SAN FRANCISCO BAY
BIRD OBSERVATORY

Western Snowy Plover Monitoring in the San Francisco Bay
Annual Report 2019

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December 20, 2019

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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*; Snowy Plover) Recovery Unit 3 working group. The goal of this collaboration is to survey managed ponds and other habitats for Snowy Plovers, track breeding success, and contribute to the management and recovery of this species in the San Francisco Bay. During the 2019 breeding season, SFBBO and EBRPD staff monitored Snowy Plover population size, 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 19-26), we counted 190 adult Snowy Plovers in the San Francisco Bay. Over the course of the breeding season (March-September), SFBBO staff determined and documented the fates of 277 Snowy Plover nests in Recovery Unit 3, all located in the South Bay. EBPRD documented the fate of nine Snowy Plover nests found at Least Tern Island. EcoBridges Consulting Biologists documented the fate of two nests at Montezuma Wetlands in the Delta. Apparent nest success (defined as the percentage of nests that successfully hatched at least one egg out of the total nests monitored) was 42.7%. Of the remaining nests, 47.2% were depredated, 4.5% flooded, 2.4% abandoned, 0.7% failed to hatch, and the fate of 1.8% was unknown. A summary of 2019 nesting activity by pond complex or management unit follows:

On Refuge property, we monitored 17 nests in the Alviso Complex (Figure 4), one nest in the Mountain View Ponds (Figure 4), six nests in the Warm Springs Complex (3), and 33 nests in the Ravenswood Complex (Figure 5). Apparent nest success was 24%, 100%, 33%, and 58% in the Alviso, Mountain View, Warm Springs, and Ravenswood Complexes, respectively.

At the Mowry Complex (Figure 7), we monitored one nest, which hatched. On Cargill's Newark Plant Site, WRA Inc. reported two Snowy Plover nests. The nest fates were unknown.

We found 79% of Snowy Plover nests in Recovery Unit 3 at CDFW's Eden Landing Ecological Reserve (Eden Landing; Figure 8). We determined the fate of 218 nests and found that apparent nest success was 40%.

On NASA-ARC/Mid-Peninsula Regional Open Space District property, we determined the fate of one nest on Crittenden Marsh West, which hatched (Figure 4).

On Wildlands Inc. property, we determined the fate of one nest on Hickory, which hatched (Figure 6).

EBRPD reported nine Snowy Plover nests on Least Tern (*Sterna antillarum browni*) island at Hayward Shoreline, with a hatch rate of 78% (D. Riensche, pers. comm.). No nests were documented at the Oliver Brother's North ponds at the Hayward Shoreline Interpretive Center, however the presence of two broods indicates at least two successful nests within the ponds (A. Graham, pers. comm.).

Across the South Bay, 28 undetected successful nests were inferred by the presence of the same number of unaccounted for broods (Table 8).

At Montezuma Wetlands in Solano County, two nests were monitored, with the fate of one unknown and another depredated. (EcoBridges Consulting, A. Wallace, pers. comm.). No nests were found at Napa-Sonoma Marshes Wildlife Area (CDFW ponds 7/7A, Green Island Unit, and Wingo Unit, K. Taylor, pers. comm.) or Hamilton Wetlands in Novato (Avocet Research Associates, J. Evans, pers. comm.).

In 2019, SFBBO banded 60 Snowy Plover chicks from nests that successfully hatched within Eden Landing, Mountain View, and Dumbarton nesting ponds. From band re-sighting surveys, we determined that at least 19 of these 60 chicks survived to fledging (28 days post-hatching) as of November 15th 2019. Our estimated apparent fledging success was 32%.

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 Snowy 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 and Striped Skunk were documented by trail cameras as nest predators of Snowy Plovers at pond E14 in Eden Landing, depredating two and one Snowy Plover nests, respectively. It is likely that these two species accounted for many of the other depredations at pond E14 and throughout Eden Landing.

From 2008-2014, we conducted a pilot Snowy Plover habitat enhancement study at Eden Landing using three 1-ha oyster shell pilot plots. The study indicated that oyster shell habitat enhancement increased Snowy Plover nest abundance and nest success within treatment areas. With these findings as support, 20.23 hectares of oyster shell were spread in two plots (Western = 6.47ha; Eastern = 13.76ha) as a large scale habitat enhancement project in September of 2014 at Eden Landing pond E14. Subsequent monitoring has shown that the oyster shell enhancement plots can attract a large number of Snowy Plovers to breed (87 nests in 2019), but have not significantly improved nest success to date.

California Least Terns (*Sternula antillarum browni*) nested at Eden Landing pond E14 for the third consecutive year, as well as at nesting islands in pond E12 for the first time. At E14, 48-52 breeding pairs established at least 101 nests between June 10 and July 22, with an estimated 5-8 fledglings. Low hatch and fledging rates were attributed to predation by Striped Skunk and

Northern Harrier, and likely other mammals and raptors. At E12, 41 pairs established 41 nests (20 nests monitored) between June 3 and July 15, with an estimated 5 fledglings. The causes of low nest and fledging success were unknown; however based upon nearby sightings, California Gulls and Northern Harriers are potential contributors. For additional information on Least Tern breeding at Eden Landing in 2019, refer to *California Least Tern Breeding at Eden Landing Ecological Reserve 2019 Report* (Pearl & Wang 2019).

During Phase 1 of the South Bay Salt Pond Restoration Project (the Project), restoration and reconfiguration of ponds that formerly supported Snowy Plover breeding habitat resulted in the loss of roughly 19% of available breeding habitat for Snowy Plovers. Since completion of Phase I activities at Eden Landing in early 2015, the Recovery Unit 3 population has averaged 221±20 adults (2015-2019). E14 has supported 35.5±9.0% of all monitored nests in RU3 during that time frame, yet due to consistently high predation pressure, E14 has had lower overall hatch success (42.7±12.5%) compared to the rest of RU3 (47.7±7.1%). Correspondingly, the Recovery Unit 3 population has declined in recent years, from 246 in 2017 to 190 in 2019. In order to reverse this trend and encourage population growth to meet Project and Recovery Unit 3 goals of 250 and 500 adults, respectively, it may be necessary to provide multiple enhanced breeding ponds in conjunction with targeted predator control efforts to reduce predation pressure in any one pond.

Phase 2 at the Refuge includes activities at the Ravenswood Complex (R3, R4, R5/S5), Alviso Complex (A8 Ponds: A8, Mountain View Ponds: A1, A2W and the Island Ponds: A19, 20). Pond R3 will be enhanced for Snowy Plovers by adding water management capabilities with the addition of a new water control structure. However, overall for Phase 2 actions at the Refuge, there will still be an additional 8% loss of remaining available breeding habitat. It will be critical to enhance remaining Snowy Plover breeding habitat at R3, R1-2, and RSF2 to account for the higher density of breeding that will likely occur in these areas. A reduction in habitat size could result in increased predation pressure at the Ravenswood Complex, especially by American Crows and Common Ravens, both of which have been frequently observed in the Complex in recent years and believed to be major nest and chick predators. Increased development adjacent to these restoration sites artificially inflates commensal predator populations such as skunks, feral cats and Common Ravens by supplying new food resources, while also confounding predator management opportunities in locations with high visitor use. Without enhancement and informed predator control efforts, population growth at the second most important breeding site in Recovery Unit 3 could be impeded.

We recommend that the Project plan Phase 2 construction activities to avoid negatively impacting breeding Snowy Plovers, as was done in Phase 1. This includes providing alternative breeding habitat when construction activities impact or eliminate Snowy Plover nesting ponds and scheduling construction activities before or after Snowy Plover breeding season.

As more Project areas are opened to tidal action or converted to ponds with islands, we recommend that the Project and local land managers maintain 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 with a mixture of exposed pond and shallow water depth during the winter and the implementation of large scale shell enhancement to attract Snowy Plovers to appropriate nesting ponds. With the opening of seasonal public trails at the ponds E12-14 in 2016, further studies are needed to assess the impact of human disturbance on Snowy Plover breeding. As such, we recommend that no additional levee trails in close proximity to Snowy Plover nesting ponds be opened to the public until impacts to Snowy Plover nest site selection and brood foraging habitat use can be assessed. We also propose continued research, adaptive management and/or enhancement of Snowy Plover nesting sites to reduce impacts from tidal restoration projects 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). The most recent 5-year review (USFWS 2019), which reviewed all available data in all six recovery units, determined that the population remains threatened due to the same threats described above.

Western Snowy Plover Recovery Unit 3 consists of the San Francisco Bay and includes Alameda, Napa, Santa Clara, and Solano counties, and the eastern portion of Marin, San Mateo, and Sonoma Counties (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, levees, and in dry, degraded marsh habitat. In 1992, the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) began surveying for Snowy Plovers on Refuge lands.

From 2003-2019, SFBBO conducted annual Snowy Plover monitoring and research within the South San Francisco Bay in support of the goals set forth by the RU3. 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 Range-wide 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) surveyed for potential avian predators , and 5) identified areas of potential disturbances from predators, trespass, construction activities and other human activities.

