SAN FRANCISCO BAY
BIRD OBSERVATORY

Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2016

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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 2016 breeding season, we monitored Snowy Plover numbers, nesting and fledging success, the use of experimental habitat enhancement sites, and potential predators.

As part of the Pacific Coast breeding season window survey (May 15-21), we counted 205 adult Snowy Plovers in the San Francisco Bay. Over the course of the breeding season (March-September), we documented 261 plover nests in all of Recovery Unit 3. In the South Bay, we determined the fate of 258 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 42%. Remaining nests failed due to predation (55%), abandonment (1.2%), flooding (0.7%), failed to hatch (0.4%), or fate was unknown (0.7%). We summarize 2016 nesting activity by pond complex or management unit below:

On Refuge property, we determined the fate of 16 nests in the Alviso Complex (pond A13) and 38 nests in the Ravenswood Complex (ponds RSF2, R1, R2, R3, R4, and R5). Apparent nest success was 88% and 55% in the Alviso and Ravenswood complexes, respectively.

Also on Refuge property, we located 12 nests in the Warm Springs complex (A22) in Fremont. Apparent nest success was 25% in Warm Springs.

We found 74% of Snowy Plover nests in Recovery Unit 3 at CDFW's Eden Landing Ecological Reserve (Eden Landing). We determined the fate of 188 nests and found that apparent nest success was 35%.

EBRPD reported four Snowy Plover nests on the California Least Tern (*Sterna antillarum browni*) island at Hayward Shoreline, all of 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 3 Snowy Plover nests at the Napa-Sonoma Marshes Wildlife Area (ponds 7/7A, Green Island Unit, and Wingo Unit) in the North Bay, of which 2 hatched (K. Taylor, pers. comm.). Sporadic monitoring efforts at the Hamilton Wetlands Restoration site in Novato were conducted by Avocet Research Associates. Although a large number of Snowy Plovers were seen prior to the breeding

season, no breeding activity was observed during the 2016 breeding season in the area (J. Evans, pers. comm.). At the Montezuma Wetlands in Solano County, a breeding window survey and incidental Snowy Plover information was collected by EcoBridges Consulting. One nest was confirmed, with only one of the eggs confirmed to have hatched (Anne Wallace, pers. comm).

In 2016, SFBBO banded 66 Snowy Plover chicks and 1 adult from nests that successfully hatched within Eden Landing nesting ponds. From band re-sighting surveys, we determined that at least 38 of these 66 chicks survived to fledging (31 days post-hatching) as of October 17, 2016. Our apparent fledging success was 27%.

Habitat availability surveys allowed for more accurate determination of nesting density compared to past seasons. During the 2016 breeding season, pond E12 had the highest nesting density among ponds with islands at 0.44 nests/ha, while pond E14 had the highest nesting density among ponds with panne, at 0.25 nests/ha (table 7).

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. Corvids (Common Ravens (*Corvus corax*) and American Crows (*Corvus brachyrhynchos*)), Peregrine Falcons (*Falco peregrines*), Red-tailed Hawks (*Buteo jamaicensis*), and Northern Harriers (*Circus cyaneus*) were among other commonly sighted predatory species. Common Ravens were documented by trail cameras as especially significant nest predators at pond E14 in Eden Landing. Thirty nests were documented being depredated by Common Ravens at this site. As there were no other species documented depredating nests this season at E14, it is likely that Common Ravens were responsible for some of the other depredated nests at E14 as well.

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. Subsequent studies show that the oyster shell enhancement plots were used extensively by Snowy Plovers, and in 2016 contained a total of 56 nests over the course of the season. It is not yet clear, however, whether enhancement improved breeding success.

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 during the nesting season, 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 as outlined in the Recovery Plan (USFWS 2007). 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 partial opening of public trails at the ponds E12-14 during the 2016 breeding season, further studies are needed to assess the impact of human disturbance on Snowy Plover nesting. As such, we recommend that no additional levee trails in close proximity to Snowy Plover nesting ponds be opened to the public until these impacts can be assessed. We also propose continued research, 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 2003-2016, 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.

During Phase I of the South Bay Salt Pond Restoration Project, restoration and reconfiguration of Eden Landing ponds that formerly supported Snowy Plover breeding habitat resulted in the loss of roughly 28% of available breeding habitat for Snowy Plovers. Phase II, focused on the Ravenswood Complex of the Refuge, will similarly result in an additional 10% of available breeding habitat. 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 2008-2015, on Eden Landing pond E14. Enhancements were made in September and October 2014 after the breeding season was complete. The 2016 breeding season marked the second year of monitoring the enhancement project.

SFBBO initiated a Volunteer Plover Docent program in June 2016 in order to encourage public support and advocacy for Snowy Plovers in the South Bay, and to encourage the public to practice eco-friendly recreation by discouraging trespassing and disturbance through education and outreach. As the South Bay Salt Pond Restoration Project continues to restore tidal marshes in the Bay, more areas will become open for public and recreational use. Some of these areas are adjacent to sensitive plover breeding and wintering sites. Trained volunteer docents will be stationed at key breeding sites once a month and communicate with the public, share information on Snowy Plover breeding ecology, show Snowy Plovers to the public using binoculars and scopes, and creative a positive association with the species.

In this report, we summarize results from the 2016 breeding season; this includes 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 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**Figure**), Coyote Hills, Dumbarton, and Mowry (Figure 1Figure). 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). 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 (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.

U.S. Geological Survey (USGS) biologists first reported Snowy Plovers nesting among California Least Tern colonies in the Montezuma Wetlands, Solano County in 2014. This is privately owned dredge placement site within the Montezuma Wetlands Restoration Project footprint. This year, Snowy Plover breeding window surveys were performed here by contracted biologists, 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, 2016, 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.

SFBBO plover volunteers surveyed the HARD ponds monthly and surveyed some low-priority Eden Landing ponds periodically to check for possible nesting activity during the season (Table 3). 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 Tarjan and Heyse 2016 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. SFBBO plover docent volunteers were stationed at Eden Landing pond E14 and Ravenswood pond R5 once a month, beginning in June 2016.

From May 15-21, 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 2016 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) and/or hand-held tablet (Apple® iPad 2 or Apple® iPad Mini 2). 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, failed to hatch, unknown, or other. In addition, we recorded whether the nest was located in an oyster shell enhancement or control plot (see *Oyster Shell Habitat Enhancements* methods below.)

We defined a nest as successful if it hatched at least one egg. We calculated apparent nest success as the percentage of nests that successfully hatched at least one egg out of the total nests monitored. 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 2016 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. Geological Survey band. All bands were then wrapped in colored auto pin-striping tape. Both darvic and acetal color bands were used depending on availability. See discussion for further details.

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).

Oyster Shell Habitat Pilot Studies

From 2009-2014, SFBBO conducted a pilot study on the effects of oyster shell enhancement on Snowy Plover breeding using a randomized block design. Each block consisted of a 1-ha oyster shell treatment plot (shells spread at 5-8 shells/m^2) and a 1-ha control plot (no shells or other treatment). Drake's Bay Oyster Farm donated the oyster shells, and SFBBO staff, volunteers, and the California Conservation Corps spread the shells by hand.

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 (referred to as New 1) and an eastern plot totaling 13.76 hectares (referred to as New 2); the remaining untreated areas are termed non-shelled 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.

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.

Apparent Estimates.

We compared apparent nest success in 1-ha shell plots (Pilot), control plots, and all other Eden Landing nesting areas (Non-Shelled) from 2009-2016 (Figure 15). Nests in E14 1-ha shell plots and control plots are not treated independently in 2015-16 as they were impacted by large scale enhancement, and were omitted from this analysis.

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 2016.

Avian Predator Surveys

To identify avian predators in the area that might affect Snowy Plovers, SFBBO and Refuge biologists and interns conducted predator surveys on the same ponds surveyed weekly for Snowy Plovers (Tables 1-2). Volunteers conducted avian predator surveys at ponds surveyed monthly for Snowy Plovers. In order to better capture predator activity, avian predator surveys were conducted intermittently with plover surveys, rather than afterwards. Observers chose survey points throughout the survey that would allow the observer to fully scan all required ponds for predators. At each survey point, the location, start time, and stop time were

recorded. Observers recorded the number, species, behavior, and habitat type at the time of sighting of any predators present. The approximate locations of the predators were marked on a map. In addition, observers documented any predator nests in the area and their fates when possible. We calculated the average number of predators observed per survey at each pond during the season. While most predators likely 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 both predator and plover surveys were conducted at this level.

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*), 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 Boneparte's Gulls (*Chroicocephalus philadelphia*), California Gulls (*Larus californicus*), Glaucous-winged Gulls (*L. glaucescens*), Herring Gulls (*Larus argentatus smithsonianus*), Mew Gulls (*L. canus*), Ring-Billed Gulls (*Larus delawarensis*), and Western Gulls (*Larus occidentalis*); Corvid species included American Crows (*Corvus brachyrhynchos*) and Common Ravens (*C. corax*); wader species included Black-crowned Night-Herons (*Nycticorax nycticorax*), Cattle Egrets (*Bubulcus ibis*), Great Blue Herons (*Ardea herodias*), Great Egrets (*A. alba*), and Snowy Egrets (*Egretta thula*); other species included 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 red fox (*Vulpes vulpes*), skunks (*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.

Habitat Availability

Habitat within the South San Francisco Bay salt ponds changes 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 continued during the 2016 breeding season.

Maps for each pond were overlaid with a grid composed of 50m x 50m squares. During each survey, the approximate location of available habitat within each pond was marked on the corresponding map. Available habitat included dry pond bottom, dry levees, and sparse vegetation cover; unavailable habitat included standing water, saturated pond bottom or mud, and full vegetation cover. Each square was considered available or unavailable for breeding based on which type constituted >50% of its space. Habitat availability surveys were conducted on the same day as each breeding survey in order to maintain comparability with nesting behavior.

Though the habitat availability maps are an estimate with some measure of error, they provide a much more accurate measure of potentially available nesting habitat over time compared to previous methods. As such, apparent nest densities in this report represent a more accurate approximation of actual nest densities compared to past reports.

RESULTS

Snowy Plover Surveys

South Bay Overall.
During the 2016 Pacific Coast breeding season window survey (May 15-21), we counted 208 adult Snowy Plovers in the Bay (Table 4). We observed a mean of 249 birds per week from March 1 through August 31 in the entire South Bay. We consistently observed the greatest numbers of Snowy Plovers at Eden Landing (Table 4, Figure 7a). We documented Snowy Plover nesting activity at 18 South Bay ponds (Figure 8, Figure 9).

Refuge.
We documented a mean of 106 Snowy Plovers per week from March 1 through August 31 on Refuge property. We observed an average of 50 Snowy Plovers per week in the Ravenswood complex, an average of 20 Snowy Plovers per week in the Warm Springs complex, and an average of 36 Snowy Plovers per week in the Alviso complex (Figure 7b).

Eden Landing.
We observed the most Snowy Plovers throughout the season at Eden Landing (Figure 7a), with a mean of 143 birds observed per week from March 1 through August 31. This was lower than in 2015 when we observed a mean of 152 birds per week during the same time period. Pond E14 supported large numbers of Snowy Plovers during the breeding season again this year, averaging 86 birds per week.

Early and Late Season Trends.
In March, we observed large flocks at A22 and E14, averaging 45 and 138 Snowy Plovers per week during this period, respectively. In August, we observed large flocks at A13 and E14, averaging 53 and 137 Snowy Plovers per week for the month, respectively (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 2016, we determined the fate of 258 Snowy Plover nests in the South Bay. Of these, 108 nests hatched (apparent nest success = 41.9%), 142 nests were depredated (55.0%), three were abandoned (1.2%), two were flooded (0.8%) one failed to hatch (0.04%), and the fate of three

were unknown (0.8%, Table 5, Figure 9). We found the second highest number of nests ever documented in the South Bay in 2016 (previous high of 298 nests in 2015). The predation rate was significantly higher in 2016 than in 2015 (33%), suggesting that high nest numbers were in part due to renesting attempts (Figure 9). Consistent with findings from previous years, predation serves as the most significant cause of nest failure.

Refuge.
In 2016, SFBBO determined the fate of 66 Snowy Plover nests on Refuge property (Table 5). We determined the fate of 12 nests in the Warm Springs complex (all at A22), 3 of which hatched (25%), while nine were depredated (75%). We determined the fate of 16 nests in the Alviso Complex (all at A13). Out of these nests, 14 hatched (87.5%), one was depredated (6.3%), and one failed to hatch (6.3%). We determined the fate of 38 nests in the Ravenswood Complex. Of these, 21 hatched (55.3%) and 17 were depredated (44.7%). We found the most nests in the Ravenswood complex on pond RSF2 (13 nests; Table5).

Zero nests were found in Alviso ponds A12, A16, and New Chicago Marsh (NCM) or in Mountain View Ponds A2E, A3N, CM-W, or CM-E (Table 5). NCM water levels were kept high for water quality purposes, resulting in little exposure of dry salt panned habitat. A3N, which hosted 11 nests in 2015 due to lower water levels for construction on A3W, returned to higher water levels, resulting in minimal available habitat. Crittenden Marsh was again flooded for the majority of the season, resulting in minimal available habitat.

Eden Landing.
We determined the fate of 188 Snowy Plover nests at Eden Landing. Of these, 66 hatched (35%), 115 were depredated (61%), three were abandoned (2%), two were flooded (1%), and the fate of two nests were unknown (1%) (Table 5). Pond E14 had the most nests (88 nests), followed by pond E8 (28 nests) and pond E6B (11 nests; Table5). E14 alone comprised 47% of the nests found in Eden Landing and 35% of the nests found in the entire South Bay in 2015. The Eden Landing complex hosted 73% of all the nests found in RU3 (Figure 10).

Hayward Shoreline.
EBRPD reported four Snowy Plover nest on the California Least Tern Island at HARD, with all four successfully hatching (D. Riensche, pers. comm.; Table 5). No nests were detected this season at the Oliver Brothers North Salt ponds at Hayward Regional Shoreline (A. Graham, pers. comm).

Napa-Sonoma Marshes Wildlife Area.
CDFW biologists found 3 nests. One was located in the Green Island Unit (hatched), pond 7/7A (hatched), and the Wingo Unit (unknown) (K. Taylor, pers. comm.; Table 5).

Montezuma Wetlands.
In 2016, the plover breeding window survey as well as incidental Snowy Plover nesting information was collected by contracted biologists during their Least Tern surveys. During the

breeding window, a total of 6 Snowy Plovers were observed. Throughout the course of the season, only one nest was confirmed, with one egg hatching and two eggs failing to hatch for unknown causes (A. Wallace, pers. Comm). Sightings of adults and chicks by other observers on site suggest that there may have been at least several other nests. However, nest and fledgling success rates cannot be determined without more detailed monitoring.

Hamilton Wetland Restoration Area.
No nesting activity was observed by Avocet Research Associates during broad monthly surveys of the wetlands (J. Evens, pers. comm).

Cargill Salt Evaporation Ponds.
Contrary to previous breeding seasons, no incidental observations of Snowy Plover breeding activity were reported by Cargill staff during the 2016 breeding season.

Breeding Chronology.
Apparent nest densities calculated using weekly habitat availability data, rather than the total area of at each pond provided 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 0.082 nests per hectare. We documented the highest apparent nest density in pond E12 at 0.437 nests/ha (Table 7). We note that the available nesting habitat in this pond and E13 (0.197 nests/ha) is provided by a handful of nesting islands, interior berms, and graveled levees, and available nesting habitat averaged 6.0 ha and 18.0 ha throughout the season, respectively. The next highest apparent nest density in Eden Landing was at pond E14 at 0.254 nests/ha (Table 7). Pond E14 had an average of 53.5 ha of available habitat throughout the season, and is more representative of the dry panne habitat that Snowy Plovers rely on for nesting in the South Bay. The third highest apparent nest density in RU3 was in pond A13 at 0.067 nests/ha (Table 6). See discussion for additional information about nesting in A13.

We recorded two peaks of nest initiation during the breeding season. During the week of May 8th, a total of 33 nests were initiated (Figure 14). During the week of June 5th, a second peak of 23 nests was initiated (Figure 14). From the week of April 10th through the week of June 26th, a nest initiation rate of 16.6 nests per week was recorded, for a total of 199 nests initiated during this period (Figure 14).

Consistent with the two observed peaks in nest initiation, two peaks in active nests were observed as well. During the week of May 8th, 96 nests were active, followed by a drop to 80 and 84 nests active the following weeks (Figure 14). The second peak began during the week of May 29th at 96 nests, and continued through the week of June 5th, reaching a high for the season of 97 active nests (Figure 14). After this point the number of nests declined each week until the end of the season in late August (Figure 1).

Chick Fledging Success.

As part of our efforts to document breeding success within the San Francisco Bay, we banded 66 Snowy Plover chicks in 2016 and determined that at least 18 chicks fledged (27%, Table 8). While most fledgling sightings were recorded during the breeding season, several came during post breeding season band resighting surveys. Due to the difficulties of resighting fledged chicks within the South San Francisco Bay Ponds, it is possible that additional chicks fledged as well (*see Discussion*).

Oyster Shell Habitat Enhancements

During the second season of large scale enhancement at pond E14, we documented a total of 89 nests; 63 nests in enhancement plots New 1 and New 2, and 25 nests in the non-shelled areas. Due to the small sample size and their geographic configuration, data from the three 1-ha pilot plots were combined with New 1 for analysis.

Apparent nest success rates in 2016 fell drastically, and throughout pond areas compared to the first study season in 2015. In enhanced areas (New 1 and New 2 combined), rates were very similar to those in non-shelled areas (24% and 20% respectively). When analyzed separately, New 2 held the lowest apparent nest success at 11%. Depredation was the most significant cause of nest failure in all areas of E14 (New 1=38%, New 2=66%, and non-shelled=58%). The average nest density in enhanced areas (New 1 and New 2 combined) during peak breeding months was calculated at 0.6 ± 0.3 nests/ha, and 0.2 ± 0.1 nests/ha in non-shelled areas. When analyzed separately, New 1 held the highest average nest density during peak breeding months at 0.8 ± 0.4 nests/ha. Higher nest density in enhancement areas may have increased conflict between breeding adults and broods as seen in 2015.

Our chi-squared analysis determined that nest location is based on the selection of treatment type (shelled or non-shelled; $p < 2.2e\text{-}16$), indicating that plovers were selecting for shelled areas and not in the same proportion as the availability of each treatment type. Common ravens were the only predator documented via nest cameras (30 documented nest depredations). For a thorough nest survival analysis and more detailed information regarding these study results, refer to Tokatlian (In prep.).

Apparent Estimates.

