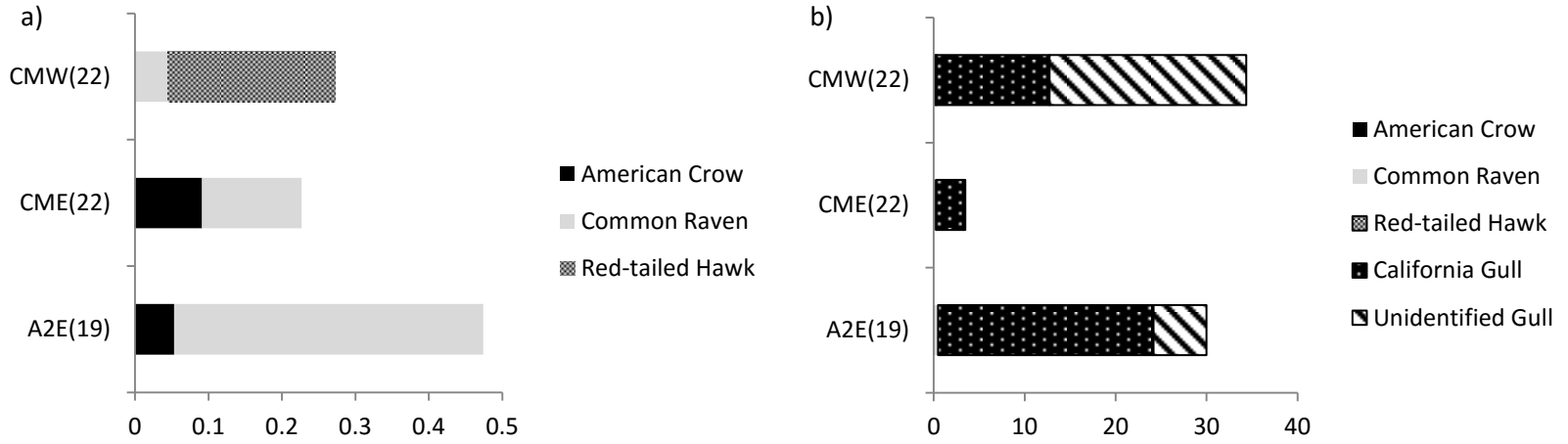

Figure 24. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at Mountain View, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

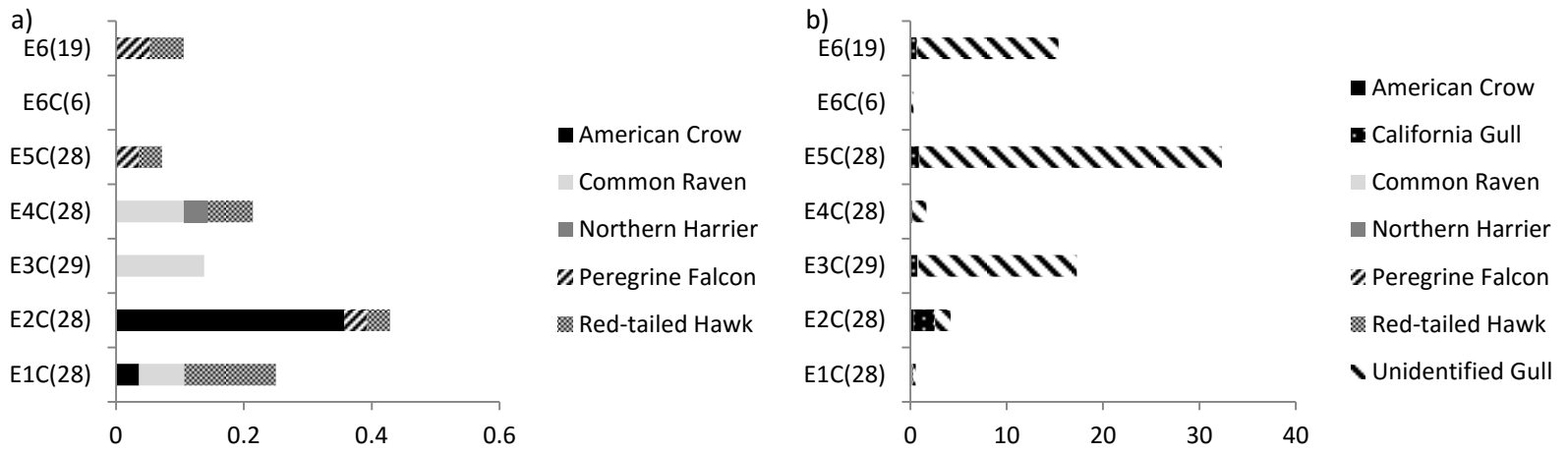

Figure 25. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey in South Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