When the Project began active restoration in 2006, project lands supported approximately 62 Snowy Plover breeding pairs (Table 1). Despite the loss of Snowy Plover breeding habitat (dry panne) expected overall through the Project's actions, the Project 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 2008-2013, on Eden Landing pond E14. Enhancements were made in September and October 2014, and 2019 marked the fifth year of monitoring the enhancement project.

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 Snowy Plover breeding and wintering sites. To encourage public support and awareness of Snowy Plovers as well as to discourage trespassing and disturbance, SFBBO has been stationing trained volunteer docents are at key breeding sites monthly since 2016 to help the public learn about and view Snowy Plovers during the breeding season.

In this report, we summarize results from the 2019 breeding season; this includes data on Snowy Plover nest distribution and habitat use, nest (hatching) success, fledging success, oyster shell enhancement studies, and avian predator abundance and distribution. Although we report Snowy Plover numbers in other areas of RU3, this report focuses on Snowy Plover activity in the South San Francisco Bay, south of the San Mateo Bridge.

METHODS

Study Area

From March 4 to September 20, 2019, SFBBO staff and volunteers conducted Snowy Plover and avian predator surveys in the South San Francisco Bay (South Bay) ponds, including all areas from the San Mateo Bridge (Highway 92) south to the extreme southern portion of the Bay (Figure 1, Table 2-3). EBRPD and HARD staff surveyed ponds just north of the San Mateo Bridge (Highway 92) (Figure 1, Table 4). In the North Bay CDFW biologists surveyed and contributed nesting information for Napa-Sonoma Marsh Wildlife Area, while Avocet Research Associates and EcoBridges Environmental Consulting contributed window survey information at Hamilton Wetlands and Montezuma Wetlands, respectively (North Bay; Figure 2). These surveys provide full coverage of all known Snowy Plover breeding habitat in Western Snowy Plover Recovery Unit 3.

The Refuge includes approximately 30,000 acres of former salt ponds, tidal marsh, mudflats, and uplands in the South Bay (Figure 1). Many of the ponds used by Snowy Plovers are currently managed as seasonal ponds, or are dried down for the purpose of creating nesting habitat. For this study, we divided the Refuge into seven geographic locations: Warm Springs (Figure 3), Alviso (Figure 4), Mountain View (Figure 4), Ravenswood (Figure 5), Coyote Hills, Dumbarton (Figure 6), and Mowry (Figure 7). The Mountain View section includes Alviso ponds

A2E and A3N as well as Crittenden Marsh, which is co-owned by Midpeninsula Regional Open Space District and the National Aeronautics and Space Administration, Ames Research Center (NASA-ARC).

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 8). In the North Bay, 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).

HARD owns the land directly north of Highway 92, on the east side of the San Francisco Bay, which is co-managed by 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 within treatment ponds that is also used by nesting Snowy Plovers. This island was monitored by EBRPD.

In the North Bay, 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 (Figure 9).

U.S. Geological Survey (USGS) biologists first reported Snowy Plovers nesting among California Least Tern colonies in the Montezuma Wetlands, Solano County in 2014 (Figure 10). This is a privately owned dredge placement site within the Montezuma Wetlands Restoration Project footprint. This year, Snowy Plover breeding and winter window surveys were performed here by contracted biologists, and adult numbers for the survey windows are included in this report. Further nesting information is not included due to inconsistent survey methods.

Cargill Inc. owns two large tracts of land used for salt production in Redwood City and Newark (Figure 11). Both locations contain potentially suitable Snowy Plover breeding habitat, depending upon pond management and resulting water levels. Although targeted Snowy Plover surveys are not performed at either location, any opportunistic sightings of Snowy Plover adults and broods by Cargill staff are relayed to USFWS and reported here.

Snowy Plover Surveys

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

From March 1 to September 20, 2019, SFBBO biologists, interns, and volunteers surveyed all potential breeding ponds weekly 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 paper map. We also recorded the color-band status, and combination if applicable, of any banded Snowy Plover sighted. Any observed instances of interspecies aggression between Snowy Plovers and other nesting shorebirds and/or seabirds were recorded.

SFBBO Snowy Plover volunteers surveyed the HARD ponds and some low-priority Eden Landing ponds monthly to check for possible nesting activity during the season (Table 4). Volunteers walked levees and stopped approximately every 0.3 miles to scan using spotting scopes.

From May 19-26, 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 all potential breeding habitat at the Refuge, Eden Landing, EBRPD, HARD, NSMWA, Hamilton Wetlands, and Montezuma Wetlands. Surveyors at all sites used the same methods for sighting and counting Snowy Plovers as described above.

Snowy Plover Docent Surveys

SFBBO Snowy Plover docent volunteers were stationed on public trails at Eden Landing ponds E12-E14 monthly during a 3-day window on the last weekend of the month. At Alviso Pond A12 and CMW, SFBBO biologists and interns were stationed on public trails concurrently with Snowy Plover surveys. During each survey, docents looked for Snowy Plovers using a combination of spotting scopes and binoculars. To assist with interactions with pedestrians, docents were equipped with a handout that provided general information about Snowy Plovers, including pictures, physical description, range, conservation status, reasons for decline, and ways to get involved with Snowy Plover conservation. During encounters with the public, docents recorded the type (pedestrian, bicyclist, other) and size of group, the nature of the contact (positive, negative, neutral), what information was shared (ecology, salt making history, conservation, etc.), and any other relevant information (Table 5).

Snowy Plover 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 hand-held tablet (Apple® iPad 2 or Apple® iPad Mini 2) and/or GPS unit (Garmin® GPS 60 or Garmin® eTrex Venture HC).

We monitored nests weekly until we determined the fate of the nest. On each survey, we recorded whether the nest was still active (adults incubating) and if visited up close, the number of eggs or chicks in the nest. During the first visit, we floated the eggs (Hays and

LeCroy 1971) to estimate egg age if incubation had been observed (typically 3 egg clutch throughout most of season, sometimes 1-2 eggs later in season). 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, at Eden Landing pond E14, we recorded whether the nest was located in an oyster shell enhancement or non-shelled 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.

Chick Color Banding and estimation of fledging rate

Since 2008, SFBBO and Refuge biologists have banded Snowy Plover chicks to study their movements and to estimate fledging success rates in the South Bay, when resources allowed. 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.

We defined a fledged chick as one that survived to 28 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 and is a conservative estimate.

Chicks fledged per male was determined using the same data for broods in which all chicks were banded, allowing for an estimate of the number of chicks fledged per male.

In addition, at pond E14, brood surveys were performed to track banded broods, observe brood behavior, and measure fledging success.

Oyster Shell Habitat

E14 Large Scale Enhancement

Our oyster shell pilot study (2008-2013) provided evidence that Snowy Plovers preferentially selected shelled areas for nest locations (Robinson-Nilsen et al. 2013). Based upon these findings, we began a large scale habitat enhancement project in September 2014 at Eden Landing pond E14 by treating 20.23 hectares 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 Western, totals 9.47 hectares when contiguous three pilot shelled one hectare plots included) and an eastern plot totaling 13.76 hectares (referred to as Eastern, **Error! eference source not found.**); the remaining untreated areas are termed non-shelled in this report. We designed a spatial configuration in which the shell blocks alternated with the non-shelled 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.

Avian Predator Surveys

To identify avian predators in the area that might affect Snowy Plovers, SFBBO and Refuge biologists and interns conducted predator surveys concurrently when surveying ponds for Snowy Plovers (Tables 2-3). Volunteers conducted avian predator surveys at ponds surveyed monthly for Snowy Plovers. Observers chose survey points that provided a comprehensive scan of 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 Snowy 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. This includes most raptors, gulls, corvids, herons, and egrets (Table 6) found within Snowy Plover breeding habitat in Recovery Unit 3. While there are a number of potential mammalian predators (Table 7), and their signs (e.g., tracks) were recorded opportunistically, these surveys were not designed to detect mammals, particularly since many are nocturnal. Among all predators, we considered corvids, gulls, mammals (especially red fox and striped skunk), and raptors to be the most critical potential predators to Snowy Plover adults, eggs, and chicks due to previous predation captured on camera and consistent with previous documentation of predation.

Due to concerns in 2018 over predators identifying nest cameras, especially red fox, SFBBO was cautious in deploying nest cameras in 2019. In March and April, biologists placed wildlife trail cameras (Reconyx PC900 HyperFire) at random locations throughout pond E14 to determine if

predators would look for eggs at the cameras. As no predators were observed at these trail cameras during this time frame, SFBBO resumed placing trail cameras at a limited number of nests in pond E14. Cameras were placed directly on the ground between 2-3 meters from each selected nest; this method was used after testing other further but unsuccessful placements. Cameras were housed in a camouflage case and made even less conspicuous by using oyster shells, wood and other debris from the surrounding area. Three rapid-fire still images were taken whenever motion was detected, in color by day and monochrome infrared by night. Cameras were checked each time the nest was checked, typically once per week, at which time the memory card and batteries were replaced as needed.

Habitat Availability

Habitats within the South San Francisco Bay ponds change 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 2019 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 used from 2003-2014.

Analytical Methods at the E14 Large Scale Enhancement

Due to small sample sizes and analytical complications, we chose to lump all observations in all western shelled treatment plots (three old 1ha plots and New 6.47ha plot) and termed this area Western (Figure 3). The 13.76ha eastern shell treatment plot is termed Eastern, and all remaining untreated areas are termed Control.