From 2009-2014, we documented higher apparent nest densities and increased hatching rates (Figure 15), as stated in previous reports. Due to the installation of large oyster shell enhancement plots that covered much of E14, nests from this pond were not included in Figure 15 beginning in 2015. The small sample size of nests in test and control plots after shells have been in use for several years limits the applicability of these data.

Avian Predators

Refuge.
As in past years, 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 23-25). 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 flying over and walking on pond bottoms (Figure 23a). In Alviso, Common Ravens and Peregrine Falcons were commonly sighted, especially at ponds A12 and A13 (Figure 24a). Gulls were often seen roosting and feeding in large flocks on pond A16 nesting islands and ponds A12-A13 (Figure 24b). At Warm Springs (ponds A22 and A23), Common Ravens were seen with the highest frequency of any area throughout the South Bay (Figure25a). Other predators seen with moderate frequency (although in small numbers) included Bald Eagles and Golden Eagles (Figure 25a). These raptors were often perched on PG&E towers, fence posts, and other available structures in the ponds or adjacent marsh, vernal pool and grassland habitat.

Eden Landing.
The most abundant critical potential avian predators at Eden Landing were California Gulls and unidentified gulls (Figures 26-28). Peregrine Falcons were the next most frequently observed predator at Eden landing (Figures 26-28). They were especially numerous at ponds E14, E6A, E6B, E8, and E16B, where they used old wooden structures, hunting blinds and power towers as hunting perches and nesting sites (Figure 27a). Common Ravens were observed most frequently in ponds E1C, E8, E14, and E16B, where they were often foraging along the pond bottom (Figures 26a-28a). At pond E14, camera traps recorded Common Ravens depredating 30 nests throughout the course of the season. Northern Harriers were observed hunting in ponds E16B and E8 (Figures 27a-28a).

In January of 2016, hunting blinds in adjacent ponds E14 and E9 used extensively as nesting and perching sites by raptors were demolished or wrapped in landscape cloth. This was done in an attempt to reduce predation risk for adults, chicks, and nests.

Hayward Shoreline.
Predator data was not available for the 2016 breeding season.

Napa-Sonoma Marshes Wildlife Area.
Predator data was not available for the 2016 breeding season.

Mammalian Predators

We frequently observed Red Fox at Eden Landing while arriving in the morning for surveys, particularly at the Whales Tail (E12-14) and Mt. Eden Creek (E11, E10, E14B-16B) loops. On many occasions, multiple Red Fox juveniles were sited at the same time. These likely came from a red fox den located in the historical saltworks in E13. Less frequently, skunks and

domestic cats were sited during surveys. No mammalian predator trapping and removal was done at Eden Landing or on Refuge property during the 2016 breeding season due to lack of funding.

On several occasions we directly observed or found evidence of humans trespassing on the ponds that are closed to the public. At Eden Landing, a trespasser was found collecting recyclables along Old Alameda Creek adjacent to ponds E6A and E8. At pond R4 on Refuge property on two separate occasions, pedestrians trespassed beyond the locked gate and onto the levee next to the bay. Over the course of the breeding season, three drones were retrieved from the pond bottom of R4. All of these actions would have disturbed Snowy Plovers in adjacent areas and could have resulted in trampling of nests or chicks.

DISCUSSION

Snowy Plover Surveys

We counted 208 Snowy Plovers in the Bay during the May breeding window survey. This was the highest amount of Snowy Plovers observed during the breeding window since 2011, when 275 were observed (Table 4). Eden Landing continues to host the majority (58%) 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. Despite our efforts to color band Snowy plover adults and chicks since 2008, the majority of Snowy Plovers within Recovery Unit 3 are not banded. 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 awaiting the results of 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 2016, we found 261 nests in RU3, the second highest amount of nests documented in the history of the recovery unit (high of 298 in 2015). Maintaining experienced field staff over several years likely attributed to the detection of more nests throughout RU3. In addition, certain ponds in Eden Landing were more heavily visited by biologists throughout the season for Brood Surveys, nest cameras checks (E14), and color banding (E6B, E8, E11, E14, E16B). The observation of unaccounted broods in most pond complexes during the breeding season indicates that some successful nests went undetected. With this in mind, apparent nest numbers alone should be interpreted cautiously, and should not necessarily be used as a definitive gauge of breeding success. Not only considering the difference in probability of detecting destroyed nests (Mayfield 1975), but also due to the ability of Snowy Plovers to

quickly renest following unsuccessful nesting attempts (Warriner et al. 1986). As depredation rates were particularly high in many ponds during the 2016 breeding season, this is an important issue to be considered.

Apparent nest success estimates ranged widely by pond and pond complex, with an overall average depredation rate of 54% (142/261) in RU3. Nest depredation rates were 60% higher compared to 2015 (33%), and were the highest in RU3 since 2010 (55%). Among the highest depredations rates at Eden Landing were E6C, at 75% (6/8), and E14, at 73% (64/88). On Refuge lands, A22 had the highest depredation rate at 75% (9/12), while R3 had a nest depredation rate of 64% (7/11), (Table 5). In total, these ponds account for nearly half of all nests monitored in RU3 (119/261). High depredation rates on Refuge lands may have been related to lack of predator management funding during the 2016 breeding season. Due in part to the high depredation rate in these ponds, 68 fewer known nests hatched during the 2016 breeding season. Low nest success is a major limiting factor to the recovery of Snowy Plovers in the South Bay and elsewhere along the Pacific Coast (USFWS 2007, USFWS and CDFW 2007).

Refuge.

In 2016, Snowy Plovers nested on seven Refuge ponds. At Warm Springs, depredation rates in 2016 (75%) were similar to previous rates (average 80% 2011-2014) after dropping down in 2015 (32%). There are several potential causes for the extremely high depredation rates. In 2016, USFWS removed the nest material (pre-egg laying) of approximately 132 California Gull nests as well as three single-egg nests (R. Tertes, pers. Comm.) These were likely gulls from nearby Mowry ponds M1/M2, M3, and M4/M5, where approximately 7240 adult breeding California Gulls were counted (Figure in Tarjan & Butler, 2016). Warm Springs is also located adjacent to Newby Island Landfill. Analysis of abatement efforts at Newby Island from 2008-2016 show that the number of gulls at the landfill has been significantly reduced compared to pre-abatement (Tarjan & Heyse, 2016). This may indicate that with a reduction in availability of a significant food source in the South Bay (trash), California Gulls are spreading out in search of new foraging patches. If so, this could have negative impacts on Snowy plover nesting success at sites where California Gulls are found. Aside from California Gulls, several other predators were frequently observed at Warm Springs. Common Ravens were the most commonly observed non-gull predator species at Warm Springs, with over 5 individuals per survey seen on average (Figure 24a). Many types of raptors, including Northern Harrier and Red-tailed Hawk, were frequently observed hunting at Warm Springs (Figure 24a). It is likely that corvids and raptors played a role in high depredation rates this past year. Further research is needed to assess the exact cause of high depredation rates at Warm Springs.

In Alviso, we observed Snowy Plovers nesting only on pond A13. Contrary to past years, A13 began the breeding season with relatively low water levels which created a substantial amount of dry nesting habitat throughout the season. SFBBO biologists also noted that portions of the A13 pond bottom were lined with small bivalve shells, similar to intertidal mussel colonies. Dark in color, these natural shells were not observed during previous breeding seasons so it's likely that they grew submerged in water and dried as water levels lowered. It is possible that

these shells acted as a natural enhancement, similar to the shell enhancement at E14, by creating substrate texture and camouflage. This may have contributed to successful plover nesting at this location. During the 2016 breeding season, 16 nests were documented on pond A13, with 14 of those hatching (Table 5). Additional information collected from a breeding survey conducted on August 4th suggested that nest numbers and success may have been substantially higher at this pond than otherwise detected. During the survey, 17 broods younger than 31 days were observed. Based on data from known nests, 5 broods less than 31 days were accounted for, leaving 12 broods from unaccounted successful nests. With no breeding activity recorded anywhere else in the Alviso complex, A13 appears to have hosted at least 26 successful nests in 2016.

Ponds A12 and A15 contained minimal available nesting habitat until late in the breeding season; no breeding activity was observed during this time. At A16, despite efforts to attract nesting Snowy Plovers using social attraction (Snowy Plover decoys and call playback) (Hartman et al., 2016), Snowy Plovers were rarely observed on the nesting islands. Consistent with past observations at A16 and other constructed nesting islands in the South Bay, Snowy Plovers showed minimal affinity for these areas (pers. obs.). Water levels were again 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.

At the Ravenswood Complex, the number of documented nests declined by 46%, from 83 nests in 2015 to 38 nests in 2016 (Table 5; Figure 20). In addition, the depredation rate increased, from 23% in 2015, to 45% in 2016 (Table 5). As was the case in 2015, water levels in pond R1 remained high for much of the season, despite efforts to draw them down (C. Strong, pers. comm.) Only two nests were found in this pond during the 2016 breeding season, with one hatching and the other depredated (Table 5). However, the lack of available habitat in R1 did not result in higher nesting numbers at other Ravenswood ponds, as appeared to be the case during the 2015 breeding season. Nest numbers in RSF2 declined by 55% from 2015 to 2016. Similarly, nest numbers in R4 declined by 63%. At both ponds, at least one undocumented brood was observed during the course of the season (pers. obs.), again providing evidence of higher nest numbers than detected.

Over the last decade, Ravenswood ponds R1-5 and RSF2 have averaged 40±22 nests per year (SFBBO 2007-2016). However, during both the 2010 (71 nests) and 2015 (83 nests) seasons, the number of nests within the complex was well above the mean plus standard deviation. This trend of high nest numbers was seen throughout RU3 during these years. It is unclear what factors led to these higher numbers. However, water level management and plant density and distribution are two environmental factors that may have affected Snowy Plover nesting. At RSF2 and R4, vegetation (mostly Slenderleaf iceplant, *Mesembryanthemum nodiflorum*) covered extensive amounts of the pond bottom, and may have excluded Snowy Plovers from nesting. At ponds R3 and R4, water levels were relatively high during the beginning of the season, and due to March rains, did not recede until early April.

With Phase 2 actions of the SBSPRP set to effectively reduce Snowy Plover habitat in the Ravenswood complex by 27%, it is vital that vegetation and water level management be controlled at ponds R1, R2, R3 and RSF2 in order to provide the maximum amount of quality Snowy Plover nesting habitat. In addition, potential habitat enhancement and water control structure improvements at R3 should help to offset the loss of Snowy Plover habitat in R4 and R5.

In past seasons, a substantial amount of nests have been found at the following ponds: A3N (Pearl et al. 2015), Crittenden Marsh (Tokatlian et al. 2014), A16 (Robinson-Nilsen et al. 2013, Donehower et al. 2012), and A17 (Donehower et al. 2012). Nesting habitat at these sites was intermittently available between seasons, often related to construction activities that temporarily lowered water levels within ponds and the weather. Use of intermittently available dry sites by breeding Snowy Plovers may help to offset the impact of permanently reducing available habitat. This season, pond A13 may have been the most successful nesting pond in all of RU3, with up to 26 successful nests. Despite its proximity to the second largest gull colony in the South Bay (Tarjan & Butler 2016), and the consistent sighting of Common Ravens and Peregrine Falcons (Figure 23a), Snowy Plovers in this pond experienced relatively low depredation rates on nests and broods (Table 5). In addition, proximity to public trails did not appear to negatively impact nesting Snowy Plovers. Considering this information and the existing infrastructure of water flow, pond A15 may be an ideal location to provide nesting habitat for Snowy Plovers. A15 may be able to be dried without affecting the other ponds in the system, and the pond bottom is elevated enough to dry thoroughly. The pond shape is also narrow which facilitates more accurate monitoring (although potentially more disturbance from trails as well). If managed specifically for plover use, Pond A15 may serve as temporary habitat during Phase 2 of the Project when some ponds will be breached and henceforth unavailable.

Eden Landing.

In 2013, construction of islands in ponds E12 and E13 for Phase I of the project resulted in major changes to the available habitat and nesting activity in these ponds. In 2014, these ponds were used with high frequency but experienced high depredation (Tokatlian et al. 2014). In 2015, E12 and E13 were used minimally for nesting(Pearl et al. 2015), but during this past season, these ponds were used for nesting with much higher frequency, hosting 9 and 20 nests, respectively (Table 5). This may have been due to high nest depredation rates at E14 early in the season. Of the first 32 nests monitored at E14, 17 had been depredated by May 12th. Following this period of high depredation, 20 nests were initiated between May 12th and June 12th in ponds E12 and E13. Out of a total of 29 nests between the two ponds, only 12 hatched. Successful nests were located in the following areas: five in the mixing basin, three on nesting islands, two on the graveled levee, and two on interior berms. Depredated nests were located in the following areas: six on interior berms, four on the graveled levee, three on nesting islands, one on a foraging mound, and one in the saltworks. In general, Snowy Plover nests were more successful at these two ponds in areas intended for nesting habitat (pond bottoms and islands) when compared to marginal available habitat (levees and berms). This

provides important information for the Project in the future when restoring ponds for both plover habitat and other functions.

Hatch rate on nesting islands was 50%, the highest on these islands since construction in 2013. These findings suggest that nesting islands may provide moderately successful nesting habitat with future moderations to design, including larger size nesting islands. In the South Bay, Snowy Plovers primarily select nesting habitat on large pond bottoms rather than nesting islands. One possible explanation may be the behavior employed by incubating adults to escape detection by predators. Breeding Snowy Plovers in the South San Francisco Bay have been documented flushing from their nest at a distance of 174.9m when approached by trail walkers (Robinson 2008). The larger size of dry pond bottoms may provide greater crypsis from approaching predators for incubating adults that have flushed, compared to smaller nesting islands where flushed adults may be less able to escape detection. Creating larger islands may create conditions more similar to dry pond bottoms. In addition, due to the semi-colonial nature of Snowy Plovers, creating a large enough area for two nests may encourage increased nesting on islands. Another factor that could prevent breeding Snowy Plovers from selecting nesting islands is higher presence of predators in the adjacent area. In ponds with nesting islands, large flocks of gulls were frequently sighted throughout the season (Figure 23b, Figure 24b, Figure 27B). With potential predators consistently present, plovers may choose to avoid nesting islands in general. Increased on-site and local landfill gull hazing could result in lower abundance of gulls at ponds with nesting islands, and thus, create conditions more favorable for Snowy Plover breeding.

At Pond E6A, a 1-ha shell plot was spread in 2008 during the first year of the pilot program. However, prior to the 2016 breeding season, only one Snowy Plover nest was recorded in this plot. Although E6A is the second largest pond used by Snowy Plovers for breeding within Recovery Unit 3, at 130 ha, large areas of the pond are intentionally flooded throughout the year for other species needs or are covered by dense vegetation. Much of the available plover nesting habitat, including the pilot plot, is located in the middle of the pond and difficult to observe from the levees that had been traditionally surveyed from. As such, it is possible that nests had gone undetected here. Prior to the 2015 breeding season, the levee between E6A and E6B was reinforced and graveled, allowing SFBBO Biologists to survey all areas of E6A more effectively in 2016. This allowed the detection of the nest in the pilot plot in 2016, and will assist in more accurate monitoring at both E6A and E6B in the future. When feasible, existing dirt levees in plover ponds should be reinforced and graveled to allow greater access.

Pond E16B contained 20 nests, the most nests monitored there since 2010, when 20 nests were monitored as well. The depredation rate at E16B was 55%, much higher than the 11% reported in 2015. The increased level of breeding activity at this pond may have attracted additional predators to the area. On several occasions in June and July, up to three Peregrine Falcons (one adult and two fledglings) were observed perched on towers in E16B and adjacent pond E11. Red-tailed hawks and Northern Harriers were seen with moderate frequency, and both Red Fox and Feral Cats were reported on several occasions on the pond or adjacent levee (Figure 27a).

At E6C, the depredation rate jumped dramatically compared to 2015. During the 2015 breeding season, all eight nests that were monitored hatched, whereas during the 2016 breeding season, only two out of the eight nests hatched (Table 5). California Gulls were the most numerous predators observed at E6C, with other predators seen infrequently (Figure 27a-b). Therefore, California Gulls may have been responsible for the low hatch rate at E6C this season, though it should be noted that this is speculation without additional evidence. Although the sample size is low, the vast difference in nest success between years indicates that while E6C can be a productive pond, additional management strategies may be needed to create a consistently high quality breeding habitat. This may include hazing gulls and/or drawing down water levels in adjacent ponds to reduce gull presence, removing potential predator perches within E6C and nearby ponds, and enhancing the pond bottom with oyster shells (or another material) to provide greater crypsis for incubating plovers. Monitoring of E6C in future years will help to determine the overall habitat quality of this pond.

Based upon three years of monitoring after the reconfiguration of E12 and E13, E14 and E8 are now the most significant ponds for nesting within Eden Landing. However, variation in nesting density at other Eden Landing ponds between seasons indicates that other areas hold importance as well (Figure 22). Past monitoring within RU3 has shown that when quality habitat is available, plovers will readily use it for nesting in multiple areas. Therefore, habitat should be made available within different ponds and should vary between years. This approach may limit the nesting density amongst all of these ponds, which in turn may reduce the likelihood of predators focusing on these areas for prey resources. Given the constraints to management of some of these ponds, this will not always be feasible.

In addition, all Snowy Plover nesting areas should be managed to remove tall and dense vegetation, to remove available predator perches, to minimize large cracks in the ground, and to reduce the abundance of critical predators. The 2016 breeding season depredation rate was the highest recorded within RU3 since 2010, and was highest in E14, the most critical pond for Snowy Plover nesting. As such, finding methods to reduce predator presence and to discourage nest depredation is a critical issue that must be addressed in order to achieve Snowy Plover population growth, and eventually, reach the USFWS Recovery Goal of 500 breeding individuals.

Napa-Sonoma Marshes Wildlife Area.

A total of three nests in North Bay ponds were found by CDFW during the 2016 season. Due to budget constraints, these areas were not frequently monitored. Combined with the fact that plovers may also breed on nesting islands intended for California Least Terns, there may have been more breeding activity than reported. An increased presence, perhaps by trained volunteers, would help us get a better handle on plover use and success in this area.

Additional Nesting Areas.

With no consistent Snowy Plover monitoring on many Cargill operated ponds, the level of nesting activity here is unknown. There were zero reported sightings of plover broods or other nesting behavior at ponds in Mowry or Newark, though it should be noted that there is no targeted monitoring of nesting species in these areas. Incidental sightings in past years, as well as the similarity of these ponds to high quality salt panne habitat with consistent breeding activity, indicate that these areas may support some level of breeding activity.

For the first time since 2008, Patterson Pond, located in Coyote Hills Regional Park, was surveyed during the 2016 breeding window survey. One female Snowy Plover was recorded, marking the first time that Snowy Plovers have been recorded at this pond since 2002. During the 2001 and 2002 breeding seasons, Patterson pond held five and six nests, respectively, which all hatched (Marriot 2003). Due to budget constraints, this area was surveyed only once, during the breeding window survey. In the future, this pond will be monitored more frequently to determine if it supports Snowy Plover breeding activity.