Figure 26. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at the Whales Tail and Old Alameda Creek Loops, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

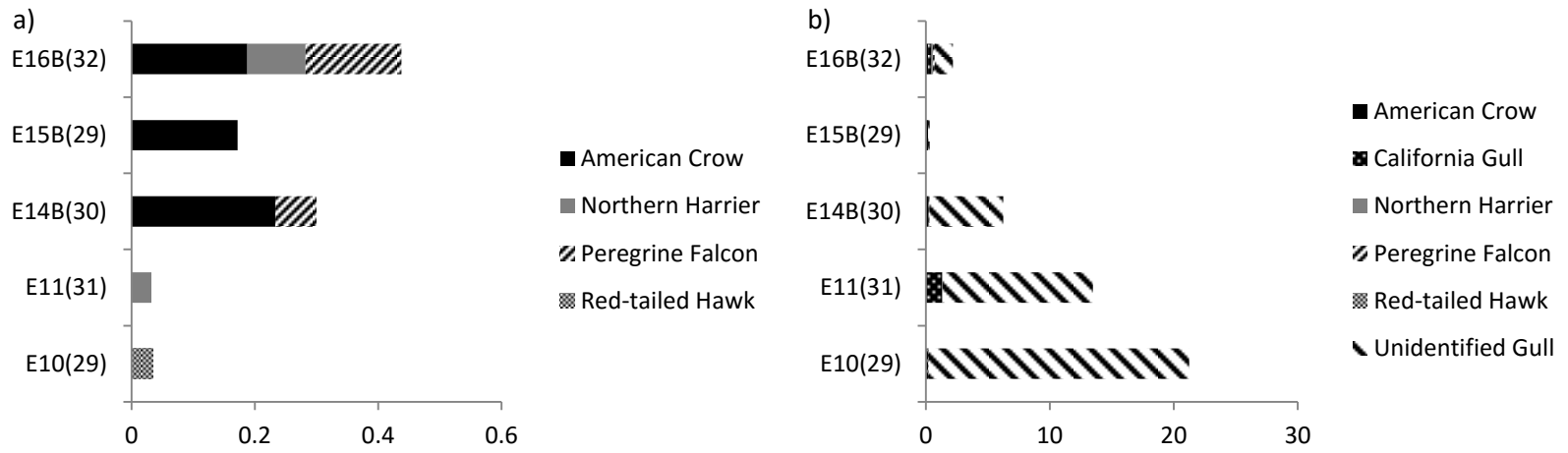

Figure 27. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at the Mount Eden Creek loop, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

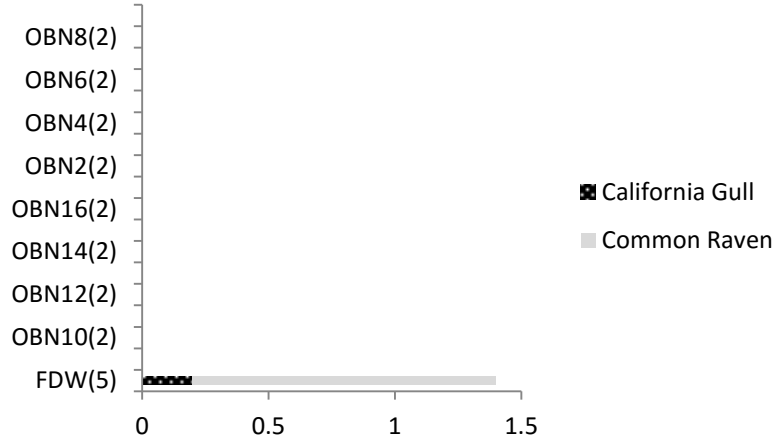

Figure 28. The average number of critical predators observed per survey at Hayward, South San Francisco Bay, California, March-August 2015. Survey sample size is in parentheses next to pond number.