Nest Densities

Nest densities were calculated for each pond and by each treatment area (Western, Eastern, Control; Figure 12) by dividing the number of nests found within each area by the available habitat in hectares.

Spatial Distribution and Nest Site Selection

Distance to nearest nest neighbor, and number of nest neighbors within a 100m radius were calculated during two peak nesting weeks within E14 (April 21-27 and July 7-13). During the 2019 breeding season, Snowy Plovers initiated nests in two peaks, with corresponding peaks of

active nests. As such, we chose one week within each peak with the highest amount of active nests and no overlap in nests between the two weeks. Spatial data was calculated and analyzed for nests in the three treatment areas (Western, Eastern, and Control; Figure 12).

In order to test for significance of nest site selection by treatment type, we calculated the proportion of all nests (2015-17) in each treatment area (Western, Eastern, Control; Figure 12). We then calculated the proportion of available habitat in each treatment type. We used a chi-square analysis to compare the percent area available and percent nest use of each treatment area (Schwarz 2015).

Nest Survival

We used a logistic regression model to determine if nest success (hatched, not hatched) could be predicted by variables including treatment type (shelled, non-shelled), nearest neighbor distance, number of nest neighbors within 100m, date of nest initiation, and date nest found.

In addition, we conducted a nest survival analysis for all nests in E14 during the 2019 breeding season in program R (version 3.3.3) (Rotella 2016). We built encounter histories with information including date nest found, last date nest known to be present, last date nest checked, and fate date. Each encounter history also included year, treatment type (Western, Eastern, and Control), camera presence, and distance to nearest levee (m) as additional covariates in order to determine their effect on nest survival rates.

Brood Behavior

We used a negative binomial regression analysis in program R to test if chick behavior, including brooding with an adult, foraging for prey, or roosting, was influenced by habitat type (shelled, non-shelled) or chick age. We used this method rather than a standard regression because our sample data were positively skewed, and did not transform properly due to a high dispersal of zero counts.

RESULTS AND COMPARISONS TO 2018

Snowy Plover Surveys

Recovery Unit 3

During the 2019 Pacific Coast breeding season window survey (May 20-27), we counted 190 adult Snowy Plovers in the Bay (Table 1, Figure 13).

South Bay Overall

We observed a mean of 229 birds per week from March 4 through September 20 in the South Bay. We consistently observed the greatest numbers of Snowy Plovers at Eden Landing (Figure 14a). We documented Snowy Plover nesting activity at 20 South Bay ponds (Figure 15, Table 8).

Refuge and Adjacent Lands

We observed a mean of 65 Snowy Plovers per week from March 4 through September 20 on Refuge property (Figure 14b). We observed an average of 33, 8, 17, and 4 Snowy Plovers per week in the Ravenswood, Warm Springs, Alviso, and Dumbarton complexes, respectively. In the Mountain View ponds, we documented a mean of 8 Snowy Plovers per week from July 28 through September 20.

Eden Landing

We observed a mean of 165 birds observed per week from March 4 through September 20 at Eden Landing (Figure 14a). Pond E14 supported the largest numbers of Snowy Plovers during the breeding season again this year, averaging 81 birds per week.

Early and Late Season Trends

In March, we observed large flocks at A22 and E14, averaging 15 and 155 Snowy Plovers per week during this period, respectively. In August, we observed large flocks at E13 and E14, averaging 43 and 32 Snowy Plovers per week for the month, respectively (Figure 16). 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).

Interspecies and Intraspecies Aggression

In recent breeding seasons, high density breeding resulted in numerous incidences of interspecies (Pearl & Chen 2018) and intraspecies aggression (Pearl et al 2016). In some instances, this was due to lack of available breeding habitat during the first two months of the breeding season. Due to a relatively high amount of habitat availability, only two incidences of interspecies aggression were documented during the 2019 breeding season. On April 15, an adult male plover of nest E12-1 was observed displaying aggression towards a pair of American Avocets (*Recurvirostra americana*) that had a nest several meters away. On the following day, both nests were observed being depredated by a Ruddy Turnstone.

On May 2, an American Avocet pair was observed constructing a nest on R4 near a known active Snowy Plover nest. During this observation, the two species alternated in showing aggression. At times, the incubating female Snowy Plover employed a broken wing display and displayed aggression towards the avocets, while at other times the avocets displayed aggression and chased off the female Snowy Plover.

Snowy Plover Docent Surveys

In 2019, SFBBO volunteers and staff conducted eight docent surveys at ponds E12-14, with six out of eight conducted on weekends (Table 5). A total of nine contacts were made during these surveys, with five contacts made during weekend surveys and four contacts made during weekday surveys. The most frequently shared information was Snowy Plover breeding ecology, followed by conservation status and information about the Project.

One weekday survey was conducted at A12, with two contacts made (Table 5). Information was shared concerning salt pond history and site information, conservation status, the Project, and general information about SFBBO.

At CMW, six weekday surveys were conducted, with 23 contacts made (Table 5). The most frequently shared information concerned both Snowy Plover ecology and conservation status, followed by general information about SFBBO.

Snowy Plover Nest Abundance and Success

South Bay Overall

In 2019, SFBBO determined the fate of 277 Snowy Plover nests and EBRPD determined the fate of nine nests in the South Bay. Of these, 122 nests hatched (apparent nest success = 42.7%), 137 nests were depredated (47.9%), seven were abandoned (2.4%), two failed to hatch (0.7%), 13 were flooded (4.5%), and the fate of five nests were unknown (1.8%; Table 8, Figure 17). We found the third highest number of nests ever documented in the South Bay in 2019 (previous high of 341 nests in 2017). The predation rate was much lower compared to 2018 (56.6%). Many nests were likely undetected, as evidenced by the presence of unaccounted broods on ponds throughout the season (Table 9). Therefore, a high nest total for the third consecutive year in a row provides evidence for recent population growth and stability. Consistent with findings from previous years, predation serves as the most significant cause of nest failure.

Refuge and Adjacent Lands

In 2019, SFBBO determined the fate of 59 Snowy Plover nests on Refuge and adjacent property (Table 8). In the Warm Springs Complex (A22 and A23), two nests hatched (33%) and four were depredated (67%). In the Alviso Complex (A12, A16, and NCM), four hatched (25%) and five were depredated (25%), and eight nests were flooded (50%). At the Ravenswood Complex (R1, R3, R4, and RSF2), 19 hatched (58%) and 14 were depredated (42%). The Ravenswood Complex contained 11% of all nests found in RU3 (Figure 18), and we found the most nests in the Ravenswood Complex on pond R4 (15 nests; Figure 19). At least three additional successful nests in A22, two additional successful nests in both R1 and R4, and one additional successful nest in both A12 and R2 were inferred by unaccounted for broods in the aforementioned ponds (Table 9).

Within Crittenden Marsh West (CMW), (NASA and Mid-Peninsula Regional Open Space District Property located next to A2E), we determined the fate of one nest, which hatched. At least one additional nest was inferred by the presence of an unaccounted for brood (Table 9).

In the Dumbarton Complex, on NPP1, no nests were monitored, however the presence of two Snowy Plover broods infer at least two successful nests on NPP1 or adjacent Hickory (Table 9). Adjacent to NPP1 on the Newark Slough Mitigation Bank Site (termed Hickory in this report) owned by Wildlands Inc., we monitored one nest, which hatched. At least one additional nest was inferred by the presence of an unaccounted for brood (Table 9).

In the Mowry Complex on M5, one Snowy Plover nest was found on the levee, which hatched (Table 8). A Snowy Plover brood reported by Cargill several weeks later on the M6 levee not far from the M5 nest was likely the brood of that nest.

Eden Landing

We determined the fate of 218 Snowy Plover nests at Eden Landing, comprising 79% of all nests found in RU3 (Figure 18). Of these, 87 hatched (40%), 112 were depredated (51%), seven were abandoned (3%), two failed to hatch (1%), and the fate of five nests was unknown (2%; Table 8). Pond E14 had the most nests (108 nests), followed by pond E8 (32 nests), E6B (23 nests) and pond E16B (19 nests; Table 8). E14 alone comprised 49% of the nests found in Eden Landing (**Error! Reference source not found.**) and 39% of the nests found in the entire South Bay in 019.

Hayward Shoreline

EBRPD reported nine Snowy Plover nests on the California Least Tern Island at HARD, seven of which hatched, one was depredated by a Killdeer (*Charadrius vociferous*), and one failed to hatch (D. Riensche, pers. comm.; Table 8). No nests were observed this season at the Oliver Brothers North Salt ponds at Hayward Regional Shoreline, however the presence of two broods observed on the ponds indicate at least two successful nests (A. Graham, pers. comm., Table 9). Anecdotal information and photographs from citizen scientists on ebird indicate that some Snowy Plover breeding occurred at Frank's Dump West (ebird 2019).

Napa-Sonoma Marshes Wildlife Area

In 2019, two Snowy Plover adults were observed during the breeding window survey, however no breeding activity was observed by CDFW during broad monthly surveys of the area (K. Taylor, pers. comm.; Table 8).