Montezuma wetlands, located in Solano County, contain 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 standardized survey methods for the second consecutive year. With confirmed plover breeding activity at this location (Anne Wallace, pers. comm.), it is important that this area be monitored more consistently during future breeding seasons.

Nesting Behavior

The use of trail cameras at selected nests in pond E14 this season allowed for close examination of plover nesting behavior, including: incubation, hatching, male and female nest attendance, and brooding. On one occasion, a male was recorded attempting to copulate with a female incubating a two week old nest with three eggs. Using nest camera footage to compare the nest's male and the male attempting to copulate with the incubating female, we found evidence to suggest that it was an unassociated male attempting to gain an extra-pair copulation; both were unbanded. In comparing the plumage patterns of these two males, there appear to be differences in the coloration of the rusty cap, the size of ear coverts, and the size of breast bands. However, without bands it is impossible to confidently determine the identity of the male. 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). Nevertheless, attempted copulation during incubation is an unusual event that to the best of our knowledge has not been previously documented in Snowy Plovers.

Trail cameras also captured the response of Snowy Plovers to increased human presence at E14. Beginning in May, a portion of trails at the Whales Tail loop of Eden Landing were opened

up to the public, including the northwest corner and west side of E14. Based on camera footage, incubating plovers exhibited a range of reactions to a variety of recreational activities including: pedestrians, bicyclists, and vehicles used by SFBBO, CDFW, or USGS. We found no clear trend between recreation type and flushing off the nest, nor was there a clear trend regarding the distance from the nest that induced flushing. It should be noted that to prevent theft, trail cameras were not placed on nests that were located in very close proximity (≈35-50m) to the levee. For nests in this range, it is possible that the reaction of incubating Snowy Plovers may have been more definitive. Further research is needed to better define the impact of all three groups on incubating Snowy Plovers at E14.

Chick Fledging Success

The fledging rate within Recovery Unit 3 decreased from 34% in 2015 to 27% in 2016 (Table 8.) Considering that the majority of Snowy Plover chicks were banded at E14, it is also possible that the Common Ravens, largely responsible for the high nest depredation rate within the pond, contributed to the low fledging rate. Common Ravens are known to be significant predators of Snowy Plover chicks (Page et al. 2009). Red Fox, which were consistently present within Eden Landing ponds but not documented as nest predators, may have also played a role in depredating chicks. In nearby Monterey Bay, past research indicates that Red Fox may be significant predators of chicks (Neumann et al. 2004). This also provides evidence that although oyster shell enhancements can attract Snowy Plovers to nest in high density, they may not increase the ability of Snowy Plover chicks to evade detection from predators. Rather, the increased predator activity attracted by the high nest density may instead result in chicks being depredated at a higher rate. Increased monitoring and better methods to estimate fledging success are needed for more definitive conclusions.

Our ability to re-sight Snowy Plover chicks in the ponds is limited by uneven topography/substrate spanning a large and complex network of ponds, sloughs, and channels. These factors, in combination with heat waves and long scoping distances create very difficult conditions for locating broods. Even when broods are observed, the ability to effectively re-sight color combinations is often quite limited. As a result, the accuracy of brood survival and fledge rates in RU3 must be viewed tentatively. The difficulties involved with banding Snowy Plover chicks in salt ponds further obfuscate our ability to accurately calculate fledge rate. Due to the precocial nature of Snowy Plover chicks, precise timing of nest hatching is required in order to catch and band chicks. The size of ponds can make catching broods difficult. This season, Snowy Plovers nested on 16 ponds totaling nearly 1300 ha, and 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.

When banding Snowy Plover chicks over the past couple seasons, banders noticed issues with Acetal bands slipping over the toes of smaller chicks. Bands that slip over the toes of Common Terns have been shown to cause serious injury, potentially resulting in loss of the foot (Nisbet 1991). This trend appeared to increase at the end of the breeding season. During this time, biologists have noticed that Snowy Plovers tend to lay smaller eggs compared to earlier in the breeding season (pers. obs.). To guard against this, Darvic bands, which in general did not have the same issue, were commonly applied on the bottom of the right leg (bottom left leg has metal USGS band that does not slip over toes). As part of the banding process, banders checked if the band on the bottom of the right leg could fit over the toes; if so, it was replaced with a different color. However, in several cases Darvic bands were also prone to this same issue. In order to protect against potentially serious injuries to banded Snowy Plover chicks, SFBBO banders will continue to look for appropriate color bands that do not have these same issues.

Oyster Shell Habitat Enhancements

Apparent Estimates.
Apparent nest success was lower in pilot shell plots (44%) than other areas of Eden Landing (51%) this season (Figure 5). This may be due to the gradual degradation of these shell plots over time. The brightness and density of the shells in many plots has degraded over time, resulting in greatly reduced camouflaging effects. In some instances, this may be due to seasonal management for wintering birds, resulting in movement and silting over of shells (E6B plots 2 and 3; E8 plots 2 and 4). In other area, natural precipitation and wind have similar effects on shells (E16B plot 2).

Large Scale Enhancement Study.
The implementation of large-scale oyster shell enhancement at pond E14 in Eden Landing allowed us to further test the efficacy of our pilot study, which indicated that oyster shells provide protective cover for nesting Snowy Plovers and suggest further breeding benefits on a larger scale. Overall nest abundance throughout the pond, and nest density in enhancement plots New 1 and New 2 were substantially higher in 2016 when compared to pre-enhancement conditions (prior to 2015). Nest abundance and density patterns in 2016 were also similar to the first season of enhancement in 2015, and overall water levels and management in nearby ponds were comparable. This suggests that large-scale oyster shell enhancement was the primary factor in the rise of nest abundance and density in 2015 and 2016.

Apparent nest success rates however were not significantly affected by this method. Fledge and behavior data can be found in Tokatlian (In prep.). Apparent depredation rates throughout E14 were alarmingly high in 2016 and uniform throughout treatment types, suggesting that enhancement does not provide substantial protective cover for nests or perhaps could not withstand the high predation pressure this season. From these preliminary results it can be argued that large scale oyster shell enhancement effectively attracts breeding plovers to an

area, but without concurrent predator control it may not effectively improve breeding success. See K. Tokatlian's master's thesis (In prep.) for a thorough nest survival analysis and details.

Data from the 2016 breeding season show that large scale oyster shell enhancements have the potential to greatly increase nest density. However, this season also provided more evidence that predators can cue in on areas of high nesting density, as Page et al. (1983) found with Snowy Plovers at Mono Lake. For the second consecutive breeding season, Common Ravens and Peregrine Falcons were the two most frequently seen critical predators (Figure27a). Common Ravens had an especially large impact on nest success, as they were documented by trail cameras depredating nearly half of all nests in the pond. Despite the high rate of nest depredation, the fledge rate (44%, Table 9) at E14 did not substantially differ from last season (44%). Further monitoring and research is needed to assess whether shell enhancements have a significant positive effect on fledge rate. This will be critical information moving forward to reach population goals for the Project and RU3. See K. Tokatlian's master's thesis (In prep.) for a thorough discussion of method applications and management recommendations.

We strongly recommend multi-year monitoring at the E14 enhancement site in order to document the variability of conditions and predation pressure, as evidenced this season. This will not only strengthen our analyses and account for the effect of rapid variability, it will also document whether Snowy Plover use of enhanced areas decreases over time which was the nesting pattern observed during our pilot study. This information will ultimately inform species and Project management, and will influence the targeted use of available resources.

As opposed to 2015, when increased nesting density resulted in territorial aggression between Snowy Plover broods, this behavior was not observed frequently during 2016, perhaps due to high nest depredation rates and relative lack of broods. Rather, density issues emerged between American Avocet broods and Snowy Plover broods. During the 2016 breeding season, American Avocets nested in high density in E13, particularly in the exposed pond bottom in the mixing basin cell. Many of these American Avocet broods moved from E13 after hatching to the northwest corner of E14 to take advantage of foraging habitat. This appeared to benefit Snowy Plover nests in the area due to the aggressive brood defense of American Avocet adults from approaching Common Ravens. However, once Snowy Plover nests hatched, they used similar areas as the American Avocet broods. On several occasions, biologists observed aggression between American Avocet adults and Snowy Plover adults and chicks. Similar behavior was also observed between American Avocets and an incubating Snowy Plover adult in Ravenswood pond R4.

On three occasions during the 2016 breeding season, a Semipalmated Plover (*Charadrius semipalmatus*) was observed scraping a nest bowl in the eastern oyster shell enhancement plot. On May 25 at 07:31, and May 28 at 06:17, nest camera footage documented a male Semipalmated Plover scraping a nest bowl and tossing material in the same location as a male Snowy Plover had been frequently scraping. This nest bowl was subsequently visited several more times by a scraping Semipalmated Plover, and by a scraping and copulating male and

female Snowy Plover. Semipalmated Plovers typically breed in open, sub-Arctic habitats from early May to August. Although there is record of one successful Semipalmated Plover nest in Coos Bay, Oregon during both the 1993 and 1994 breeding season (Hallett et al. 1995), there is no evidence to suggest that a Semipalmated Plover nest was initiated in the San Francisco Bay. It instead displayed typical breeding behavior, perhaps instinctually, before physically migrating to its northern breeding range. Camera footage showed no nest completion by either species at this location.

Additional Considerations.
The shift in large Snowy Plover flocks from A22 to A13 (Figure 7c) may have been due to changes in water availability. At A22, borrow ditches and seasonally flooded areas gradually dried up over the course of the season, resulting in relatively little foraging opportunities within the pond. Conversely, at A13, although water levels did gradually recede during the breeding season, there remained water spread throughout the pond in channels, thereby providing a continuous source of brine flies. As such, A13 may have become the more desirable location for post-breeding and staging Snowy Plovers in the Alviso area by the end of the breeding season.

Nesting locations in general can be attributed to habitat availability as a result of water level management and habitat conversion due to tidal restoration projects. Accurately documenting inter-seasonal and intra-seasonal changes in breeding habitat availability is imperative as available habitat shifts over the years. 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. Although shell plots are one way to achieve the higher nest densities needed to reach the Recovery Unit goal of 500 breeding birds, there are a couple of issues with oyster shells that warrant further consideration. Due to the closing of Drake's Bay Oyster Company in Marin County in 2014, large amounts of local oyster shells are no longer available. Acquiring large amounts of oyster shells in the future may require the implementation of an oyster shell collection program from local restaurants, a task that could require significant resources to accomplish. In addition, the aforementioned tendency of oyster shells to degrade over time means that shell plots may need to be supplemented with new shells on a consistent basis (approximately every 5-10 years) in order to maintain their benefits for Snowy Plover breeding. As such, other more readily-available materials should be tested in Snowy Plover nesting areas, including gravel, wood debris or bivalve shells. These materials should be tested in a pilot study for efficacy and durability prior to being implemented on a larger scale.

With large increases in nest density, additional efforts must be undertaken to reduce the effect of nest depredation on the recovery of Snowy Plovers. This may include increased predator management, including deterrence methods. To further guard against the potentially deleterious effects of high nesting density, managers should identify all potentially suitable areas for snowy plover nesting not slated for restoration or reconfiguration by the project. At these sites, installation of new water control structures or other management actions may allow for appropriate management of Snowy Plover habitat during the breeding season.

Avian Predators

Common Ravens were documented as the most significant predator affecting Snowy Plover recovery in Recovery Unit 3 during the 2016 breeding season. At E14, where ten trail cameras were used to monitor nesting activity, ravens were recorded depredating 30 out of 60 nest depredation events. Of the remaining 34 nests that were depredated, based upon the proximity to nests where ravens were confirmed as the predator, as well as the date of depredation, it is likely that more nests were also depredated by ravens. Trail cameras recorded ravens partially depredating nests on five separate occasions. At four of the nests, ravens returned to the nest anywhere from 1-5 days later to finish depredating the nest. At the fifth nest, a raven depredated two eggs on one day, allowing the third to hatch the following day. This provides evidence that ravens may be capable of remembering where nests are located. In many instances, ravens were documented swallowing eggs whole, rather than eating the contents of the egg at the nest site, which was commonly recorded. This provides evidence that ravens were placing eggs in their antelingual pouch and caching them at a location for later consumption. Caching is a well-documented behavior in ravens (and other Corvids) that allows the storage of food supplies that may vary in abundance on a temporal scale (Heinrich & Pepper 1998). Considering this behavior, it is possible that many of the depredations at E14 were the result of only a few individuals that depredated nests for both immediate and future needs.

We were concerned that ravens cued in on the presence of trail cameras located next to nests, and thus, we conducted two separate informal experiments to determine if ravens recognized trail camera. Between the two experiments, ten cameras were placed at over 50 separate locations over a total of eight weeks. During this time, ravens were seen on camera at these locations a total of four times; only on two occasions did they appear to be inspecting for eggs near the camera. This information, combined with a high depredation rate at E14 when trail cameras were removed from the pond for several weeks, suggest that ravens do not associate trail cameras with nests.

During the 2015 breeding season, a pair of Peregrine Falcons nested in an E9 hunting blind located approximately 200 meters from E14, fledging two juveniles by early June. Prior to the 2016 breeding season, several hunting blinds in E9 and E14 were either destroyed or made unavailable to nesting raptors by wrapping them in landscape cloth. As a result, there was no Peregrine Falcon nesting observed this past season in E9. Despite this, Peregrine Falcons were

consistently seen hunting throughout Eden Landing, including two fledglings in mid-June. On two occasions, a Peregrine Falcon and two Common Ravens were observed fighting in flight over E14, which may be evidence of the two species fighting over resources and/or protecting their young. 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.

Contrary to 2015, a Peregrine Falcon nest was not found within the general vicinity of Eden Landing Snowy Plover Ponds. However, on multiple occasions, two Peregrine Falcons were observed hunting in the Old Alameda Creek loop of ponds (E8, E6B, E6A). On one occasion, the remains of an American Avocet were found near an active Snowy Plover nest in E8. Based on this anecdotal information, and their observed direction of flight when flushed, it is possible that they nested this year within a hunting blind located in South Eden Landing (ponds E1-7), though a nearby building or bridge is also possible.

We frequently observed Red-tailed Hawks, Peregrine Falcons and Common Ravens perched in the transmission towers within ponds throughout the South Bay. The Refuge coordinated with Pacific Gas and Electric (PG&E) to remove eight Common Raven nests and two Red-tailed Hawk nests in towers over sensitive habitat in the South Bay in 2016 (Strong and McCracken 2016). In addition, 233 California Gull nests were removed from pond A22 located within Snowy Plover nesting 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 38,040 breeding birds in 2016, a decline of nearly 10,000 from the 47,866 breeding birds recorded in 2015 (Tarjan and Heyse 2016). Although the second largest gull colony in the bay (Alviso A9/A10/A14 colony) was located a short distance from A13, they did not appear to have a significant affect upon the success of Snowy Plover nesting and fledging within that pond. Only at two ponds, R1 and E6C, does evidence suggest that California Gulls were responsible for nest depredations. This is in sharp contrast to 2009-11, when gulls were identified as a major predator to nesting Snowy Plovers (Robinson-Nilsen et al. 2011, Demers et al. 2012). This may be linked to the fact that their population appeared to decline by approximately 21% from 2015 to 2016. Since 2011, SFBBO and Refuge biologists have coordinated a gull hazing program and successfully prevented gulls from nesting in areas identified as sensitive plover habitat (Robinson & Demers 2012; Washburn & Butler, 2015.). Continued California Gull hazing and tracking is essential to prevent gulls from nesting in sensitive areas in future years.

Mammalian Predators

During the 2016 breeding season, non-native red foxes continued to use a den located in the north-western part of E13. During the first half of the season, fox pups were frequently observed near the den entrance. As the pups grew older, many were observed on levees and pond bottoms throughout ponds E12-14, particularly during the early morning hours when

biologists arrived on site. On one occasion, as biologists went to check a trail camera in the central part of E14, they observed a red fox juvenile flush from beneath the remnants of a torn down hunting blind. There are four distinct torn down hunting blinds in E14, all of which could provide hiding places for red fox and other mammalian predators. These remnants will be removed prior to the 2017 breeding season to ensure that mammalian predators are unable to use these areas within sensitive breeding habitat. On another occasion, an adult red fox was observed resting in oyster shells on the pond bottom of E14. After being harassed by a biologist, it then walked toward the perimeter and easily walked across the borrow ditch to emerge at the northwest corner. The borrow ditch was saturated and muddy, and the water level reached the adult fox's upper leg when crossing. Considering the ease in which this fox crossed the flooded borrow ditch, it's questionable that mammalian predators are effectively discouraged by them from accessing pond bottoms, as we previously believed.

Though Snowy Plover nest predation pressure remained this season, we continued to decide against the use of single nest exclosures because of the risk of adult mortality and of making nests more conspicuous to predators (Dave Lauten, pers. comm.). Furthermore, exclosures improve rates of nest success but are ineffective in supporting chick survival or fledge success. We continue to investigate alternative methods of predator control where resources allow.

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 RSF2, E12-13, and A16, contain constructed nesting islands. Islands are intended to provide waterbird nesting and roosting habitat. Other ponds, such as E14 and R3, are or will be enhanced specifically to provide quality Snowy Plover nesting 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).

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.

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 will enhance pond R3 for plover nesting habitat while breaching other pond 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 therefore decreasing conflict between plovers and construction activities. Furthermore, managers should begin drying ponds in the fall prior to construction in order to allow pond bottoms enough time to dry and become available by the start of breeding season.

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. Four of the ponds opened to tidal action or converted to other management regimes historically hosted large numbers of Snowy Plovers (A8, E12-13 and E8A; Figure 14, Figure 17, Figure 18, and Figure 19). Losing the breeding habitat in these nesting ponds may reduce the number of Snowy Plovers nesting in the San Francisco Bay Area in the long-term, although this has not yet happened. Nest numbers in 2016 were the second highest in the history of the Recovery Unit. Reducing the amount of habitat available to nesting Snowy Plovers may have unintended consequences on the success of breeding attempts as nest densities increase. In 2015, SFBBO documented significant issues resulting from high density nesting in E14, including brood aggression and high nest abandonment rates. In 2016, it appeared that predators, especially Common Ravens, keyed in on the high nesting density at E14, resulting in extremely high nest depredation. This provides evidence that Snowy Plovers will need to have quality habitat spread throughout the bay to minimize these affects.

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. For the second year in a row, SFBBO monitored these ponds as part of normal breeding surveys during the 2016 breeding season. As was the case last year, no Snowy Plovers were observed on either island with Snowy Plover decoys. As such, the efficacy of social attraction for plover nesting should be reviewed for future breeding seasons (Hartman et al., 2016).