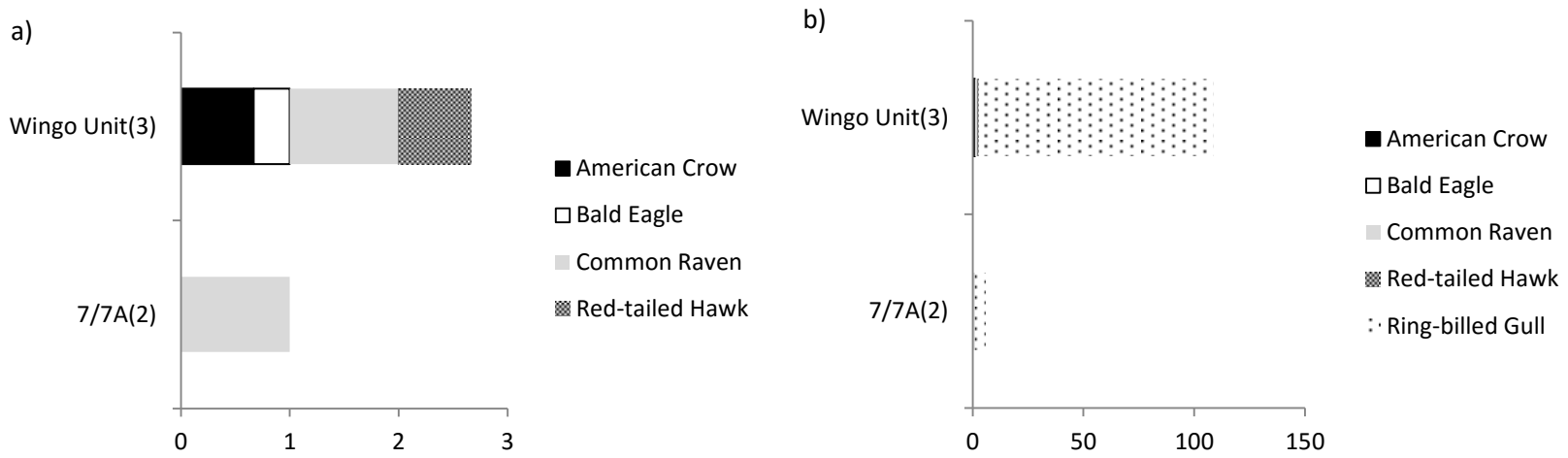

Figure 29. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at Napa, North San Francisco Bay, California, March-August 2015. The number of surveys per pond is in parentheses. Survey sample size is in parentheses next to pond number.

Table 1. Ponds surveyed weekly within the Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, California, 2015.

Location	Ponds
Alviso	A3N, A12, A13, A15, A16, Impoundment, NCM
Mountain View	A2E, CM-W,CM-E
Ravenswood	R1, R2, R3, R4, R5, RSF2
Warm Springs	A22, A23

Table 2. Ponds surveyed weekly within California Department of Fish and Wildlife's Eden Landing Ecological Reserve, San Francisco Bay, California, 2015.

Location	Ponds
Eden Landing Ecological Reserve	E6, E6A, E6B, E8, E8XN, E10, E11, E12, E13, E14, E15B, E16B, E1C, E2C, E3C, E4C, E5C, E6C

Table 3. Additional areas surveyed in the San Francisco Bay, California, 2015. These areas were surveyed less often than weekly surveys and as presence/absence surveys, or were surveyed by biologists from different agencies.

Location	Land Owner	Ponds
Oliver Brother's ponds	HARD	OBN1-16
Least Tern Island	EBRPD	Island 5
Napa-Sonoma Marshes Wildlife Area	CDFW	7, 7A, Napa Plant Site, Wingo Unit
Dumbarton	Cargill	N1, NPP1, N2, N3
Eden Landing Ecological Reserve	CDFW	E8A, E9, North Creek Managed Pond

Table 4. Number of Western Snowy Plovers observed at Recovery Unit 3 sites during annual breeding window surveys in May, 2005-2015