Montezuma Wetlands

In 2019, two Snowy Plover nests were monitored at Montezuma Wetlands, with one nest depredated and the fate of the second nest unknown (A. Wallace, pers. comm.). This site is specifically monitored for breeding Least Terns, with targeted Snowy Plover surveys only occurring during window surveys, therefore it remains possible that additional breeding occurred (A. Wallace, pers. comm.).

Hamilton Wetland Restoration Area

In 2019, zero Snowy Plovers were observed during the breeding season. High water levels within the restoration site precluded Snowy Plover nesting at this site (J. Evens, pers. comm.).

Cargill Salt Evaporation Ponds

At Cargill's Newark Plant Site, two Snowy Plover nests and two broods were reported. Due to the size of the Newark Plant Site and lack of targeted surveys, it is likely that additional plover

breeding occurred there in 2019. Zero Snowy Plover breeding activity was observed at the Redwood City Plant Site.

Breeding Chronology and Density

Over the course of the season, average apparent nest density in the South Bay (across all ponds with dry panne) was 0.17 nests per hectare. On Refuge Lands, we documented the highest apparent nest density in NCM at 0.43 nests per hectare (Table 10). At Eden Landing, we documented the highest apparent nest density in pond E8 at 0.56 nests/ha (Table 11). This is the largest apparent nest density over the course of a season ever recorded in a RU3 pond using current methods, excluding ponds E12 and E13, which contain only small amounts of available habitat on levees and islands.

We recorded two periods of high nest initiation during the breeding season. Between the weeks of April 7 and April 28, an average of 24±6.3 nests were initiated per week, for a total of 96 nests. Between the weeks of May 19 and June 9, an average of 22.3±3.3 nests were initiated per week, for a total of 89 nests. This this is in contrast to last year when we recorded one peak from April 7 to June 24 when an average of 18.8±5.9 nests initiated per week (225 nests total) was recorded.

For the third year in a row, we observed one extended period of active nests across the season rather than two distinct periods. Between the weeks of April 21 and July 20, an average of 92.6±7.7 nests were active, with a high of 103 nests active (Figure 21). During the same time frame last year, an average of 77.3±7.8 nests were active, with a high of 85 active nests.

Chick Fledging Success

As part of our efforts to document breeding success within the San Francisco Bay, we banded 60 Snowy Plover chicks in 2019. At least 19 chicks fledged (32%, Table 12) from 22 separately banded broods, resulting in a chicks fledged per male rate of 0.86 (Table 13). We found eight of the fledglings during the breeding season, and another 11 during post breeding season band resighting surveys (Table 13). Considerable effort was put into finding fledglings during band resighting surveys, yet due to the difficulties in finding and reading banded Snowy Plovers in San Francisco Bay, it is possible that additional chicks fledged as well.

Oyster Shell Habitat Enhancements

During the fifth season following large scale enhancement at pond E14, we documented a total of 108 nests in pond E14; 38 nests in Western (which includes the three 1-ha pilot plots), 46 nests in Eastern, and 24 nests in the non-shelled areas of the pond (Control).

The apparent nest success in all of E14 was 41%, comparable to 2018 (40%). Examining the treatments individually, Western nest success was 37%, a decrease from 2018 (44%), while Eastern nest success was 48%, an increase from 2018 (36%). Apparent nest success in Control

was 33%, a decline from 2018 (45%). Depredation was the most significant cause of nest failure in all areas of E14 (Western=44%, Eastern=68%, and Control=50%).

Nest Density

We observed especially high nest density in Western and Eastern during peak breeding months (April 21-July 20, Figure 21). During this timeframe, the average nest density in shelled areas (Western and Eastern combined) was calculated at 1.20 ± 0.29 nests/ha, and 0.33 ± 0.34 nests/ha in Control areas. When analyzed separately, Western held the highest average nest density during this timeframe at 1.33 ± 0.44 nests/ha.

Spatial Distribution and Nest Site Selection

Our Nearest Neighbor analysis found that nests during weeks 17 and 28 had an average of 2.8±1.3 neighbors located within 100m, with those nests located an average of 68.8±13.9 meters away. The closest neighbor was located an average of 53.8±20.7 meters away.

Our chi-squared analysis determined that plovers preferred nesting in oyster shell plots in 2019 ($p=7.35e^{-16}$)(Table 14). While New1+New2 accounted for 41% of available nesting area in E14 during 2019, these areas accounted for 81% (87/108) of all nests found in E14 during that time.

Nest Survival

We tested several different logistic regression models in R to examine the influence of four variables on nest survival, including date of nest initiation, number of Snowy Plover nest neighbors within 100m, nearest nest distance, and habitat type (Table 15). We chose the model with the lowest Akaike's Information Criterion, which indicated the best fit. The best logistic regression model included date of nest initiation, number of nest neighbors within 100m, and their interaction term (Table 16). This model showed that date of nest initiation in the season (estimate=0.084±0.029, p=0.003) and number of neighboring Snowy Plover nests within 100m (estimate=3.493±1.247,p=0.005) had a positive impact upon nest survival. The interaction between these two variables (estimate=-0.023±0.008, p=0.005) indicated that an increasing amount of neighbors within 100m reduced nest survival as the season progressed. Other models that were tested included general treatment type (shelled, non-shelled) and nearest nest distance, but neither of those variables were found to be significant predictors of nest survival (hatched, not hatched).

Nest survival models using RMark in program R determined that the constant daily survival rate (DSR) in E14 in 2019 was 95.6%, with a 22.6% probability that a nest would survive for 33 days to hatch (Table 17). No other models (treatment plot, time of season, distance to levee, camera presence) showed a significant affect upon DSR.

Brood Behavior

The results of our negative binomial regression found that chick status was a significant predictor of brooding (p=<0.001; Table 18) and roosting (p=<0.001; Table 19) behavior, but was not a predictor of foraging (p=0.143; Table 20) behavior. Younger chicks (estimate= -2.03) were

more likely to be brooding, while older chicks (estimate=1.48) were more likely to be roosting. Habitat type appeared to have a significant effect (p=0.016) upon brooding behavior, with brooding (estimate=-1.29) more likely in shelled habitat. This was likely due to a general lack of foraging opportunities in shell plots.

Avian Predators

Refuge

We found that California Gulls and unidentified gulls (presumably mostly California Gulls given time of year and location) were the most abundant avian predators in all areas of the Refuge (Tables 21-29). Excluding gulls, Common Ravens, American Crows, Snowy Egrets, and Great Egrets were the most abundant predators observed. At Ravenswood, we frequently observed corvids walking on the pond bottom and flying over the ponds, several times near active Snowy Plover nests (Table 21). Red-tailed Hawks were the most frequently sighted raptor at Ravenswood, and were often perched on the PG&E towers and available perches on the pond bottom. In Alviso, Snowy Egrets and Great Egrets were the most frequently sighted avian predators, and were primarily observed at A16 and New Chicago Marsh (NCM)(Table 22). Northern Harriers and Peregrine Falcons were the only raptors frequently observed at Alviso, and were observed most often at ponds A12 and the levees around A13 and A15. At Warm Springs (A22 and A23), Snowy Egrets, Common Ravens, and Red-tailed Hawks were the most frequently observed predators, with most sightings occurring in A22 (Table 24). Red-tailed hawks were the most frequently observed raptor, and were seen with similar frequency in both ponds. Peregrine Falcons were frequently observed at both ponds. At Dumbarton (Hickory and NPP1), Snowy Egrets, Red-tailed Hawks, and Common Ravens were the most frequently observed predators, with the majority of sightings at Hickory (Table 15). Peregrine Falcons and White-Tailed Kites were also occasionally observed at Hickory.

Eden Landing

As was the case at the Refuge, California Gulls and unidentified gulls were the most numerous predators at Eden Landing (Tables 26-29). Great Egrets and Snowy Egrets were the next most frequently observed predator at Eden Landing. They were especially numerous at the Old Alameda Creek loop (ponds E6A, E6B, and E8; Table 28) where they were commonly seen foraging on the pond. Peregrine Falcons were the most commonly observed raptor at Eden Landing, and were most commonly observed at the most active Snowy Plover breeding ponds in the complex (E6A, E6B, E8, E13-E14, and E16B). Northern Harriers and White-tailed Kites were also commonly observed hunting in ponds E14 (Table 27).

In January of 2016, hunting blinds in adjacent ponds E14 and E9 that were 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. During the 2019 breeding season, the landscape cloth was still intact, resulting in no observed raptor nesting within these blinds.

Predator data was not collected for any other regions in RU3 during the 2019 breeding season.

Mammalian Predators

SFBBO does not conduct targeted surveys for mammalian predators. However, opportunistic data collected during avian predator surveys, other visual observations, camera trap images, and tracks are reported to aid in analyses of predator threats. Feral Cats were observed on several occasions at A12, NCM, and SF2, while red fox were observed on one occasion E14. Striped Skunks were recorded on camera traps on multiple occasions, and their tracks were found throughout pond E14 during a large scale depredation event of Snowy Plover and Least Tern nests. For the first time, Coyotes were observed by SFBBO biologists at Eden Landing Ecological Reserve.