Another goal of the 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). Past research showed that Snowy Plovers in the South Bay are very sensitive to recreational disturbance and flush from their nests when walkers are at an average distance of 164 m when approached directly, or 145.6 m when passed tangentially (Robinson 2008 and Trulio et al. 2012). However, this season a portion of the trails at E12-14 were opened to the public, including the west and northwest side of E14. While initial anecdotal

monitoring didn't detect any significant impacts to nesting plovers in this area, further monitoring is needed to adequately assess how pedestrians affect Snowy Plover behavior in this area. Therefore, public access should be limited or prohibited on trails in other areas adjacent to Snowy Plover nesting ponds during the breeding season (March-August); access at E14 during this time period will be limited to the northwest corner of the pond. 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. 2003). 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 (~2 feet tall, such as is present at RSF2) and smaller diameter chick fencing to keep Snowy Plover chicks off of trails and roads. This may be beneficial in areas of the newly opened E12-14 trail, although care should be taken to not cut broods off from foraging habitat which changes over the season as ponds dry. 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. 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.
2. The effects of avian predator management on Snowy Plover breeding success.
3. Impacts of Common Raven, Peregrine Falcon, and California Gulls on nesting Snowy Plovers.
4. Long term use of E14 large-scale oyster shell enhancement by breeding and wintering Snowy Plovers.
5. Potential impacts to nesting Snowy Plovers of human disturbance from recreational trail use at Eden Landing, Ravenswood, and Alviso.
6. Effectiveness of taste aversion studies in reducing egg depredation by Common Ravens
7. Nest success of Snowy Plovers on islands in managed ponds, and methods to improve nesting use and success on islands.
8. Snowy Plover nesting habitat selection (use versus availability).
9. Northern Harrier territory size and habitat use and impacts on nesting Snowy Plovers, especially as tidal marsh nesting habitat increases for harriers.
10. Snowy Plover foraging habitat use (borrow ditches, open channel, muted tidal, shallow pools, dry substrate) and invertebrate prey availability within the salt ponds.
11. Snowy Plover use of the ponds for foraging and roosting during the non-breeding season.

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 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, whereas the USFWS Recovery Goal is 500 breeding adults; therefore, in order to reach the USFWS 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 Patterson Pond in Coyote Hills, Frank's Dump locations in Hayward, Crown Beach in Alameda, and Bayfront habitat in Foster City and Redwood City. As the amount of managed 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, the Redwood City Plant Site and others) as habitat is available.
5. SFBBO should continue to monitor the large scale oyster shell habitat enhancement at pond E14, and apply these findings to future enhancement opportunities, such as at pond R3.

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 2017 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. At ponds A22, E8, and RSF2 cell 3, efforts should be made to remove grasses and halophytic vegetation on the pond bottom that are reducing available nesting habitat. This may be achieved through flooding ponds, applying excess salt or gypsum, direct removal, or a combination of these methods.
8. Water levels should be kept higher or interior channels should be added to pond E16B to increase the amount of foraging habitat in this pond.
9. As designated breeding plover habitat, cell 3 in RSF2 requires some 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.
10. 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 R1, R2, and R3 would allow for better water management. Water levels in the borrow ditches should be maintained higher in pond R3 in order to keep interior channels full. This may enhance foraging habitat, and potentially, the numbers of Snowy Plovers using the complex. Removal of remnant salt production structures used as predator perches would be beneficial for adult and chick survival.
11. 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. Smaller structures should be removed or treated with a bird deterrent such as Nixalite to discourage predator perching.
12. Law enforcement patrols should be increased in areas with Snowy Plover breeding habitat to minimize disturbance from trespassing humans. This will become progressively more important as additional areas are opened to the public as part of the Project.
13. 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.
14. SFBBO, along with CDFW and the Refuge, should continue to develop a Snowy Plover outreach program in areas that are adjacent to public access. Actions should be taken now to educate the public on Snowy Plover conservation and disturbance issues.
    - **a.** Additional interpretive panels should be placed in public areas to provide information on Snowy Plover habitat needs, disturbances, and conservation issues.
    - **b.** Continue to station volunteer docents 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.

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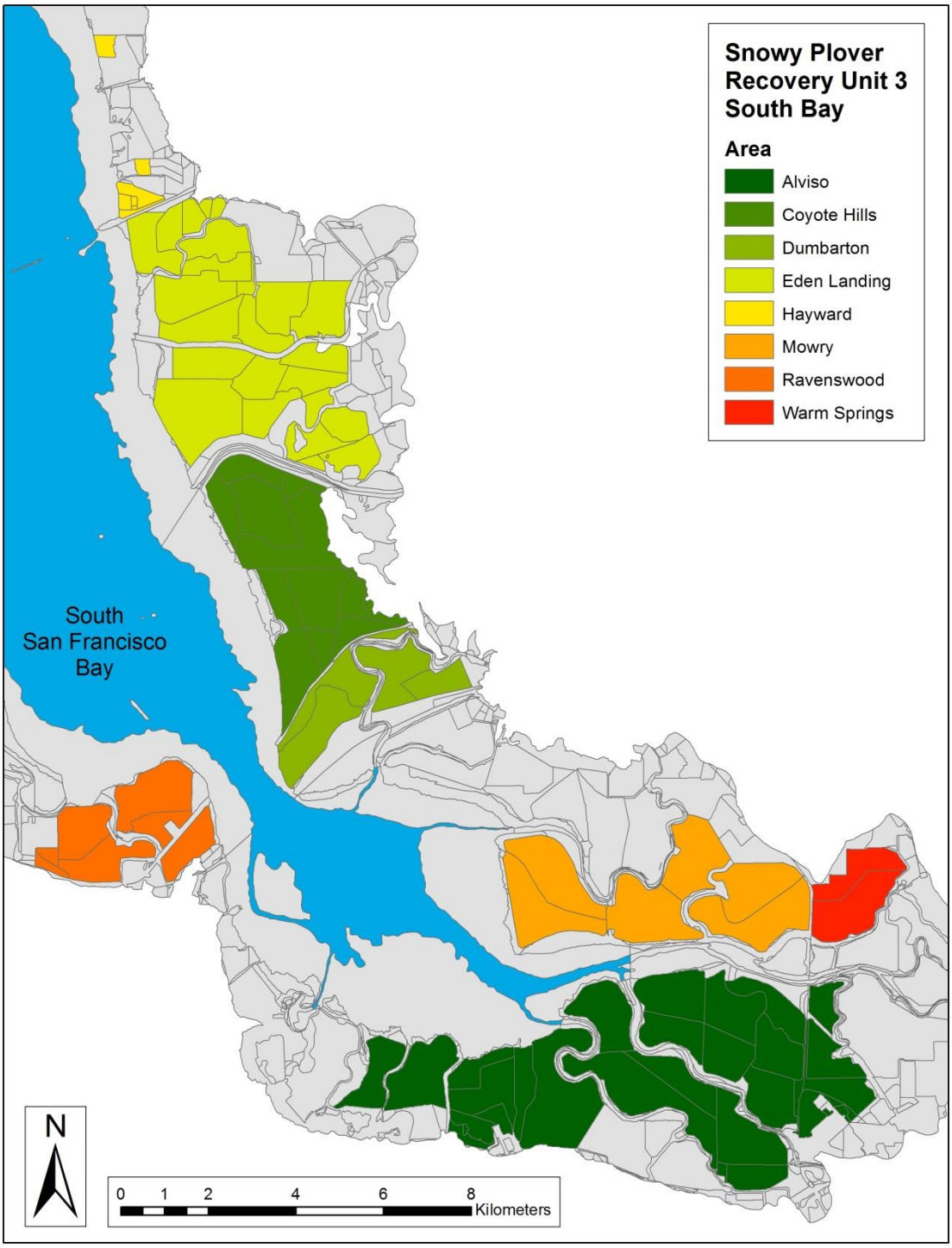

Figure 1. The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's Eden Landing Ecological Reserve, East Bay Regional Park District and Hayward Area Recreation and Park District lands in the South San Francisco Bay, California.

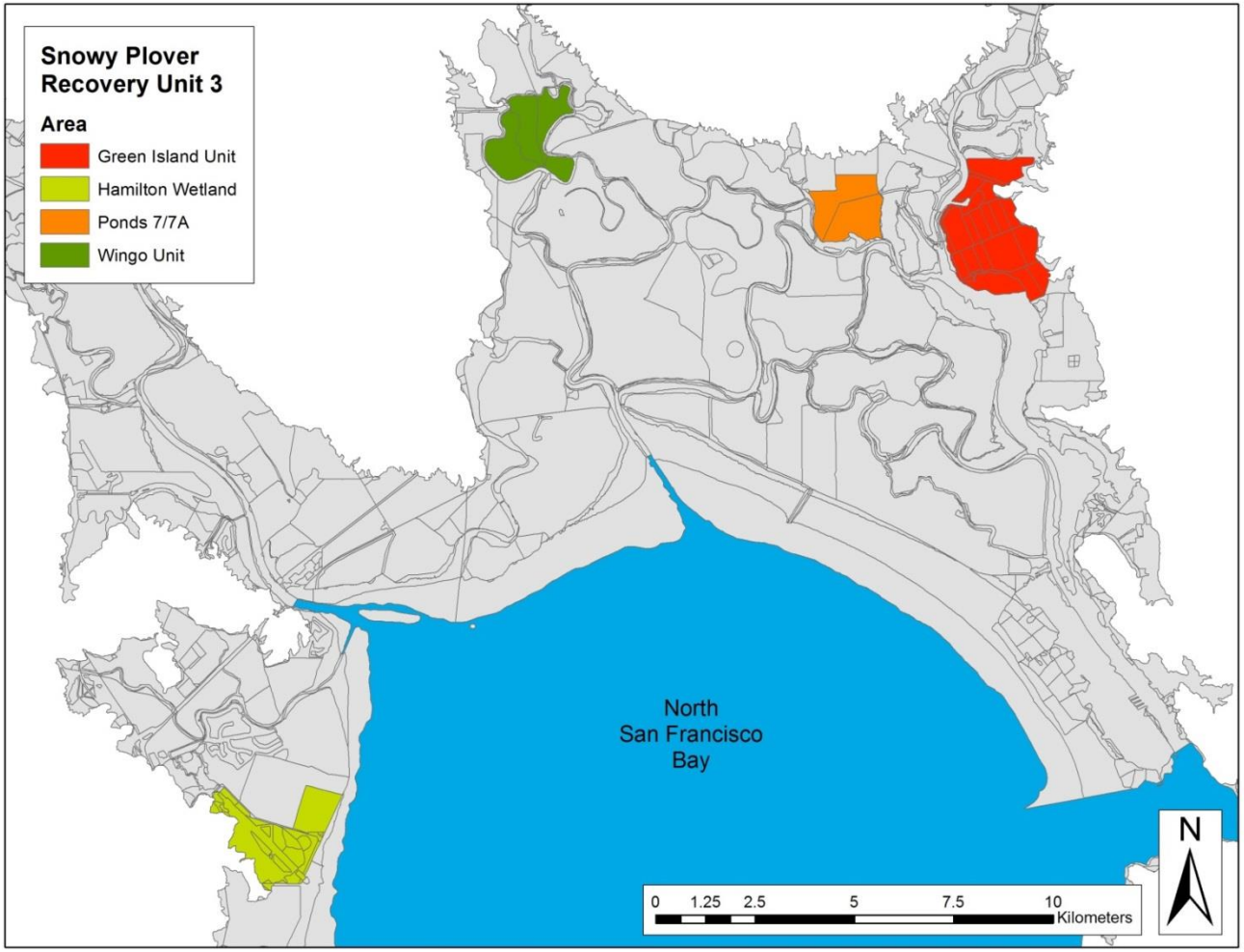

Figure 2. Snowy Plover nesting areas in the CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site), North San Francisco Bay, California.

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Figure 3. Ponds located in the Refuge's Warm Springs area, near Fremont, South San Francisco Bay, California. See Figure 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 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 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 for location of Eden Landing Ecological Reserve within South San Francisco Bay.

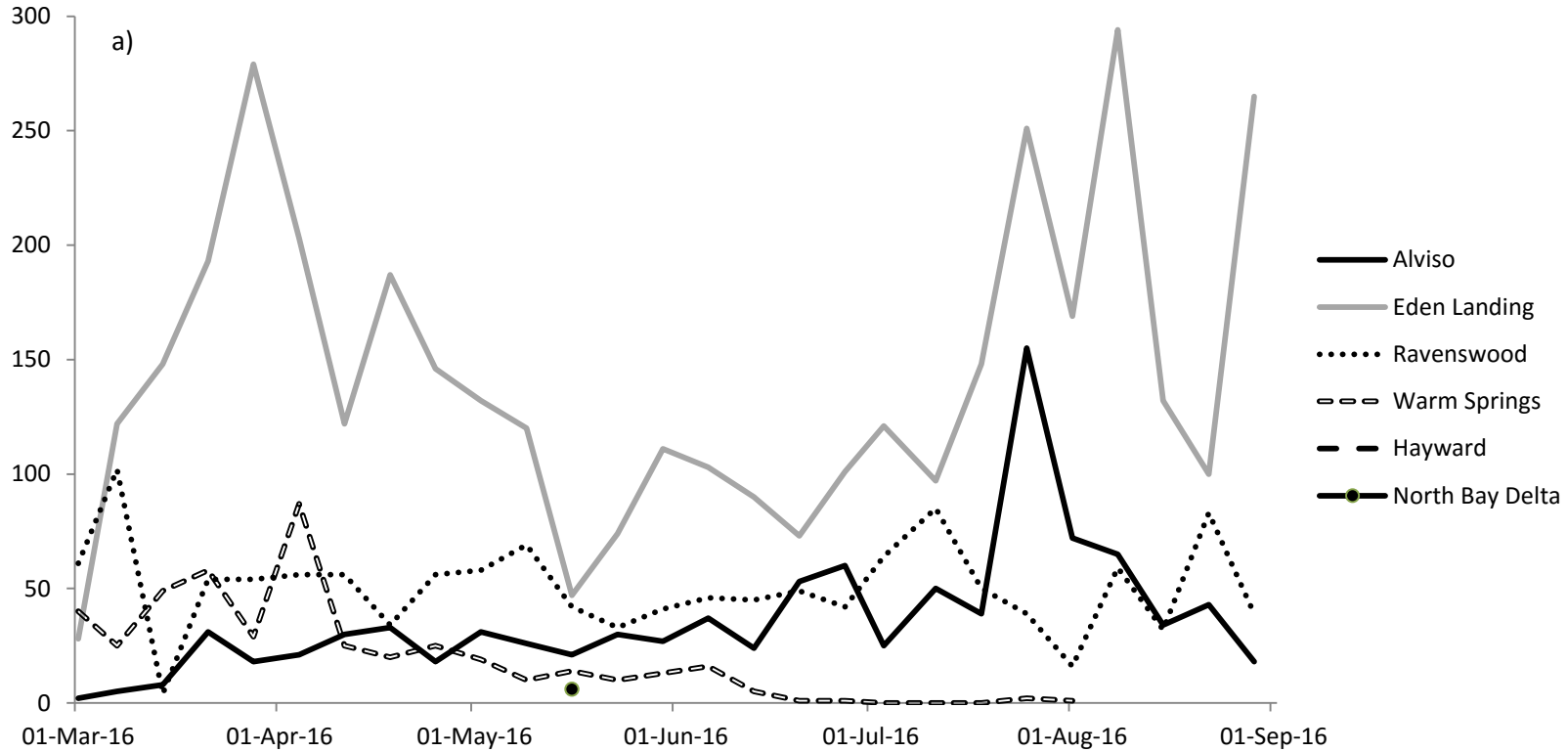

Figure 7a. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2016. Data are presented here for all locations monitored where plovers were observed. Note the high number of Snowy Plovers observed in late March and August are presumed to be migrating and not breeding in the San Francisco Bay.

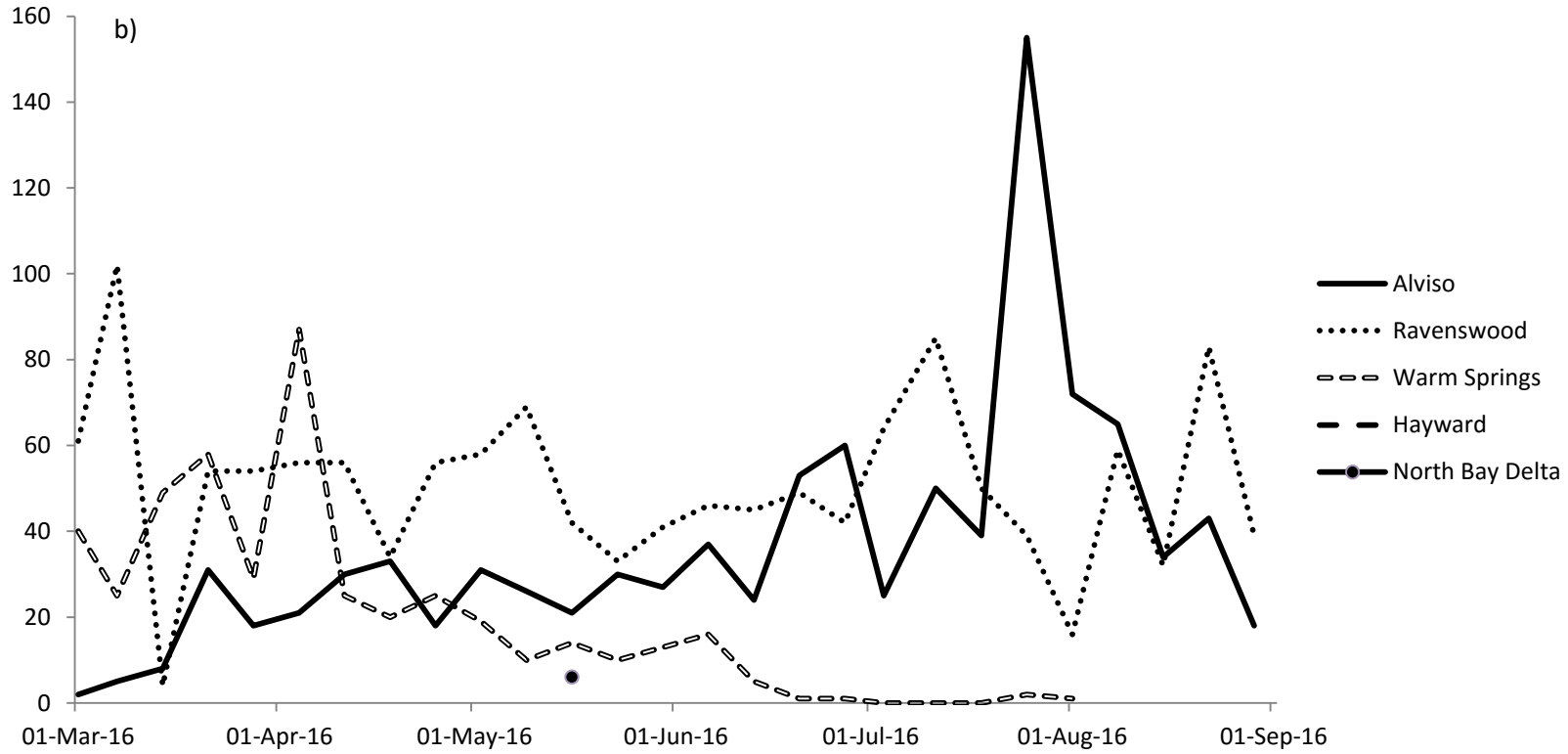

Figure 7b. Counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2016. To facilitate interpretation, data are presented for all locations monitored excluding Eden Landing. Note the high number of Snowy Plovers observed in late March and August are presumed to be migrating and not breeding in the San Francisco Bay.