REGION	SITE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Alameda	Eden Landing	91	84	162	94	88	184	185	82	97	94	76
	Coyote Hills	0	0	0	0	0	0	0	0	0	0	0
	Crown Beach	-	-	-	-	-	-	-	-	-	0	0
	Dumbarton	0	0	2	0	0	0	0	0	0	0	0
	Hayward	0	0	0	1	4	12	8	9	32	7	2
	Warm Springs	23	7	0	3	14	27	17	3	1	11	24
Napa	Napa	0			0	12	10	1	0	3	10	10
San Mateo	Ravenswood	3	3	23	24	21	42	27	33	59	45	68
Santa Clara	Alviso	7	8	20	11	8	0	11	20	10	0	1
	Mountain View	-	-	-	-	-	-	-	-	-	11	0
North Bay Delta	Montezuma Wetlands	-	-	-	-	-	-	-	-	-	-	14
Total Unit 3		**124**	**102**	**207**	**133**	**147**	**275**	**249**	**147**	**202**	**178**	**195**

Table 5. Snowy Plover nest fates by pond in the South San Francisco Bay, California, 2015.

Location	Hatched	Depredated	Abandoned	Flooded	Unknown	Other	Total nests
Alviso							
NCM	0	0	0	0	0	0	**0**
A3N	5	6	0	0	0	0	**11**
A9	0	0	0	0	0	0	**0**
A12	0	0	0	0	0	0	**0**
A13	4	0	0	0	0	0	**4**
A16	0	1	0	0	0	0	**1**
Eden Landing							
E6A	1	1	0	0	0	0	**2**
E6B	4	7	1	2	1	0	**15**
E8	11	12	1	0	1	0	**25**
E12	1	3	0	0	2	0	**6**
E13	0	2	0	0	0	0	**2**
E14	59	31	7	0	1	0	**98**
E16B	8	1	0	0	0	0	**9**
E11	1	2	0	0	0	0	**3**
E6	0	2	0	0	0	0	**2**
E6C	8	0	0	0	0	0	**8**
E4C	1	0	0	0	0	0	**1**
E3C	0	0	1	0	0	0	**1**
E1C	1	2	0	0	0	0	**3**
Ravenswood							
R1	5	1	1	0	0	1	**8**
R2	1	0	0	0	0	0	**1**
R3	7	4	0	0	0	0	**11**
R4	23	6	0	0	1	0	**30**
R5	4	0	0	0	0	0	**4**
RSF2	19	8	2	0	0	0	**29**
Warm Springs							
A22	14	7	0	0	1	0	**22**
A23	0	0	0	0	0	0	**0**
Mountain View							
A2E	0	0	0	0	0	0	**0**
CME	0	0	0	0	0	0	**0**
CMW	0	1	0	0	0	0	**1**
Hayward							
Hayward Shoreline	1	0	0	0	0	0	**1**
OBN16	0	0	0	0	0	0	**0**
Total South Bay	**178**	**97**	**13**	**2**	**7**	**1**	**298**

Table 5 continued

Location	Hatched	Depredated	Abandoned	Flooded	Unknown	Other	Total nests
NSMWA - 7/7A	2	0	0	0	0	0	**2**
NSMWA - NPS	2	2	0	0	0	0	**4**
Total North Bay	**4**	**2**	**0**	**0**	**0**	**0**	**6**
RU3 Total	**182**	**99**	**13**	**2**	**7**	**1**	**304**

Table 6. Snowy Plover averaged apparent nest densities (nest/ha) by pond on Refuge property in the South San Francisco Bay, California, 2015. We calculated nest densities (nest/ha) in each pond every week using data from habitat availability surveys; weekly densities were then averaged. By using the actual available nesting habitat rather than the total area of each pond potentially available for nesting, we are able to calculate more accurate nesting densities within ponds as water levels changed throughout the season. [1]Weekly habitat availability not available, total pond area used for calculation instead.

Location	Average Nest/ha
A3N	0.041
A13	0.014
A16	0.088
R1	0.012
R2	0.004
R3	0.024
R4	0.052
R5	0.056
SF2	0.132
A22	0.040
CM-W[1]	0.004

Table 7. Snowy Plover averaged apparent nest densities (nests/ha) by pond at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2015. We calculated nest densities (nest/ha) in each pond every week using data from habitat availability surveys; weekly densities in each pond were then averaged. By using the actual available nesting habitat rather than the total area of each pond potentially available for nesting, we are able to represent more accurate nesting densities within ponds as water levels changed throughout the season.