DISCUSSION

Population Size

During the May breeding window survey, we counted 190 breeding adult Snowy Plovers, a 19% decline from the 2018 count (235; Table 1). Eden Landing continues to host the majority (62%) of breeding adult Snowy Plover in 2019, as it has since breeding window surveys in RU3 began in 2004. However, the number of adults counted at Eden Landing declined from 2018 (142) to 2019 (117). It is unclear what may have caused the apparent population decline.

After a 33% decline in the Ravenswood population between 2017 (76 adults) and 2018 (51 adults), the population remained stable at Ravenswood in 2019 (41 adults, Table 1). Due to the observed RU3 population decline, Ravenswood represented 27% of the apparent RU3 population in 2019. It is important to note that Ravenswood presents numerous challenges to surveying, including large pond sizes, varied texture that can obscure visibility, and lack of a drivable levee between R3 and R4 that further reduces detection ability. Numerous unaccounted for broods discovered at Ravenswood each year indicate that a number of successful nests, and likely unsuccessful nests, go undetected at Ravenswood each year. As such, it is likely that the Ravenswood population is undercounted, and a reminder that while the window survey methods allow examination of trends across years and throughout the Pacific Coast, they merely provide an index of abundance and not an exact number of breeding Snowy Plovers in the San Francisco Bay.

Nest Abundance and Success

In 2019, we found 290 nests in RU 3, representing the third highest total recorded since SFBBO began monitoring Snowy Plovers in 2003. For the sixth consecutive year in a row, we found a greater number of nests than the number of adults counted during the breeding window survey. Continued research focus on high activity breeding areas, including brood surveys, chick banding, and least tern surveys at E14, likely contributed to a high rate of nest detection.

However, nest totals should be viewed as an index rather than a precise total since not all successful nests are detected and unsuccessful nests are even less likely to be detected (Mayfield 1975). This is exemplified by our observation of at least 28 broods from unknown nests across the South Bay (Table 9). It is likely that a number of unsuccessful nests also went undetected.

The overall observed nest depredation rate within Recovery Unit 3 was 47% (n=290; Table 8). Although this is a decline from 2018 (57% depredation rate), it should be noted that an unusual mid-May rainstorm resulted in an abnormally high rate of nests flooding (5%). Apparent nest success varied greatly by pond. Across the South Bay, the ponds with the highest depredation rates (minimum 10 nests) were E6B (78%; n=23), E13 (56%; n=18) and E8 (53%; n=32). The ponds with the lowest depredation rate (minimum 10 nests) were R3 (27%; n=11), E16B (21%; n= 19) and R4 (40%, n=15).

Depredation continues to be a major limiting factor in the recovery of Snowy Plovers in the South Bay and across the Pacific Coast (USFWS 2007, USFWS and CDFW 2007). Better understanding of the different factors influencing predator abundance throughout RU3, including pond accessibility, predator perches, proximity to predator source populations, as well as the overall impact of mammalian predators on breeding success, is pivotal to creating more successful breeding sites throughout RU3, which will provide greater stability and protect against localized population decline.

Refuge and Adjacent Lands

At Alviso, appropriate Snowy Plover breeding habitat is typically sparse during the first half of the breeding season. However, in the area of NCM located south of the railroad spur, known as Spreckles Marsh, an ample amount of habitat was available in April and May. As a result, ten Snowy Plover nests were monitored in this area in April and May. On April 10, SFBBO biologists noticed that water levels had begun to rise in Spreckles Marsh, placing the two known active nests at risk of flooding. After consulting with USFWS and learning that they only own a portion of Spreckles Marsh and don't manage water levels in it, SFBBO contacted multiple City of San Jose departments in an effort to determine who operates the water pump located at Gold Street that controls water levels. It was eventually determined that the City of San Jose Department of Transportation operates this pump, and after speaking with the operator they were able to lower water levels and prevent the nests from being flooded. Between that date and May 15, an additional eight nests were monitored within Spreckles Marsh. On May 15, SFBBO biologists noticed that water levels had again begun to rise, placing the nine active nests in danger of being flooded out. Although SFBBO again asked the Gold Street Pump Station operator to lower water levels, they were unable to operate the pump due to low water levels in the pump station. Adding to the rising water levels, whose origins remain unknown, May 15 was the first day of a late Spring storm that brought approximately 1.3 inches of rain to the region (ValleyWater.Org). As a result of previously rising water levels and rainstorms, eight Snowy Plover nests and numerous American Avocet and Black-Necked Stilt nests were flooded out.

At A12, active construction began on the South Bay Shoreline Project in 2019. As part of the project, water levels in A12 were lowered with the use of pumps in late May. As a result, A12 provided a large amount of suitable breeding habitat during the second half of the breeding season. On May 30, H.T. Harvey & Associates Biologists monitoring for the South Bay Shoreline Project observed a Snowy Plover brood, however as this was the first sighting of a Snowy Plover on A12 during the 2019 breeding season, it is unclear if the brood came from A12 or had come from an adjacent pond. The first confirmed nest in A12 was detected on June 5, and another five nests were detected throughout the season, with the last nests located on July 3. Of the six known nests, two hatched, while the remaining four were depredated (Table 8). However, an additional three young broods (less than two weeks old) and two older broods (greater than two weeks old) were observed on A12 on August 25 (Table 9). This indicates that at least five successful nests that were active between early July and late August went undetected, and it is likely that additional successful and unsuccessful nests also went undetected in the pond. The large size and nature of the pond, which is characterized by deep fissures that obscure visibility, as well as large amount of habitat created by draining of the pond, make effective surveying of A12 difficult.

At CMW, Snowy Plover breeding was observed for the second consecutive year, and only the fourth time since 2003. One nest went undetected, as evidenced by an unaccounted for brood on the pond, while a second nest was monitored, confirmed to hatch, and all three chicks were banded (Table 13). Interestingly, the male of the nest that was monitored was banded as a chick at CMW in 2018. The nest that it was banded at in 2018 was located approximately 100m away from the nest that it established in 2019, showing an example of high natal side fidelity. This provides some support for the need to ensure adequate Snowy Plover breeding habitat in Santa Clara County.

Consistent with recent years, Snowy Plover nests in the Ravenswood Complex had a higher apparent hatching rate (58%, n= 19) and lower apparent depredation rate (42%, n= 13) than the rest of RU3. However, there is evidence to suggest that this data may greatly underrepresent the total breeding effort of Snowy Plovers at the Ravenswood Complex. During the first half of the breeding season (March 1-June 9), when an average of 209.0 ha of habitat were available for Snowy Plover breeding, 23 nests were located. After this date, when an average of 489.3 ha of breeding habitat was available, only ten additional nests were located within the pond complex. Yet the presence of six undetected broods implied that least six additional nests went undetected during this time frame, and if the ratio of apparent hatching and depredation rates in the Complex are accurate, at least four undetected nests may have been depredated. The relatively low detection ability at the Ravenswood Complex is consistent with our findings since we began recording habitat availability in 2015 (Pearl et al. 2019). The Ravenswood Complex is the most difficult to survey due to large pond sizes, complex texture, and lack of drivable levees that result in long scoping distances locations. The All-American Canal, which separates R3 and R4, is in the process of being filled and turned into a drivable levee. This will likely result in increased detection ability throughout both ponds, providing a more accurate assessment of

Snowy Plover breeding at Ravenswood regardless of habitat conditions. The impending tidal marsh restoration of R4 will also likely increase detection rates throughout the Ravenswood Complex by decreasing the available habitat area.

On March 30, 2019, SFBBO and the Refuge led a volunteer Mud Stomp habitat enhancement effort at RSF2 Cell U3 (Figure 22). Volunteers walked on the pond bottom to create depressions, which increased pond texture and provides nesting scrapes and improves camouflage and cover for breeding Snowy Plovers. In addition, SFBBO staff and volunteers spread small pea gravel, medium sized pebbles, and large cobblestones in an attempt to provide further crypsis. We selected these enhancement materials based upon the high quality breeding habitat that Eel River gravel bars in Humboldt had been documented to provide in the past (Colwell et al. 2011). Although a pair of Snowy Plovers was observed within the enhancement area after the event, no nests were detected within the Mud Stomp area in 2019. However, it should be noted that high water levels in the pond at the time of the event reduced the amount of area in which volunteers could create depressions. Furthermore, the frequent presence of a large flock of American Crows, likely the same flock that was often observed hunting in R3-4, may have dissuaded Snowy Plovers from breeding in high density on the pond. Between April 2 and June 15, six nests were initiated within the pond, however only the first nest of the season hatched, while the remaining six were depredated. The brood from the hatched nest was not observed past the first week. Crows were the most frequently observed predator on the pond (Table 21), and were observed systematically working their way through the pond in search of food. Thus we believe that crows were likely responsible for the depredation of the aforementioned Snowy Plover nests and brood, in addition to numerous American Avocet and Black-necked Stilt nests and broods that had been located in the same area of the pond.

With the impending tidal restoration of pond R4-5S in the Ravenswood Complex as part of Phase 2 of the Project, approximately 27% of currently available Snowy Plover breeding habitat in the Complex will be opened to tidal action. Based upon the large amount of Snowy Plover nests found in the Ravenswood Complex in recent years, we expect that post-restoration, R3, RSF2, and R1-2 will consistently host a larger amount of Snowy Plover breeding. At R3, improving nesting habitat will be critical. We recommend removing predator perches on the pond, spreading oyster shells, gravel, or other materials to increase crypsis, and providing a limited amount of vegetative cover for broods in foraging areas. At R3, it will be imperative that water levels are managed appropriately to prevent extensive vegetative growth and to provide quality foraging habitat throughout the season.