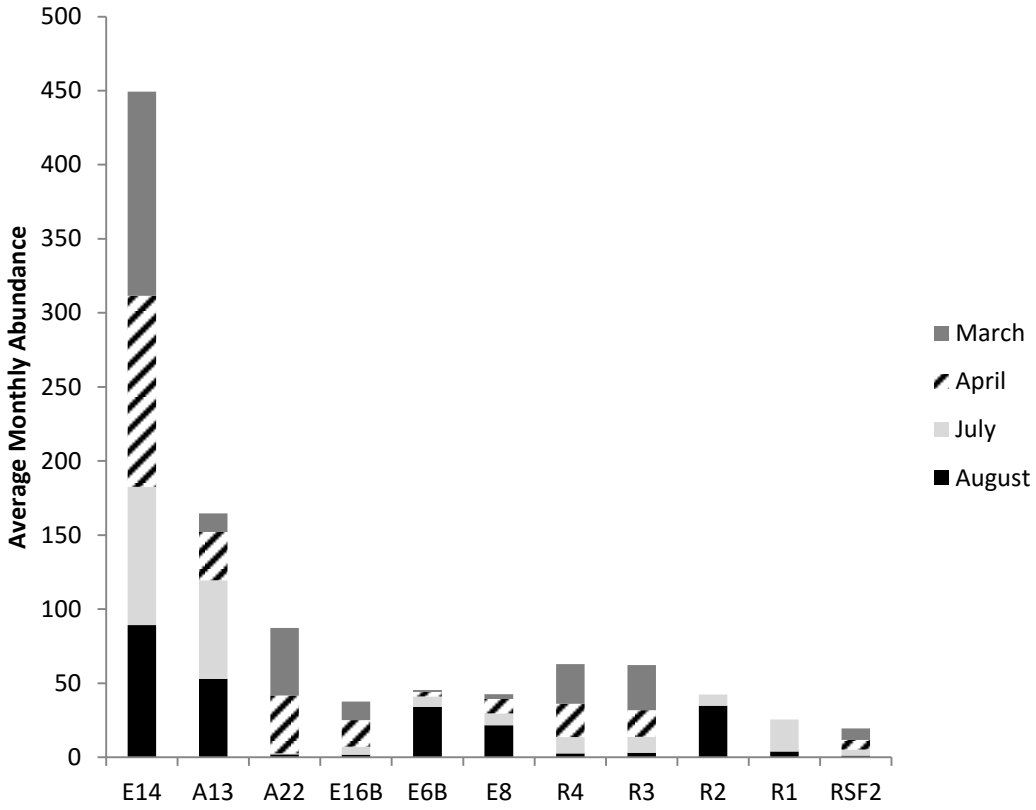

Figure 7c. Abundance of adult plovers at significant ponds during March, April, July and August, 2016. The purpose of this figure is to show that ponds are used by plovers in varying intensity during the beginning and end of the breeding season.

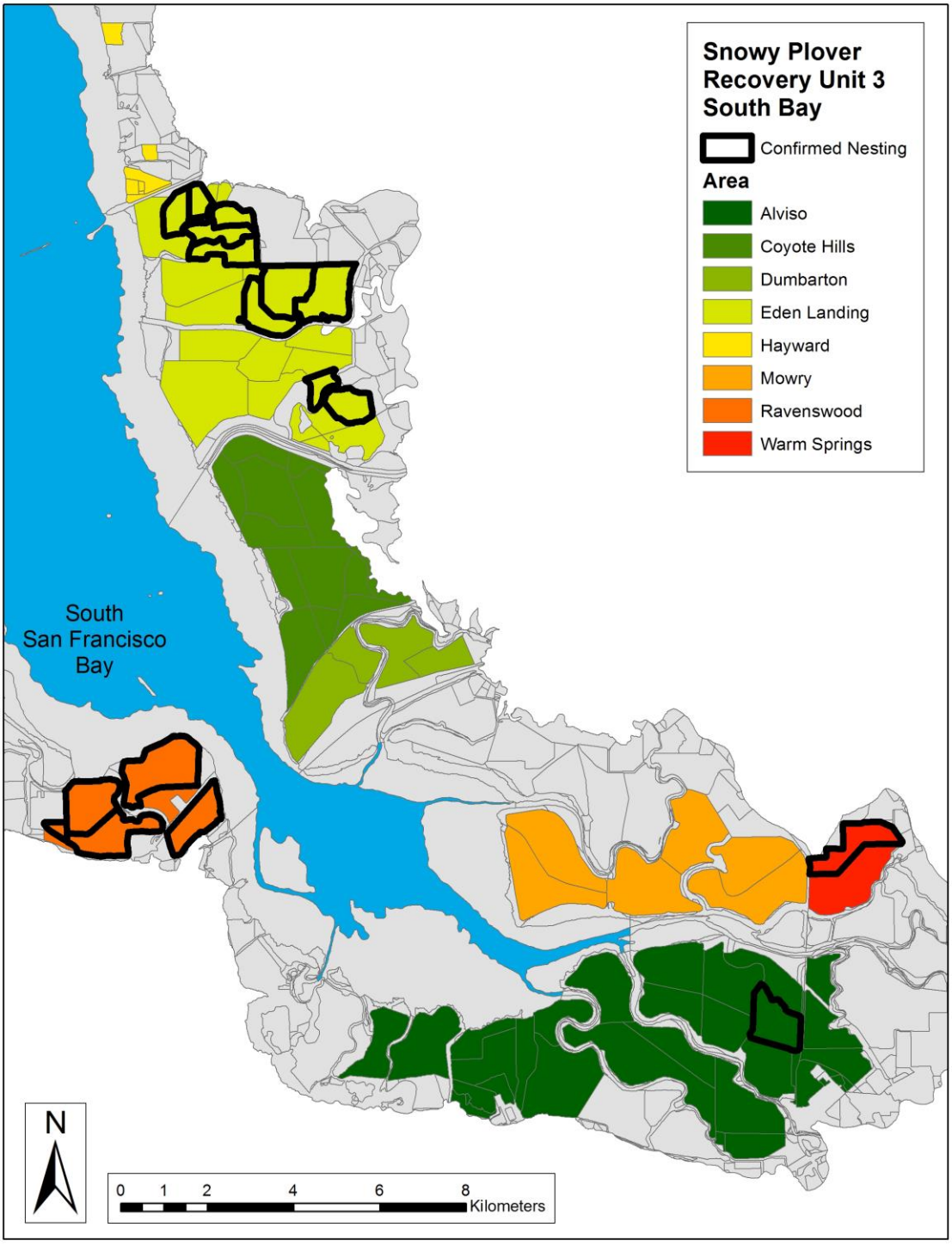

Figure 8. Areas (black outline) with documented Snowy Plover nesting activity during the 2016 breeding season, South San Francisco Bay, California.

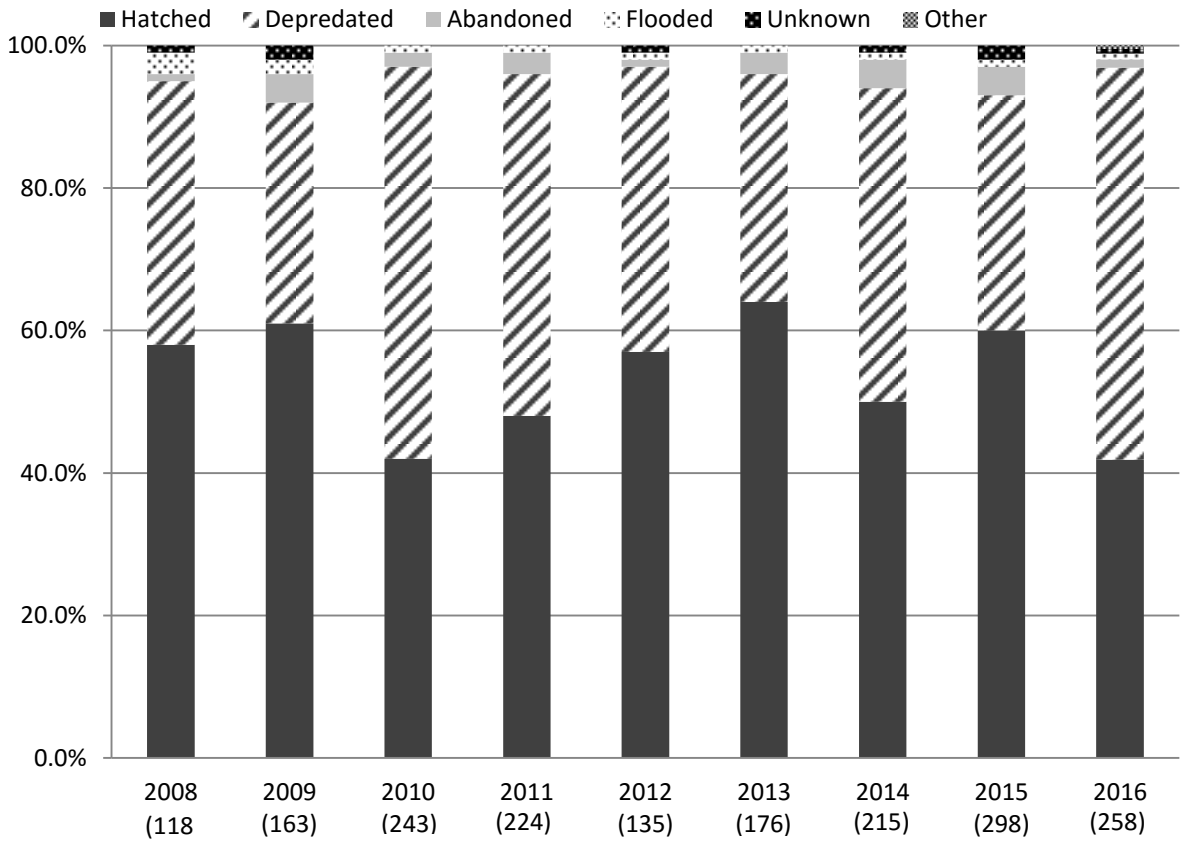

Figure 9. Annual apparent Snowy Plover nest fates in the South San Francisco Bay, California, 2008-2016. The number of nests monitored is indicated in parentheses beneath the year.

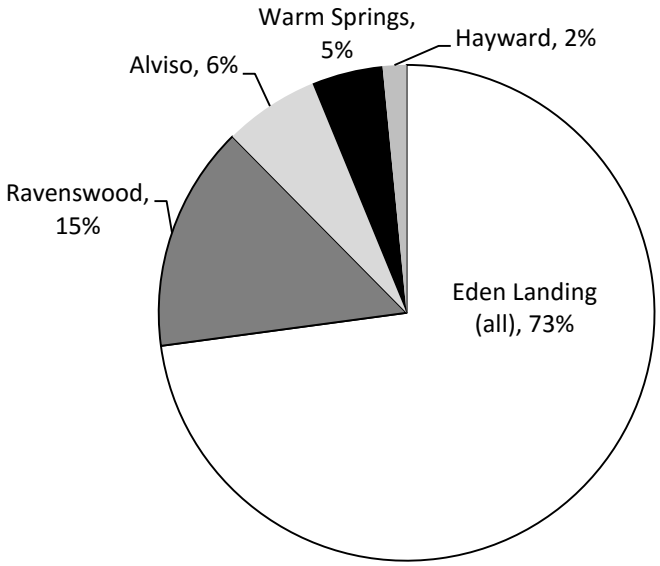

Figure 10. The proportion of Snowy Plover nests found in each pond complex in the South San Francisco Bay, California, 2016.
*Percentages rounded to nearest whole number, resulting in >100%

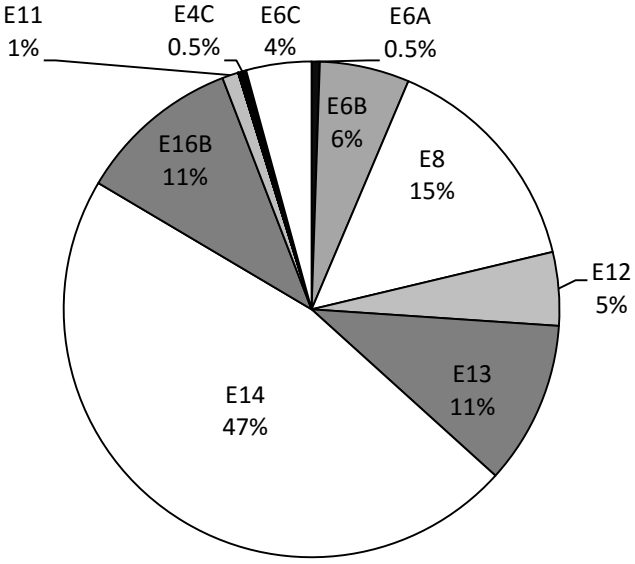

Figure 11. The proportion of Snowy Plover nests found in each Eden Landing pond within the Eden Landing Ecological Reserve in Hayward, California, 2016. Note that 47% of Eden Landing nests were found in pond E14.
*Percentages rounded to nearest whole number, resulting in >100%

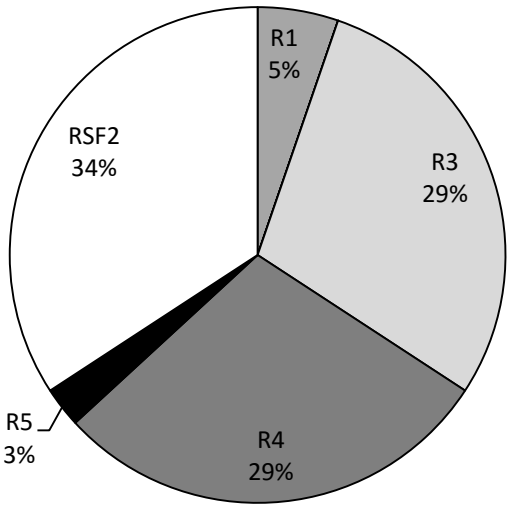

Figure 12. The proportion of Snowy Plover nests found in each Ravenswood pond within the Ravenswood Complex, Menlo Park, California, 2016.

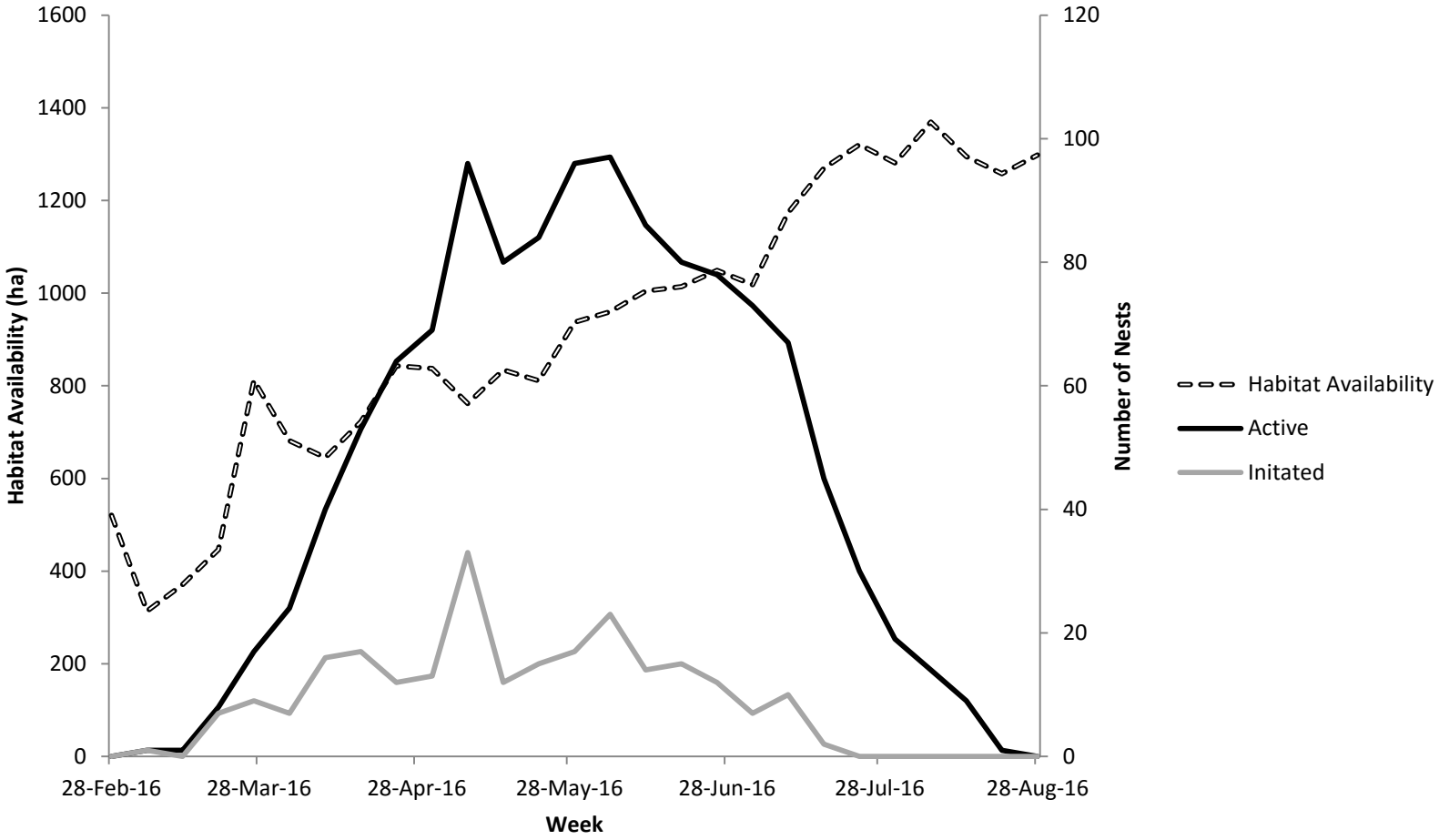

Figure 13. The weekly number of initiated and active Snowy Plover nests and estimated habitat availability in the South San Francisco Bay, California, 2016.