Location	Average Nest/ha
E11	0.012
E12	0.390
E13	0.022
E14	0.324
E16B	0.056
E1C	0.021
E3C	0.031
E4C	0.003
E6	0.025
E6A	0.010
E6B	0.035
E6C	0.052
E8	0.062

Table 8. Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, California, 2008-2015. Chicks were considered fledged if they survived to 31 days. *N* is the number of chicks banded.

Year	Fledgling Success	*N*
2015	34%	116
2014	27%	52
2013	36%	14
2012	50%	8
2011	14%	36
2010	41%	39
2009	25%	113
2008	29%	83

Table 9. Apparent fledging success of Snowy Plover chicks by pond in the South San Francisco Bay, California, 2015. Chicks were considered fledged if they survived to 31 days. *N* is the number of individuals banded.

Pond	*N* Chicks	*N* Adults	Fledgling Success
E14	59	26	44%
E8	19	8	42%
E6B	8	0	0%
RSF2	30	4	17%
IWS Total	116	38	34%

Table 10. The number of nests in each shell plot at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2015.

			2009	2010	2011	2012	2013	2014	2015
Pond	Shell plot	Year shells spread	Total nests	Total nests	Total nests	Total nests	Total nests	Total nests	Total nests
E14	1	2009	-	0	0	0	1	5	3
E14	2	2009	-	0	0	1	1	2	2
E14	3	2009	-	0	0	2	3	4	10
	Total		**-**	**0**	**0**	**3**	**5**	**11**	**15**
E16B	1	2008	5	5	4	2	1	0	0
E16B	2	2008	9	6	2	0	1	0	1
E16B	3	2008	2	0	0	0	0	0	0
	Total		**16**	**11**	**6**	**2**	**2**	**0**	**1**
E6A	1	2008	0	0	0	0	0	0	0
	Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**
E6B	1	2008	2	7	1	1	0	5	2
E6B	2	2009		12	1	0	0	3	2
E6B	3	2009		0	1	0	0	0	0
E6B	4	2010			5	2	0	2	7
	Total		**2**	**19**	**8**	**3**	**0**	**10**	**11**
E8	1	2008	7	11	7	2	1	2	0
E8	2	2008	1	2	2	1	2	1	3
E8	3	2010	-	-	10	7	0	6	2
E8	4	2010	-	-	3	0	1	2	2
	Total		**8**	**13**	**22**	**10**	**4**	**11**	**7**
Totals			**26**	**43**	**36**	**18**	**11**	**32**	**34**

Table 11. Number of nests monitored, apparent nest fates, and apparent nest densities for control plots, shell plots, and other areas at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2015. Other ELER areas include ponds E11, E16B, E15B, E14B, E12, E13, E14, E6A, E6B, E8 and E6. Note that E14 was removed from the 2015 table due to implementation of two large enhancement plots.

	2009			2010			2011		
	Control Plot	Shell Plot	Other ELER	Control Plot	Shell Plot	Other ELER	Control Plot	Shell Plot	Other ELER
Number of plots	7	7	-	12	12	-	15	15	-
Nests monitored	0	26	49	4	43	82	3	36	64
Nest density (nests/ha)	0	3.71	0.07	0.33	3.58	0.13	0.2	2.4	0.1
Observed hatched	-	69%	49%	0%	23%	37%	33%	50%	45%
Observed depredated	-	8%	45%	100%	65%	62%	67%	39%	52%

	2012			2013			2014		
	Control Plot	Shell Plot	Other ELER	Control Plot	Shell Plot	Other ELER	Control Plot	Shell Plot	Other ELER
Number of plots	15	15	-	15	15	-	15	15	-
Nests monitored	5	18	62	3	11	110	9	32	93
Nest density (nests/ha)	0.33	1.2	0.1	0.2	0.73	0.17	0.60	2.13	0.14
Observed hatched	40%	50%	42%	33%	73%	66%	33%	44%	40%
Observed depredated	40%	44%	56%	67%	27%	30%	67%	47%	58%

	2015		
	Control Plot	Shell Plot	Other ELER
Number of plots	12	12	-
Nests monitored	4	19	35
Nest density (nests/ha)	0.33	1.58	0.12
Observed hatched	75%	37%	29%
Observed depredated	25%	42%	57%