For the third consecutive year, we confirmed Snowy Plover breeding activity at Hickory (Newark Slough Mitigation Bank), located directly next to pond NPP1 in the Dumbarton Complex. This site, owned by Wildlands Inc., was monitored throughout the season for Snowy Plover breeding activity. Over the course of the season, one nest was monitored, which hatched (Table 8) and all three chicks were banded (Table 10). On the day that the brood was banded, another recently hatched brood was observed on Hickory, and on adjacent NPP1, one older brood (>2 weeks old) and one recently hatched brood were observed on the pond (Table 9). Thus,

Hickory supported at least one additional successful nest, while NPP1 or (possibly Hickory) supported at least two successful nests. Although Hickory is a marsh mitigation bank and will eventually be opened to tidal action, in the meantime the degraded, dry marsh serves as suitable Snowy Plover breeding habitat. With minimal habitat management and enhancement, such as removing dense and tall vegetation from the pond and levees, Hickory could serve as a moderate quality breeding site for Snowy Plovers until it is restored to tidal action.

Eden Landing

As has been the case since 2014, the majority of 2019 Snowy Plover breeding activity at Eden Landing was found at E14 (n=108, Table 8). This marks the second consecutive year that over 100 nests have been monitored at E14, which is a far greater amount of nests than have ever been documented in any other area in RU3. In addition to the Snowy Plover nests, at least 101 Least Tern nests were found at E14. Snowy Plover nests in E14 experienced lower rates of hatch (41%) and higher rates of depredation (51%) compared to RU3 as a whole (43% hatch, 48% depredation; Table 8). The large amount of nesting activity at E14 by Snowy Plovers, and especially by Least Terns, who's breeding activity is much more conspicuous due to mate and chick provisioning and piscivorous diet, appeared to attract a large amount of avian and mammalian predators. Northern Harriers, Peregrine Falcons, and Common Ravens were frequently sighted hunting on the pond (Table 27), while evidence of wide scale striped skunk nest depredation was observed in July at tern and plover nests. Thus, high density breeding in one pond, especially when Least Terns are present, may present challenges to both species breeding success unless increased efforts are made to track and control predator activity.

Ponds E12 and E13 were used with moderate frequency, hosting seven and 18 Snowy Plover nests, respectively (Table 8). Nests in these ponds experienced mixed success, with an apparent hatch rate of 57% (E12) and 44% (E13). Snowy Plovers nested on interior berms and levees with much greater frequency in 2019 (n=11, hatch rate = 36%) compared to 2018 (two nests). USDA removed a large number of red foxes from ELER in 2018, and as a result, the red fox den in the saltworks did not appear to be active in 2019. The lack of red fox consistently on the levee likely resulted in Snowy Plovers selecting these nest locations with greater frequency. Levees and berms provide low quality breeding habitat due to low habit complexity and high chance of predators finding nests by chance, however Snowy Plovers continue to use this habitat. Therefore, minor enhancements to these habitats such as shells on berms and cobble on the sides of levees may incrementally increase nest and brood survival.

Snowy Plovers experienced relatively high breeding success at E16B in 2019 (n=19, hatch rate = 58%; Table 8). The relatively high hatch rate may have been in part due to the consistent efforts of USDA-APHIS to remove mammalian predators. Red foxes had been observed on the pond during recent seasons, but were not reported in 2019. Although Peregrine Falcons and White-tailed Kites were observed on the pond (0.50 and 0.27, respectively) with relative frequency, only four nests were confirmed as depredated on the pond throughout the course of the season. Management of adjacent E11 as shallowly flooded habitat may have provided Peregrine Falcons with a steady source of larger prey, including gulls, American Avocets, Black-

necked Stilts, and other medium sized shorebirds (pers. obs.). Based upon frequent diurnal sightings, rodent populations (mice and voles) at Eden Landing appeared to be abundant in 2019, potentially providing White-Tailed Kites with a steady source of preferred prey (pers. obs.).

Nests in ponds E6B and E8 experienced poor hatching success in 2019, at 17% (n=23) and 32%(n=32) respectively. This is consistent with Snowy Plover breeding success in these ponds in 2017 (Pearl et al. 2017) and 2018 (Pearl et al. 2019). It is unclear which predators are responsible for the poor success in recent years, however there are issues with both ponds that may affect nest success. Both ponds lack habitat complexity, resulting in relatively poor crypsis for breeding Snowy Plovers. In addition, there remained a large amount of remnant salt production fencing and dividers in both ponds that provide perches for predators. Providing additional habitat complexity by conducting a mud stomp event which includes spreading oyster shells or another material, as well as removing predator perches, could result in improved nest success in these ponds. As opposed to the poor reproductive success in E6B an E8, nests in E6A experienced moderate hatching success (44%, n= 9). In addition, one nest failed to hatch after being incubated past the expected incubation period of approximately 33 days. Aside from having greater habitat complexity provided by sparse vegetation in some areas, much of the suitable breeding habitat can only be accessed by crossing water channels. Although mammalian predators are able to cross these channels, they may nevertheless deter hunting in these areas, leading to higher nest success.

In 2019, two nests were monitored in E6, one of which hatched (Table 8), and at least one additional nest was inferred by the presence of an unaccounted for brood (Table 9). This pond provides a moderate amount of potential breeding habitat and ample foraging habitat, yet due to large berms and tall vegetation that reduce visibility, may preclude Snowy Plover breeding in most areas. Although this pond is slated for tidal marsh restoration during Phase II of the Project, in the meantime it could provide alternative habitat for Snowy Plovers with some minor habitat restoration. At nearby E6C, which at times has supported at least eight nests, zero Snowy Plover breeding activity was observed in 2019. This pond is planned to be managed for Snowy Plover breeding as part of Phase II actions, including installation of water control structures. Although it is unclear why Snowy Plover breeding in this pond has varied greatly between years, we anticipate that providing suitable breeding habitat throughout the season, enhancing the pond with shells or other materials, and removing hunting blinds and remnant salt production structures used as predator perches will result in consistent breeding in E6C.

Nesting Islands

We monitored ten Snowy Plover nests on nesting islands in E12 and E13, finding an apparent hatch rate of 50%. Six of these nests were located on the medium salinity nesting island in E12 where a Least Tern colony was located. As four of these nests were initiated after the colony was established, it seems likely that Snowy Plovers were attracted to nest on the island by the presence of Least Terns. Snowy Plover nests and broods appeared to have a high rate of survival on the island while the colony remained active. However, between July 12 and July 15 a

large depredation event resulted in the depredation of at least one active Snowy Plover nest and up to 26 Least Tern nests. Snowy Plover broods and Least Tern chicks that had been on the island were either depredated or abandoned the island. The presence of large California Gull flocks in E12 and E13 around this time, as well as the rapid collapse of breeding on the island, suggest that California Gulls were the cause of nest and brood loss.

At A16, one Snowy Plover nest was initiated in mid-April, when minimal habitat was available in Alviso for Snowy Plover breeding. Although the nest appears to have hatched, it would have hatched approximately one week before a large rainstorm began on May 15. This rainstorm appeared to wipe out early season broods across the South Bay, and as the brood was never observed at A16, it is likely that they did not survive the storm. Zero Snowy Plover nests were found at RSF2, and no Snowy Plovers were observed on the islands in RSF2 throughout the season. The consistent lack of Snowy Plover breeding and roosting on constructed nesting islands at these ponds suggest that Snowy Plovers preferentially selected nesting habitat on large, dry pond bottoms rather than nesting islands. The larger size of dry pond bottoms may provide more escape time and reduce predator detection for incubating adults flushing in response to approaching predators than the smaller nesting islands. Larger islands may create conditions more similar to dry pond bottoms. In addition, due to the semi-colonial nature of Snowy Plovers, creating larger islands may encourage increased nesting on islands. However, larger sized islands may be more attractive to breeding gulls, and smaller islands have been recommended for other breeding shorebirds and terns in the South Bay (Ackerman et al. 2014).

North Bay

Although zero Snowy Plovers were reported during the breeding window survey at Montezuma Wetland, in mid-June two nests were located and monitored (Table 8). This area is not systematically monitored for Snowy Plovers throughout the breeding season, but instead opportunistically observed during Least Tern surveys. Based upon the documented nesting and large amount of available habitat, it is likely that additional nesting occurred in 2019. In the future, targeted surveys throughout the breeding season may allow for more complete knowledge of Snowy Plover breeding at the site.

Two Snowy Plovers were reported during the breeding window survey at Napa-Sonoma Marshes Wildlife Area, but zero evidence of breeding was observed at the site in 2019 (K. Taylor, pers. comm.) However, it should be noted that the area is not systematically surveyed for Snowy Plovers throughout the breeding season, but instead opportunistically observed during Least Terns, therefore it is possible that breeding occurred but went undetected. In the future, targeted surveys throughout the breeding season may allow for more complete knowledge of Snowy Plover breeding at the site.