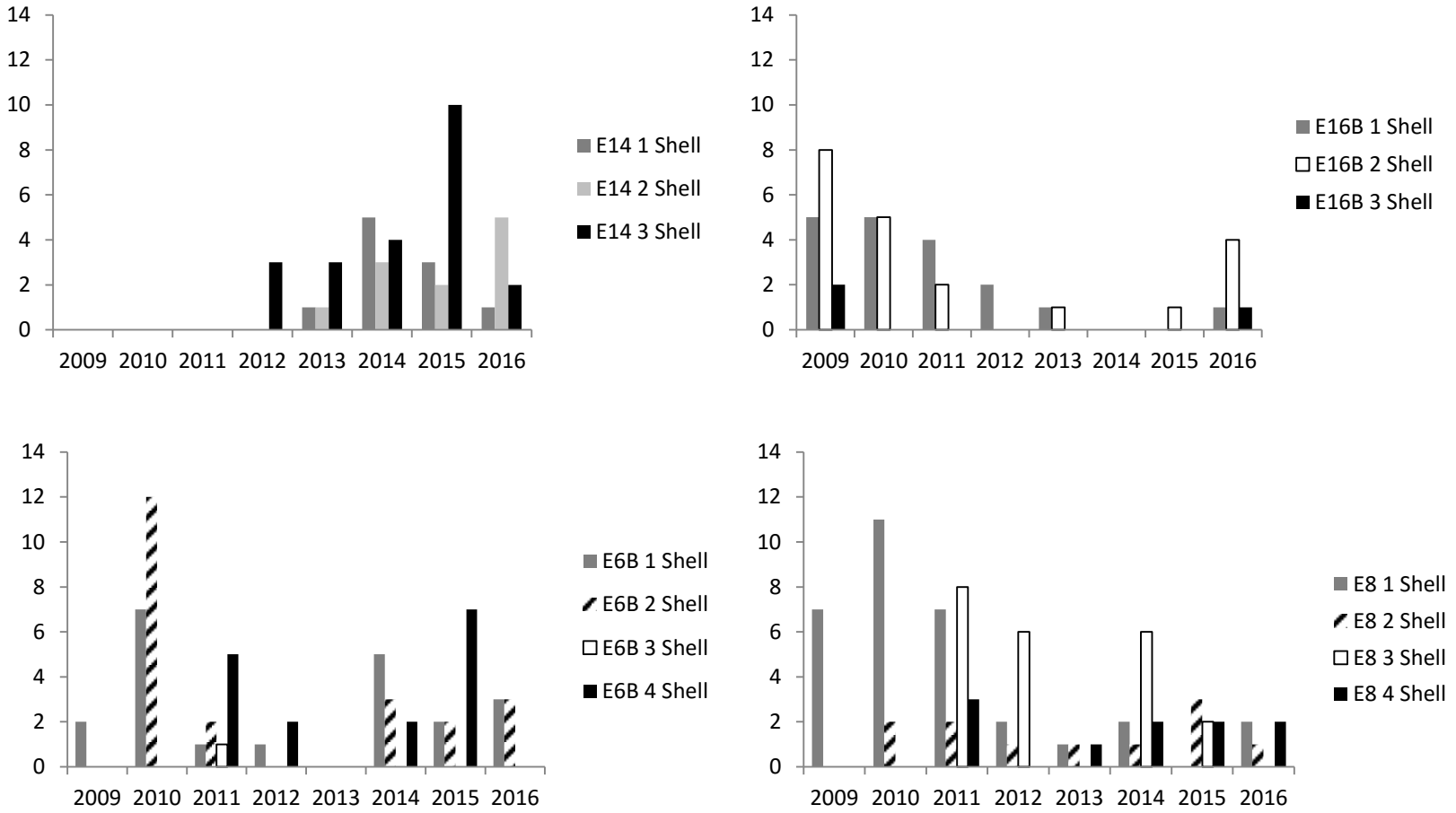

Figure 14. The number of Snowy Plover nests in each shell plot at Eden Landing Ecological Reserve, South San Francisco Bay, California, 2008-2016. Miniscule numbers were used to represent "0" nest values versus "null" values on each graph in order to signify years in which plots were not yet established. Shell plots considered to be in good condition are E6A-1, 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 surrounded by a new large shell plot, and thus no longer serve the same function since 2015.

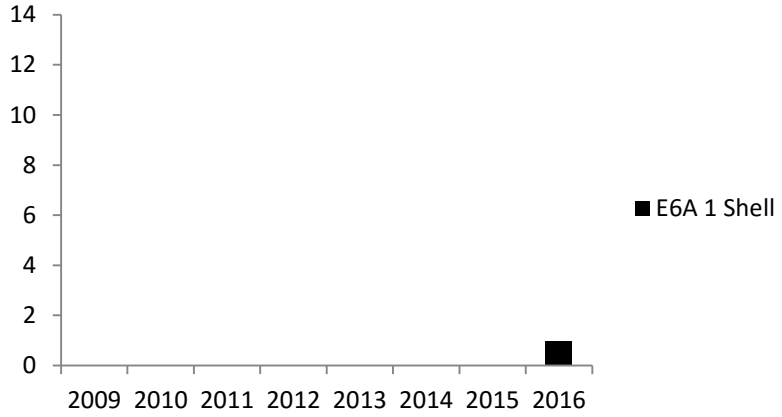

Figure 14 (ctd). The number of Snowy Plover nests in each shell plot at Eden Landing Ecological Reserve, South San Francisco Bay, California, 2008-2016. Miniscule numbers were used to represent "0" nest values versus "null" values on each graph in order to signify years in which plots were not yet established. Shell plots considered to be in good condition are E6A-1, 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 surrounded by a new large shell plot, and thus no longer serve the same function since 2015.

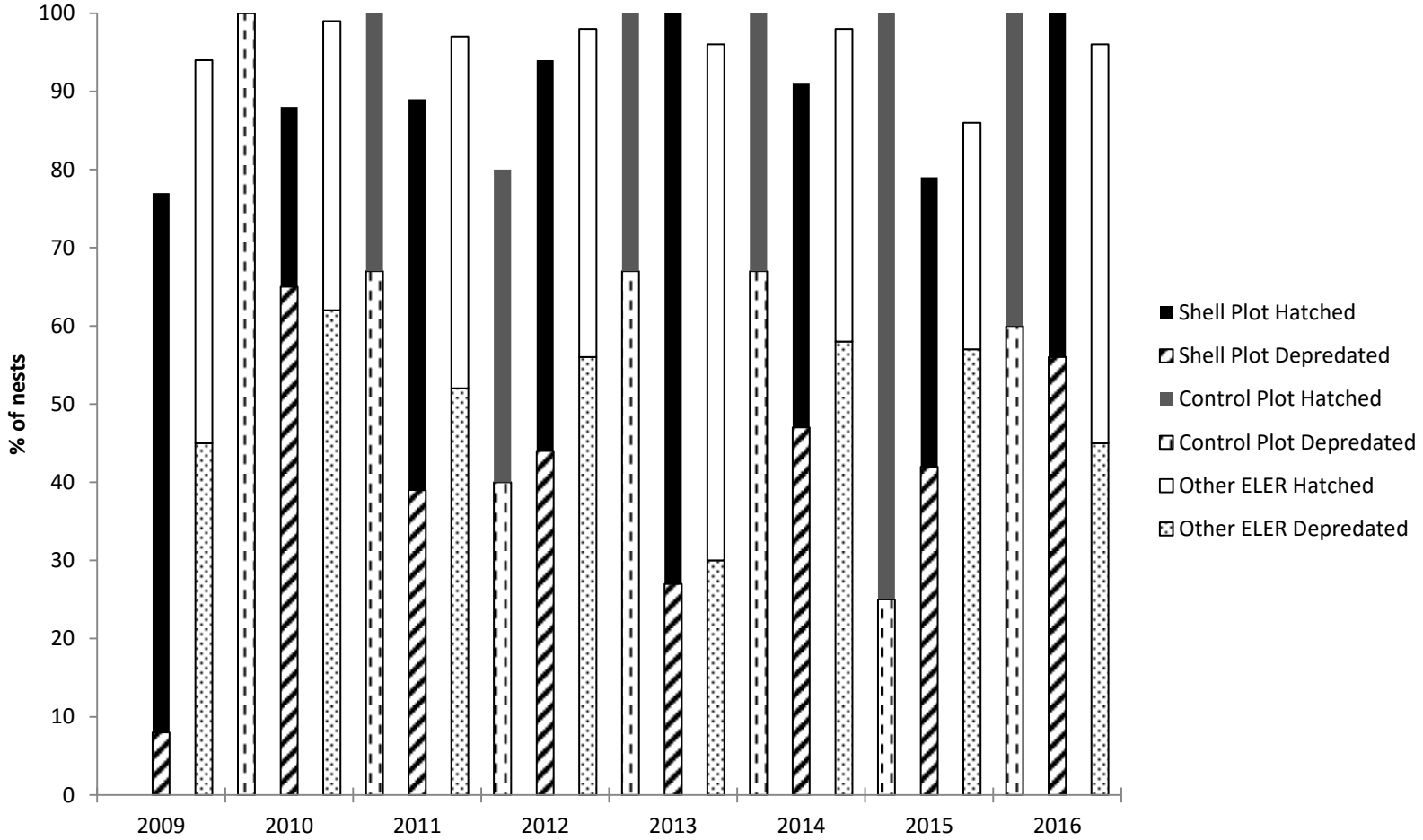

Figure 15. The fate of nests in shell plots, control plots, and all other areas of Eden Landing Ecological Reserve. In some instances the fate of nests was unknown, resulting in a number less than 100%. Note that E14 was removed beginning in 2015 due to implementation of two large enhancement plots.

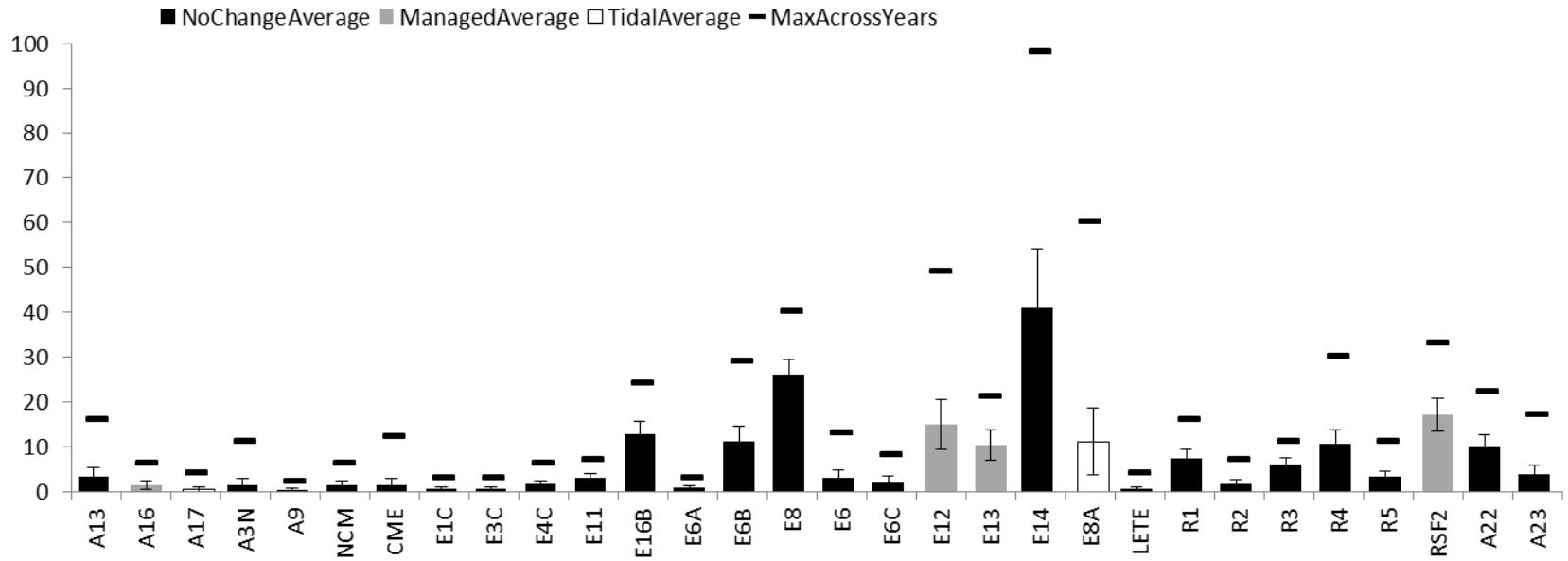

Figure 16. Average number of Snowy Plover nests initiated by pond in South San Francisco Bay, California from 2009-2016. Data are shown as mean + 1SD. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 1 restoration plans of the South Bay Salt Pond Restoration Project. White bars denote ponds that have been 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 and "LETE" = Hayward Least Tern Island; refer to Figs. 3-6 for other pond names and locations.

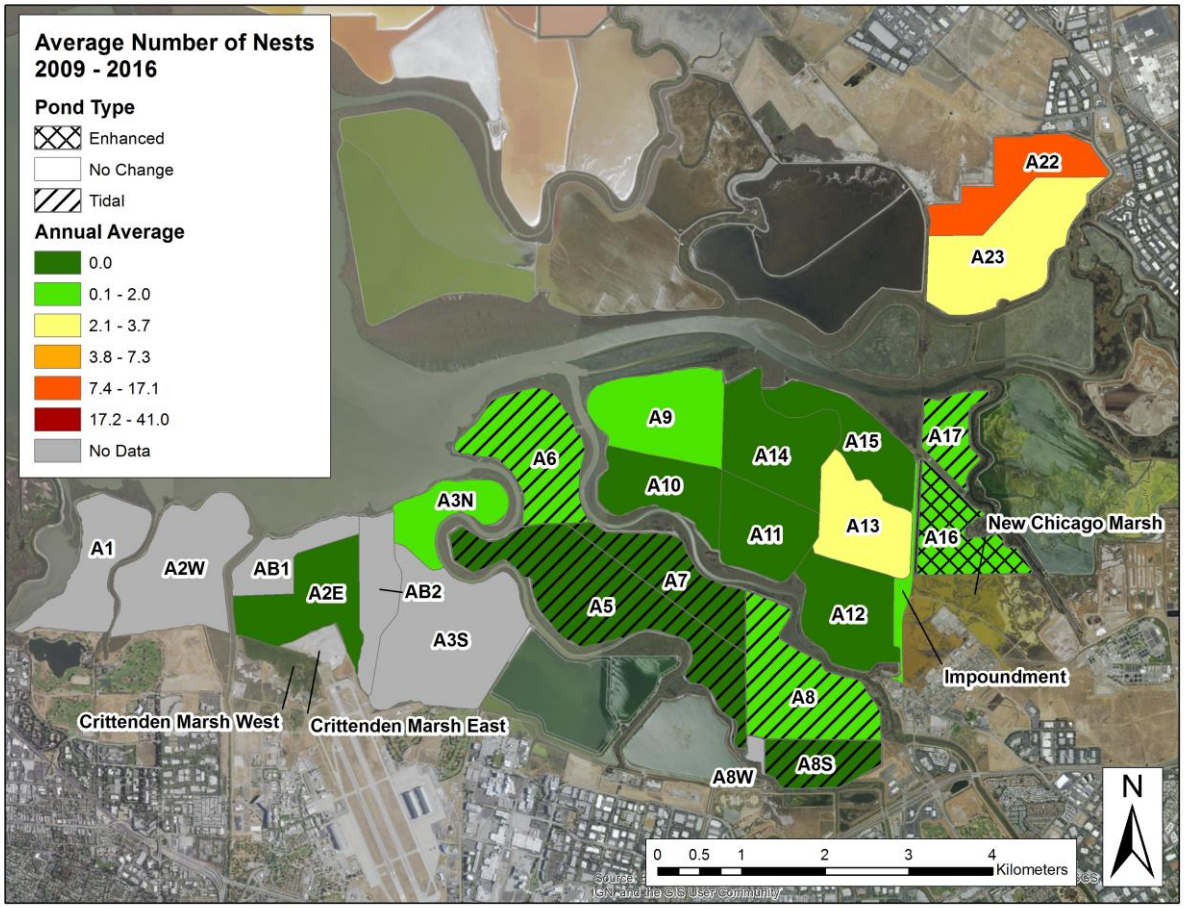

Figure 17. Average number of Snowy Plover nests initiated by pond in the Alviso Complex, South San Francisco Bay, California from 2009-2016. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in 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.

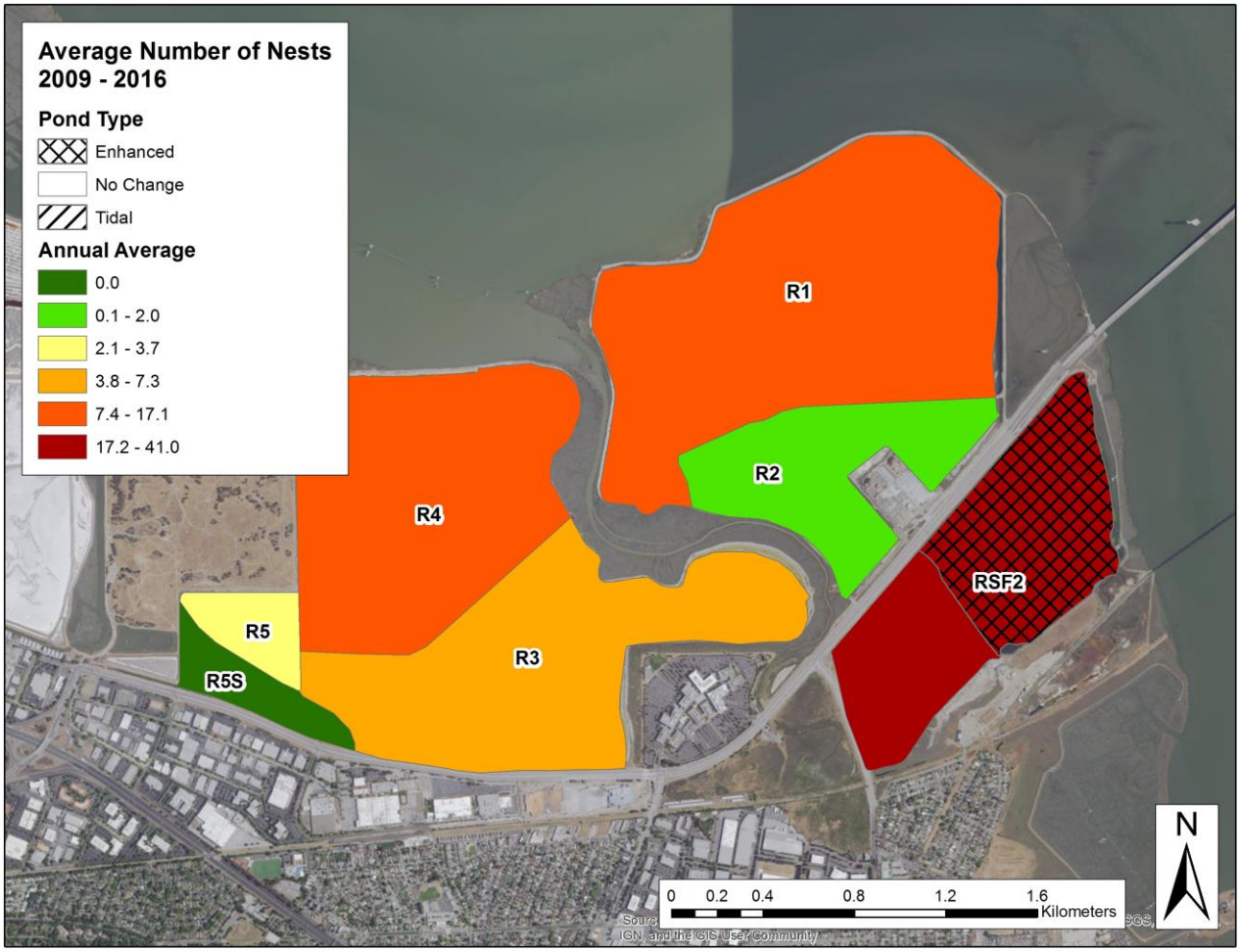

Figure 18. Average number of Snowy Plover nests initiated by pond in the Ravenswood Complex, South San Francisco Bay, California from 2009-2016. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included 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.

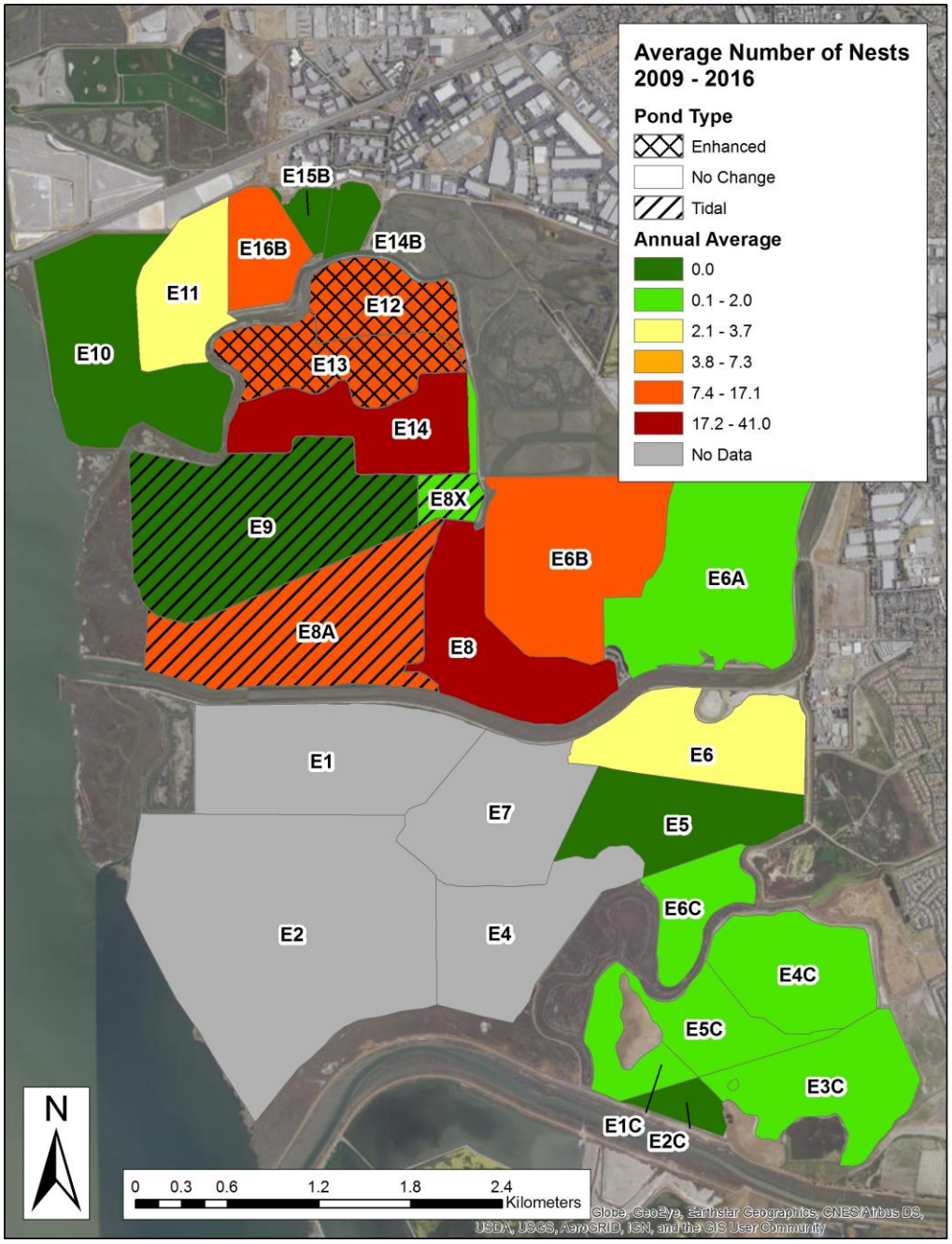

Figure 19. Average number of Snowy Plover nests initiated by pond in the Eden Landing Ecological Reserve, South San Francisco Bay, California from 2009-2016. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds 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.

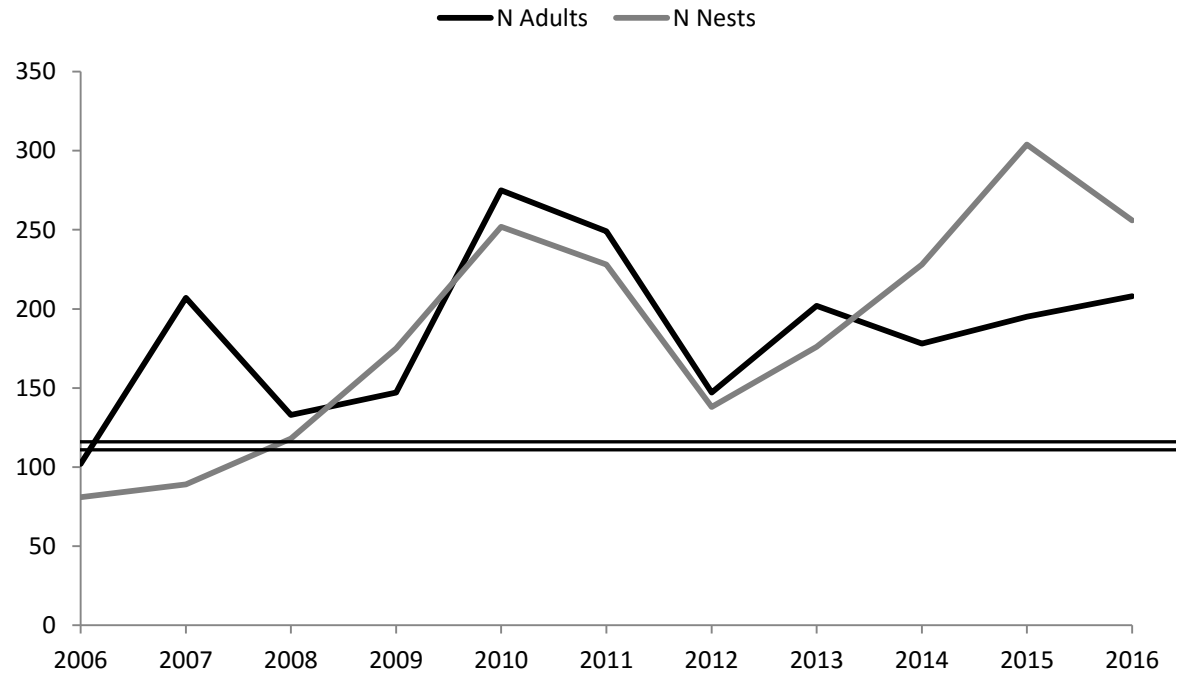

Figure 20. The total number of Snowy Plover adults counted during the breeding window survey and the total number of Snowy Plover nests counted during the season in all regularly monitored Recovery Unit 3 (RU3) areas, San Francisco Bay, from 2006-2016. The double line indicates the South Bay Salt Pond Restoration Project NEPA/CEQA baseline of 113 breeding adults in RU3, established from the average number of breeding birds from 2004-2006.

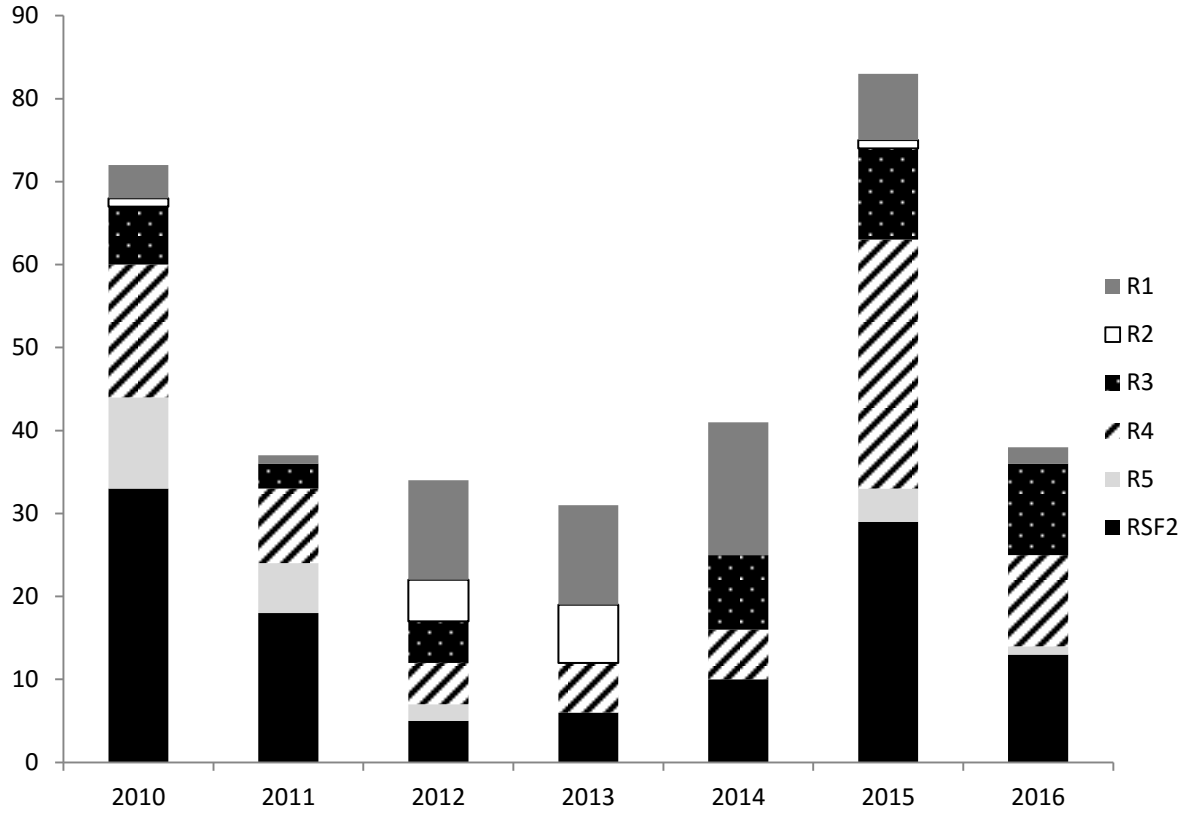

Figure 21. The number of snowy plover nests in the Ravenswood complex (ponds R1-5, RSF2) in Don Edwards National Wildlife Refuge, South San Francisco Bay, California, from 2010-2016. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years.

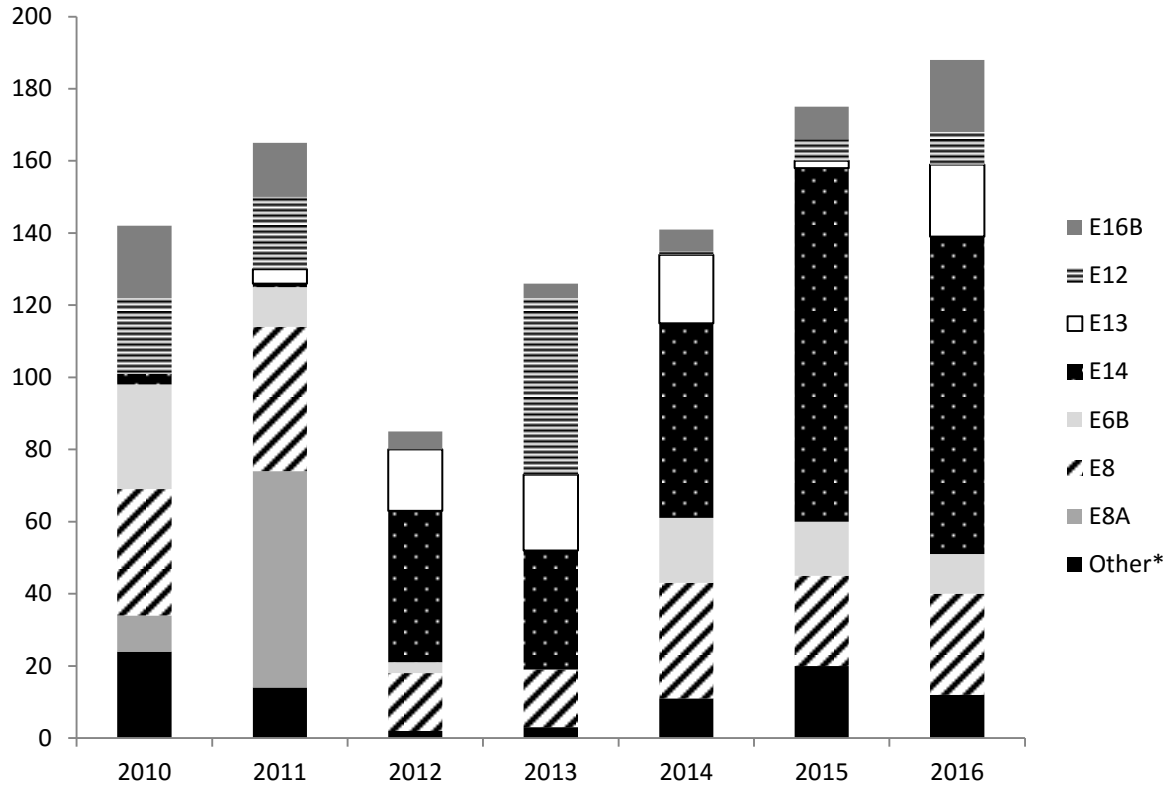

Figure 22. The number of Snowy Plover nests in Eden Landing Ecological Reserve, South San Francisco Bay, California, from 2010-2016. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years. It also shows an apparent positive trend in number of nests from 2012-2016. 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.

*Includes ponds E11, E6A, E6, E1C-E6C

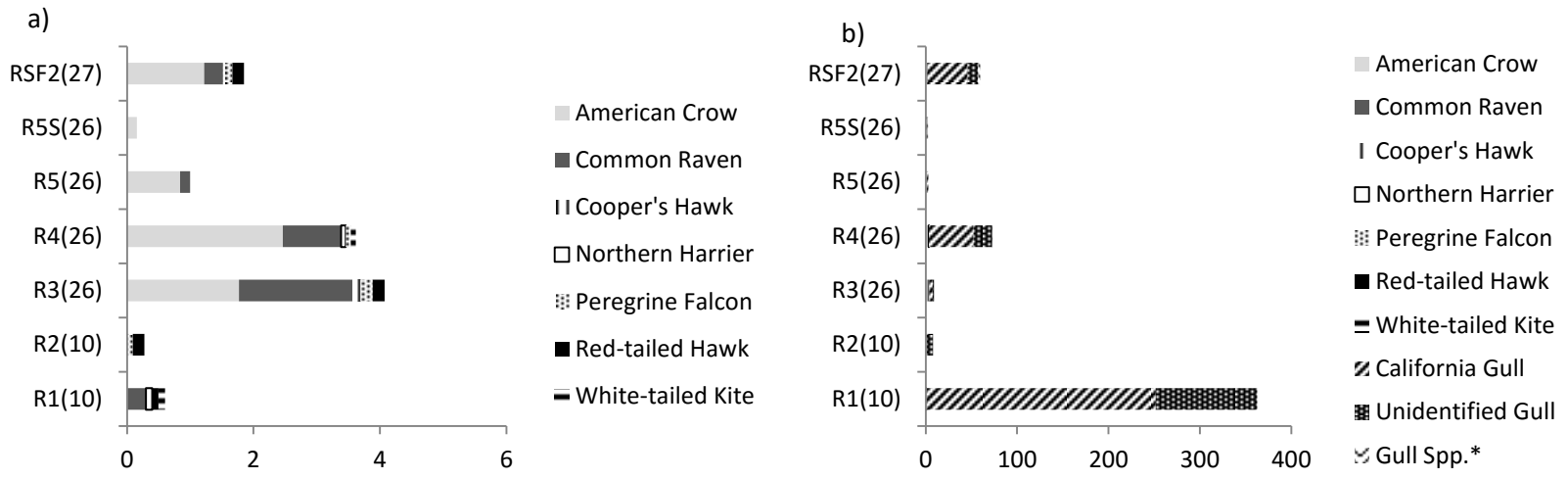

Figure 23. The average number of critical predators, a)excluding gull species, and b)including gull species, observed per survey at the Ravenswood Complex, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number. *Includes Ring-billed, Western, Herring, Glaucous-Winged, and Mew Gulls (in order of average seen per survey)