RU3 Habitat Outside SBSPRP

As the vast majority of Snowy Plover breeding habitat in RU3 occurs on SBSPRP lands, identifying and improving Snowy Plover habitat outside of the Project footprint will be critical to reaching the RU3 population goal of 500 adults. In 2019, two areas in the South Bay outside

of the project footprint supported Snowy Plover breeding, including CMW and NCM (south of the railroad spur). Both of these areas appear to provide moderate to high quality Snowy Plover breeding and foraging habitat when exposed, yet are primarily managed as flood control basins by multiple agencies at each location. Identifying a way to provide Snowy Plover breeding habitat throughout the breeding season while meeting flood control needs in these areas could improve overall RU3 population growth. It would also provide a viable long-term Snowy Plover breeding habitat in the far South Bay, where it is currently lacking.

Another area that has supported Snowy Plover breeding activity in the past is Patterson Pond, located along the Alameda Flood Control channel next to the Coyote Hills ponds. In 2019, one Snowy Plover was found in this pond during the breeding window survey, and up to three adults observed on follow up surveys. Although no breeding activity was observed at this pond in 2019, the confirmed presence of Snowy Plovers, relative abundance of suitable habitat, and lack of consistent surveys mean that breeding effort could have gone undetected. Enhancement and management of this area for Snowy Plover breeding would provide an additional area to support Snowy Plover breeding that would not be at risk for tidal marsh restoration.

Hayward Shoreline supported a moderate amount of confirmed nests at Least Tern Island (9, Table 8), while three broods between the Oliver Brothers North ponds and Franks Dump West inferred additional breeding at Hayward Shoreline. These and other areas along the Shoreline may be able to support additional Snowy Plover breeding with moderate habitat enhancement and management.

In the North Bay, suitable habitat remains sparse. Hamilton Wetlands may one day support some Snowy Plover breeding, however issues with levees overtopping during high tides preclude nesting in the North Seasonal wetlands. Current known Snowy Plover breeding habitat at NSMWA is limited to narrow levees managed to provide habitat for Least Terns, however high predation in recent years may have precluded finding evidence of breeding. At both NSMWA and Montezuma Wetlands, where Snowy Plover breeding was documented in 2019, lack of dedicated surveys and a large amount of potential seasonal breeding habitat create uncertainty in the ability of these areas to support consistent Snowy Plover breeding.

Chick Fledging Success

Based on the subset of chicks that were banded (n=60), the apparent fledging rate within Recovery Unit 3 was 32%, with an estimated chicks fledged per male rate of 0.86 (Table 12). At E14, 8 of 29 banded chicks were confirmed to have fledged, compared to at E16B, where 10 of 14 banded chicks were confirmed to have fledged. The higher apparent fledging success of banded chicks at E16B compared to E14 illustrates the importance of managing multiple large areas for Snowy Plover breeding. Since the large amount of Snowy Plover and Least Tern breeding appeared to attract numerous avian and mammalian predators, it is likely that these predators had a major impact upon chick survival at E14. By providing alternative breeding habitat nearby at E16B, among other ponds, breeding Snowy Plovers were able to utilize

habitat with comparatively low predation pressure. This strategy will remain important as additional ponds are restored to tidal marsh.

At E8, one three chick brood was banded early in the season (Table 12). This brood was not resighted again after banding, consistent with low apparent survival of unbanded broods in ponds E8 and E6B. At E6B, one two chick brood was banded late in the season. Due to rising water levels in the pond, this brood moved over to the southwest corner of E6A, where one chick was observed through two weeks of age. Neither chick is believed to have fledged. Although no chicks were banded at E6A in 2019, unbanded chicks survival appeared to be relatively high in the southwest corner of the pond. This area contained ample foraging habitat for Snowy Plovers, but as it was relatively shallow in the middle of the habitat, did not have large flocks of feeding gulls, heron, and egrets, as is common in many other areas of E6A, E6B, and E8. Further reducing water depth in this area by adding soil could promote higher quality chick rearing habitat.

Banding a small subset of hatched chicks in a few ponds limits our ability to accurately estimate fledge rates, both within those ponds or in RU3 as a whole. Ponds vary greatly and survival rates likely differ greatly among them. SFBBO staff was limited in 2019 by the number of qualified Snowy Plover banders on our permits. In 2020, an additional staff member that was trained throughout 2019 will be ready to be added to the permit early in the season. This will greatly increase SFBBO's ability to band Snowy Plover chicks. Furthermore, the filling of the All-American canal and conversion into a drivable levee is expected to be completed in time for the 2020 breeding season. This will greatly increase the detection ability within ponds R3 and R4, allowing SFBBO staff to potentially band and keep track of Snowy Plover chicks at these important ponds. Increased and consistent banding at significant breeding ponds will help improve our estimates of chick fledging success. Furthermore, in 2020-21 SFBBO plans to participate in a North American GPS tagging study of adult Snowy Plovers at Eden Landing that will provide additional information on brood survival and brood use of habitat.

Oyster Shell Habitat Enhancement

Large Scale Enhancement Study

The implementation of large-scale oyster shell enhancement at pond E14 in Eden Landing allowed us to test the efficacy of oyster shells as camouflage for nesting Snowy Plovers. Overall nest abundance throughout the pond, and nest density in enhancement plots Western and Eastern were substantially higher in 2019 when compared to pre-enhancement conditions (prior to 2015). Nest abundance and density patterns in 2019 were also similar to the first four years of the enhancement (2015-2018), 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 2015-2019.

Spatial Distribution and Nest Site Selection

The high density of nests in shelled areas (1.20±0.29 nests/ha) during peak months (April 21-July 20) resulted in Snowy Plovers having a large amount of neighboring nests (2.8±1.3) within 100m. Powell (2001) found that Snowy Plover nest success was highest at close (51-100m) and medium distance (101-200m) from other nests, while lowest at very close (<50m) and far distance (201-500m) from other Snowy Plover nests. Although the average neighbor distance within a 100m radius was 68.8±13.9m, the average nearest neighbor distance was 53.8±20.7m away, indicating that there were clusters of nests found <50m from each other. Nests that are <50m away from the nearest neighbor may be more prone to depredation, and suggests that during peak breeding months, breeding density in E14 may exceed that which is optimal for breeding Snowy Plovers.

The results of our chi-squared analysis indicated that Snowy Plovers preferentially selected to nest in shelled areas in E14 over non-shelled areas, yet the shells did not result in high breeding success. High density breeding in E14 may increase predation pressure and reduce Snowy Plover nest success, thus it may be advantageous to spread oyster shells in other Eden Landing pond with ample breeding and foraging habitat to reduce the amount of breeding concentrated in E14 and thereby ease density dependent effects. E8 and E6B, which have consistently hosted a large amount of Snowy Plover breeding and low nest and fledging success in recent years, may benefit from addition of oyster shells. Although our monitoring since 2015 has not found that oyster shells significantly improve breeding success since, they may ensure a moderate level of breeding success. During March-September of 2015-2019, E14, E8, and E6B have all been managed for plover breeding, with consistent predator control beginning in April 2018. Despite similar management and much higher nesting density, average nest success in E14 (42.7) has been slightly higher than E8 (42.3) and much higher than E6B (26.3).

Nest Survival

The best logistic regression model showed a significant positive effect of date of nest initiation on nest survival in E14. This makes intuitive sense, as early nests may be exposed to a greater number of predators during Spring migration, as well as stochastic weather events such as the mid-May storm that flooded multiple nests in E14. The model also found a significant positive effect of number of nest neighbors within 100m on nest survival in E14. Snowy Plovers are loosely colonial, and benefit from the increased predator detection that may be afforded by nearby neighbors. However, the interaction between these two variables showed a decline in nest survival as the season progressed. This provides evidence that during the peak of the breeding season, nest density in E14 may exceed that which provides benefits to nesting Snowy Plovers due to a higher likelihood of predators finding nests.

Using RMark to conduct a nest survival analysis (Laake & Rexstad 2008), we found the constant Daily Survival Rate (DSR) of Snowy Plover nests at E14 to be 95.6%. The probability that a nest survived to 33 days, the time it takes from nest initiation to begin hatching, was 22.7%. This is much lower than the observed hatch rate of 41% in E14, and may indicate that a large number of depredated nests at E14 went undetected.

In 2019, the unexpectedly high amount of Least Tern breeding at E14 reduced our ability to keep weekly track of nest and chick status at all known tern nests, let alone find all observed nests. As such, Least Tern data could not be used for either the logistic regression model or nest survival analysis. Nevertheless, until July 1 there appeared to be increased nest survival of Snowy Plover nests located nearby to the Least Tern colony. Beginning on July 1, we found evidence of widespread Least Tern nest loss, and some Snowy Plover nest loss, both of which were later attributed to striped skunks. Skunks have excellent hearing, and may have been attracted to the pond by calls of the many Least Tern chicks that had recently hatched (Eric Covington, pers. comm.). Thus, due to high predation pressure, overall Snowy Plovers nest survival may have decreased with decreasing distance from the Least Tern colony, despite on-site predator control efforts. This may also help explain the negative interaction between nearest Snowy Plover nest neighbor and date of nest initiation that was observed in the logistic regression model selected.