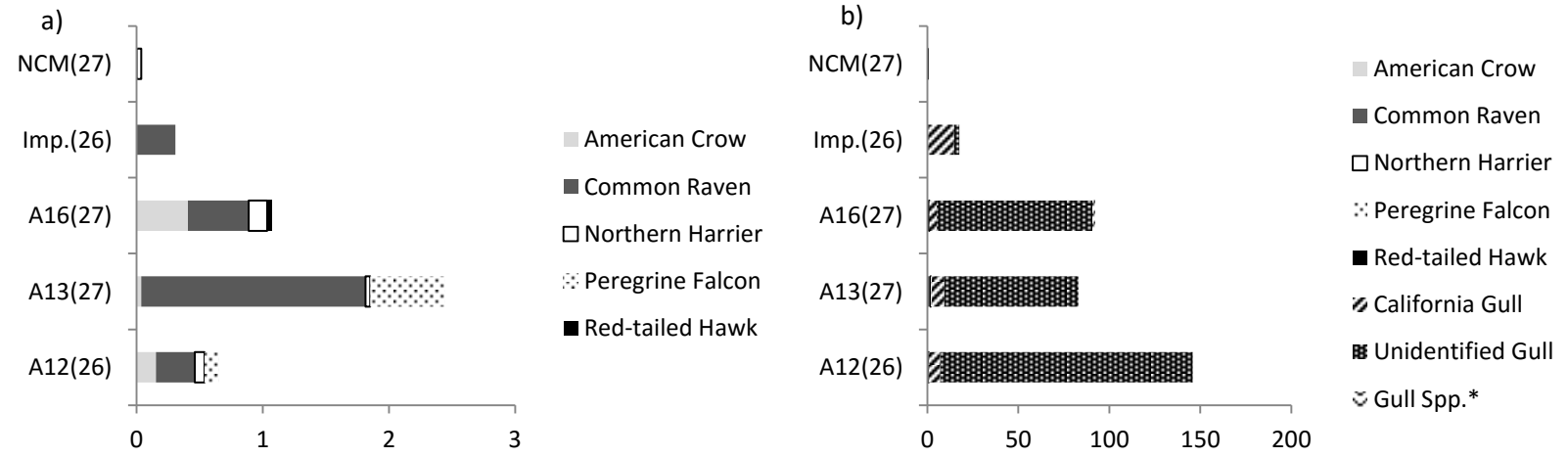

Figure 24. The average number of critical predators, a) excluding gull species and b) including gull species, observed per survey at the Alviso Complex, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number. *Includes Ring-billed, Western, Herring, and Bonaparte's Gulls (in order of average seen per survey)

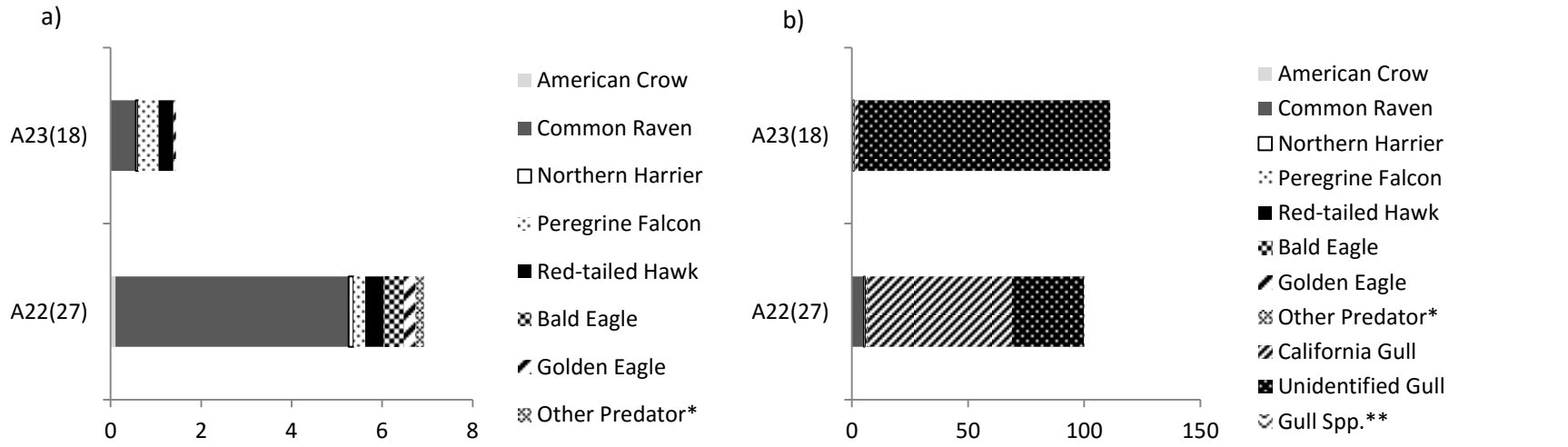

Figure 25. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at Warm Springs, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number.
*Includes Cooper's Hawk, American Kestrel, and Loggerhead Shrike (in order of average seen per survey)
**Includes Herring and Glaucous-winged Gulls (in order of average seen per survey)

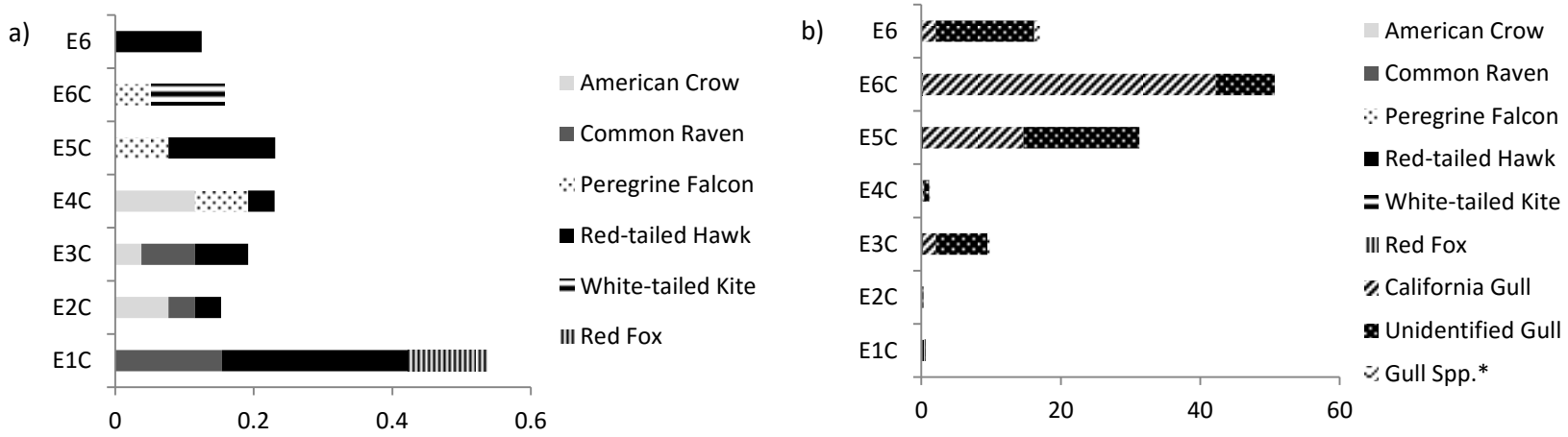

Figure 26. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey in South Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number.
*Includes Mew, Ring-billed, and Western Gulls (in order of average seen per survey)

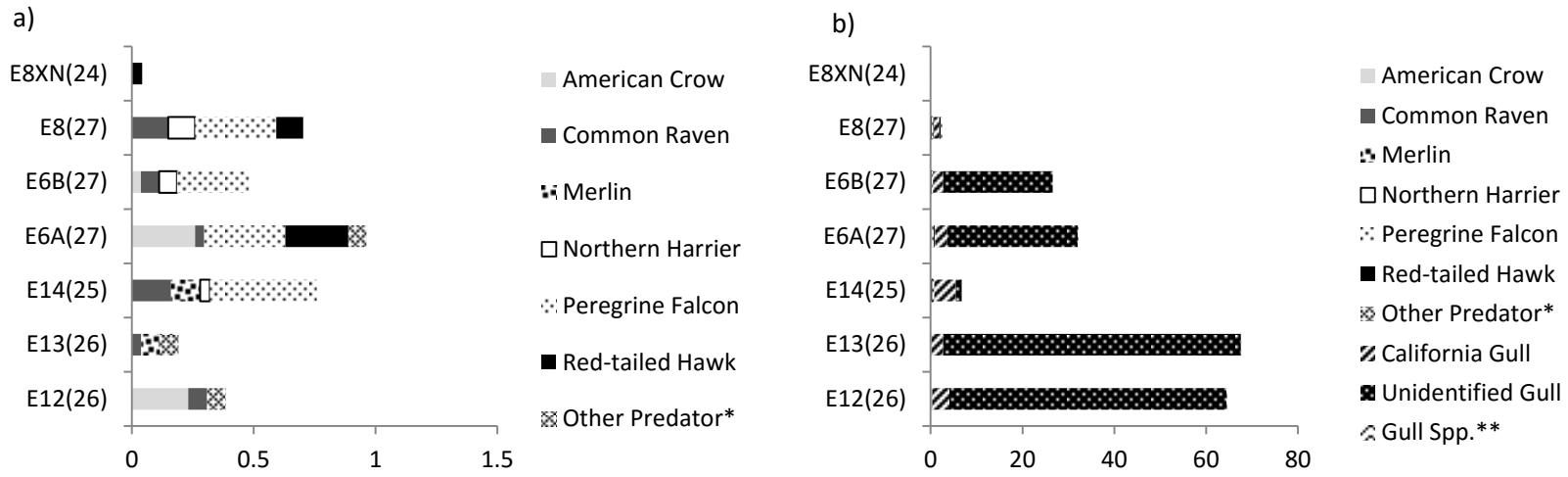

Figure 27. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at the Whales Tail and Old Alameda Creek Loops, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number.

* Includes American Kestrel, Feral Cat, and Red Fox (in order of average seen per survey)

**Includes Mew, Ring-billed, and Western Gulls (in order of average seen per survey)

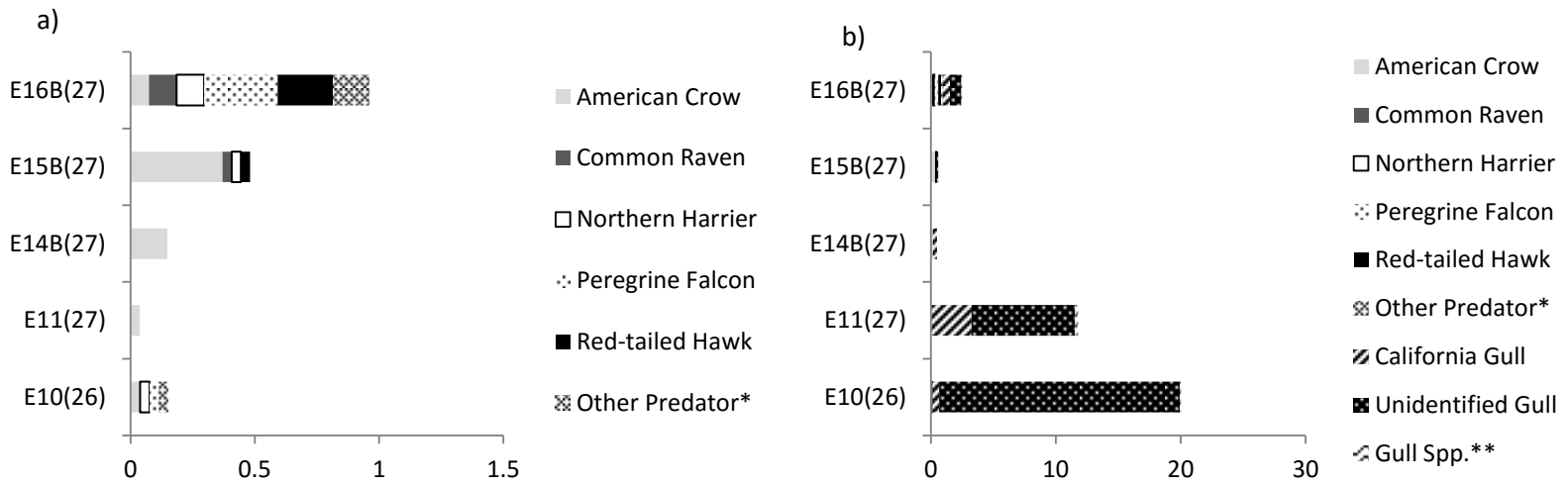

Figure 28. The average number of critical predators a) excluding gull species and b) including gull species, observed per survey at the Mount Eden Creek loop, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-August 2016. Survey sample size is in parentheses next to pond number.

* Includes Red Fox, Feral Cat, and American Kestrel (in order of average seen per survey)

**Includes Western, Herring, and Ring-billed Gulls (in order of average seen per survey)

Table 1. Ponds surveyed weekly within the Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, California, 2016.

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, 2016.

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, 2016. 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
Coyote Hills Regional Park	EBRPD	Patterson Pond
Least Tern Island	EBRPD	Island 5
Napa-Sonoma Marshes Wildlife Area	CDFW	7/7A, Green Island Unit, Wingo Unit
Dumbarton	Cargill	NPP1, N1, 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, 2005-2016

REGION	SITE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Alameda	Eden Landing	91	84	162	94	88	184	185	82	97	94	76	120
	Coyote Hills	0	0	0	0	0	0	0	0	0	0	0	1
	Crown Beach	-	-	-	-	-	-	-	-	-	0	0	0
	Dumbarton	0	0	2	0	0	0	0	0	0	0	0	0
	Hayward	0	0	0	1	4	12	8	9	32	7	2	4
	Warm Springs	23	7	0	3	14	27	17	3	1	11	24	14
Marin	Hamilton Wetlands	-	-	-	-	-	-	-	-	-	-	-	0
Napa	Napa	0			0	12	10	1	0	3	10	10	0
San Mateo	Ravenswood	3	3	23	24	21	42	27	33	59	45	68	42
Santa Clara	Alviso	7	8	20	11	8	0	11	20	10	0	1	21
	Mountain View	-	-	-	-	-	-	-	-	-	11	0	0
North Bay Delta	Montezuma Wetlands	-	-	-	-	-	-	-	-	-	-	14	6
Total Unit 3		**124**	**102**	**207**	**133**	**147**	**275**	**249**	**147**	**202**	**178**	**195**	**208**

Table 5. Snowy Plover nest fates by pond in the South San Francisco Bay, California, 2016.

Location	Hatched	Depredated	Abandoned	Flooded	Failed to Hatch	Unknown	Total Nests
Alviso	0	0	0	0	0	0	**0**
NCM	0	0	0	0	0	0	**0**
A3N	0	0	0	0	0	0	**0**
A9	0	0	0	0	0	0	**0**
A12	0	0	0	0	0	0	**0**
A13	14	1	0	0	1	0	**16**
A16	0	0	0	0	0	0	**0**
Eden Landing							
E6A	0	1	0	0	0	0	**1**
E6B	6	5	0	0	0	0	**11**
E8	15	13	0	0	0	0	**28**
E12	4	5	0	0	0	0	**9**
E13	8	10	1	1	0	0	**20**
E14	20	64	2	1	0	1	**88**
E16B	8	11	0	0	0	1	**20**
E11	2	0	0	0	0	0	**2**
E6	0	0	0	0	0	0	**0**
E1C	0	0	0	0	0	0	**0**
E3C	0	0	0	0	0	0	**0**
E4C	1	0	0	0	0	0	**1**
E6C	2	6	0	0	0	0	**8**
Ravenswood							
R1	1	1	0	0	0	0	**2**
R2			0	0	0	0	**0**
R3	4	7	0	0	0	0	**11**
R4	8	3	0	0	0	0	**11**
R5		1	0	0	0	0	**1**
RSF2	8	5	0	0	0	0	**13**
Warm Springs							
A22	3	9	0	0	0	0	**12**
A23	0	0	0	0	0	0	**0**
Hayward							**0**
LETE	4	0	0	0	0	0	**4**
OBN1	0	0	0	0	0	0	**0**
OBN12	0	0	0	0	0	0	**0**
OBN13	0	0	0	0	0	0	**0**
OBN14	0	0	0	0	0	0	**0**
OBN16	0	0	0	0	0	0	**0**
Total South Bay	**108**	**142**	**3**	**2**	**1**	**2**	**258**
NSMWA - 7/7A	1	0	0	0	0	0	**1**
NSMWA - GIU	1	0	0	0	0	0	**1**
NSMWA - Wingo	0	0	0	0	0	1	**1**
Total North Bay	**2**	**0**	**0**	**0**	**0**	**1**	**3**
RU3 Total	**110**	**142**	**3**	**2**	**1**	**3**	**261**

Table 6. Snowy Plover averaged apparent nest densities (nest/ha) by pond on Refuge property in the South San Francisco Bay, California, 2016. 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.

Location	Average Nest/ha
A13	0.07
R1	0.01
R3	0.02
R4	0.02
R5	0.01
RSF2	0.06
A22	0.03

Table 7. Snowy Plover averaged apparent nest densities (nests/ha) by pond at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2016. 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	0.01
E12	0.44
E13	0.20
E14	0.25
E16B	0.12
E4C	0.00*
E6A	0.00*
E6B	0.03
E6C	0.05
E8	0.08

*Less than 0.00

Table 8. Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, California, 2008-2016. Chicks were considered fledged if they survived to 31 days. *N* is the number of chicks banded.

Year	Fledgling Success	*N*
2016	27%	66
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, 2016. Chicks were considered fledged if they survived to 31 days. *N* is the number of individuals banded.

Pond	*N* Chicks	*N* Adults	Fledgling Success
E16B	3	0	0%
E14	26	0	42%
E12	3	0	0%
E11	5	0	0%
E8	17	1	18%
E6B	6	0	67%
RSF2	6	0	0%
Total	**66**	**1**	27%

Table 10. The number of nests in each shell plot at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2016.

			2009	2010	2011	2012	2013	2014	2015	2016
Pond	Shell plot	Year shells spread	Total nests	Total nests	Total nests	Total nests	Total nests	Total nests	Total nests	Total nests
E14	1	2009	-	0	0	0	1	5	3	1
E14	2	2009	-	0	0	1	1	2	2	5
E14	3	2009	-	0	0	2	3	4	10	2
	Total		**-**	**0**	**0**	**3**	**5**	**11**	**15**	**8**
E16B	1	2008	5	5	4	2	1	0	0	1
E16B	2	2008	9	6	2	0	1	0	1	4
E16B	3	2008	2	0	0	0	0	0	0	1
	Total		**16**	**11**	**6**	**2**	**2**	**0**	**1**	**6**
E6A	1	2008	0	0	0	0	0	0	0	1
	Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
E6B	1	2008	2	7	1	1	0	5	2	3
E6B	2	2009		12	1	0	0	3	2	3
E6B	3	2009		0	1	0	0	0	0	0
E6B	4	2010			5	2	0	2	7	0
	Total		**2**	**19**	**8**	**3**	**0**	**10**	**11**	**6**
E8	1	2008	7	11	7	2	1	2	0	2
E8	2	2008	1	2	2	1	2	1	3	1
E8	3	2010	-	-	10	7	0	6	2	0
E8	4	2010	-	-	3	0	1	2	2	2
	Total		**8**	**13**	**22**	**10**	**4**	**11**	**7**	**5**
Totals			**26**	**43**	**36**	**18**	**11**	**32**	**34**	**26**