Brood Behavior

The negative binomial regression model we ran provided evidence to suggest that young Snowy Plover broods were more likely to brood in shelled areas than unshelled areas. However, there was not an effect related to broods foraging in shelled areas. One of the issues with the large shelled areas in E14 is that they contain a minimal amount of water throughout much of the season, and thus don't provide foraging habitat. Without foraging opportunities, broods are inevitably forced to leave the safety of the shells to forage along borrow ditches where prey abundance will be greater.

After five years of monitoring the large scale oyster shell enhancements, we have seen increased nest density in Snowy Plovers and attracted a relatively large amount of Least Terns to breed. Since late 2015, predators have appeared to cue in on areas of high nest density, as was found at Mono Lake by Page et al. (1983). In 2019, we continued to observe a significant proportion of Snowy Plover nesting at E14. The presence of Least Terns at E14 likely contributed to consistent predator activity at the pond, and thus, could have affected Snowy Plover breeding success. Our anecdotal observations and evidence from 2017 suggest that the presence of Least Terns may reduce the effects of Common Raven predation of Snowy Plover nests. If left unchecked, the potential increase in mammalian predators attracted to the Least Tern colony may negate any benefits to Snowy Plovers. Consistent predator control must also be implemented each year.

Monitoring and research should continue at the E14 enhancement site. Future research should seek to address the effect of mammalian predators on Snowy Plover breeding success in shelled areas. Consistent monitoring will document how Snowy Plover use of the enhancement site changes over time, a critical piece of knowledge to inform future restoration efforts within Recovery Unit 3 and across the Pacific Coast.

Additional Considerations

As the amount of available Snowy Plover nesting habitat around the South Bay is reduced due to tidal marsh restoration, Snowy Plover nesting density will need to increase in order to maintain or increase breeding numbers within a smaller habitat footprint. Shell plots are one way to achieve the higher nest densities. However, the efficacy of oyster shells can decline over time due to winter management of ponds for ducks and resulting sedimentation. Past research observed a decline in use of shell plots by breeding Snowy Plovers over time (Robinson-Nilsen et al. 2013) , therefore shells may need to be refurbished or supplemented on a consistent basis (approximately every 5-10 years) in order to maintain their benefits for Snowy Plover breeding. The closing of Drake's Bay Oyster Company in Marin County in 2014 means that a large amount of local oyster shells are no longer available, necessitating the need for an alternative source. Establishment of an oyster collection program in local restaurants may provide consistent sources of shells. However, since Drake's Bay oyster shells were grown to a larger size for canning, it is unclear if the smaller size oyster shells found in restaurants may affect Snowy Plover breeding in a different way. Gravel and cobble, which have shown promise as a nesting substrate along the Eel River (Colwell et al. 2011) and at Point Reyes (L. Stenzel, pers. comm.), were tested on a small scale as an enhancement material at RSF2 in 2019. Although no evidence of Snowy Plover breeding was observed among the graveled areas, a more formal pilot study in RU3 should be conducted to more thoroughly assess the potential value of these materials.

Avian Predators

Aside from gulls, Snowy Egrets and Great Egrets were the two most commonly observed predators throughout Recovery Unit 3. Although SFBBO has not confirmed these species as nest predators, they may have an effect on breeding success. It is possible that these species, as well as Great Blue Herons and Black-crowned Night Herons (collectively termed herons) serve as significant chick predators, especially at ponds E6A, E6B, E8, E12, and E13. During the early and late part of the breeding season, heron and gull species often form large multi-species feeding flocks on small fish in the same areas where chicks forage.

A large American Crow flock (27.5±20.6) was consistently observed at the Ravenswood ponds during peak Snowy Plover breeding months (April 25-July 25), and based upon observed foraging behavior in RSF2, R3, and R4, it is likely that they were responsible for a large amount of Snowy Plover nest and brood losses in these ponds. Common Ravens were consistently observed throughout Recovery Unit 3, especially at ponds with a moderate to high amount of Snowy Plover breeding (A12, A22, E6B, E14, NCM, and R1-5). They were confirmed by cameras as nest predators at E14 on two separate occasions (Table 30), though it should be noted that cameras were used sparingly in 2019. For the second consecutive year, SFBBO biologists observed Least Terns successfully mobbing and chasing off Common Ravens in E14, providing further evidence that their success may lead to increased Snowy Plover breeding success. One Common Raven nest located in a power tower along Highway 94 near the toll plaza was removed by PG&E in coordination with USFWS. Shortly after, USDA-APHIS was able to remove

the pair that had been associated with the nest. After removal of the nest and pair, Snowy Plover nest and brood success appeared to increase, indicating that the Common Ravens were likely consistent predators in E14. In future years, consistent efforts should be made early in the season to identify Common Raven nests located in power towers adjacent to Snowy Plover breeding habitat.

Aside from gulls and herons, Northern Harriers were the most consistently observed predator at E14 (0.7 per survey), and were visually confirmed depredating at least one Snowy Plover nest (Table 30). Based upon our past identification of Northern Harriers as nest predators in RU3 (Robinson-Nilson and Demers 2009) and research from Oregon (Psiropoulos and Burrell 2013) that identified Northern Harriers as a main nest predator of Snowy Plovers, we believe that this may have also been the case at E14. Northern Harriers were frequently observed attacking the Least Tern colony, and on at least three occasions were observed successfully hunting for Least Tern chicks. It is likely that they also depredated many Snowy Plover chicks. As the amount of suitable harrier breeding habitat (e.g., tidal marsh) around E14 increases, the Northern Harrier population may continue to increase. RU3 biologists should keep track of Northern Harrier hunting activity while at important Snowy Plover and Least Tern breeding areas. Areas with consistent Northern Harrier activity should be monitored consistently by biologists, USDA-APHIS trappers, and/or using trail cameras to estimate the impact of Northern Harriers on Snowy Plover nest success. If there is evidence of Snowy Plover and/or Least Tern nest or chick predation by Northern Harriers, or consistent sightings of Northern Harrier in Snowy Plover foraging areas, Northern Harriers should be removed to prevent extensive nest and chick loss.

We frequently observed Common Ravens, Peregrine Falcons, and Red-tailed Hawks perched in transmission towers near Snowy Plover breeding ponds throughout the South Bay. The Refuge coordinated with Pacific Gas and Electric (PG&E) to remove seven Common Raven nests in towers over sensitive habitat in the South Bay in 2019 (Tertes & Muckenhirn 2019). At Eden Landing, the removal of one Common Raven nest along Highway 92, as well as subsequent removal of the pair, appeared to improve breeding success at E14 (pers. obs.). 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 45,026 breeding birds in 2019, a decrease of 1,750 from the previous year (Tarjan & Burns 2019). At Eden Landing, large California Gull flocks (up to 150) were frequently observed at E12-13 during the early (March-April) and late (July-August) part of the breeding season. Especially late in the season, these gull flocks may opportunistically depredate Snowy Plover eggs and chicks due to the narrow width of levees, berms, and nesting islands and resulting high chance of inadvertently finding nests and broods. The fourth largest gull colony was found at ponds M4/M5, directly next to ponds A22 and A23. Gulls were frequently observed obtaining nesting material from A22 during April and May, and could have opportunistically depredated Snowy Plover eggs and/or chicks. In contrast to recent years, when hundreds of empty nests near sensitive Snowy Plover breeding areas were removed from levees and boardwalks, zero California Gull nests were

removed in 2019 (Tertes & Muckenhirn 2019). For the second consecutive year, no gulls attempted to nest on the A22/23 levee.

Mammalian Predators

Since SFBBO does not conduct mammal focused predator surveys, there is relatively little sighting data to report. In 2019, we opportunistically observed red fox and feral cats during surveys, and coyotes outside of surveys. Camera trap evidence at E14 indicates that skunks may have had a major impact on Snowy Plover nest success, and potentially on chick fledging success. Although predator control efforts at Eden Landing have been consistent since April 2018, and appear to have been effective in reducing the influence of red fox, there is an acute need for increased trapping effort at several ponds, including E12-14, E8, and E6B. In addition, greater use of camera traps at pond access points may facilitate better knowledge of mammal hunting on the ponds and lead to development of more nuanced strategies for removing problematic individuals.

Restoration and Snowy Plover Nesting

The majority of RU3's Snowy Plover breeding habitat is located within the South Bay Salt Pond Restoration Project area. The Project aims to restore large areas of former salt ponds to tidal marsh, yet one of the Project's long-term goals is to support 250 breeding Snowy Plover adults within the Project area (USFWS and CDFW 2007). It will be critical that enough suitable breeding habitat is maintained to support the population goal on project lands. During Phase II of the Project at Ravenswood, installation of water control structures and enhancement of R3 breeding habitat prior to breaching R4 will help to ensure that there is high quality nesting habitat available to Snowy Plovers when overall habitat availability decreases. Further enhancement of RSF2 and R1-2 for Snowy Plover breeding, including spreading of a camouflage enhancing substrate (oyster shells, gravel, etc.) and removal of remaining predator perches, could also help to offset the loss of R4. If ponds are to be drained during construction, providing breeding habitat throughout the season in R1 and R2 could reduce breeding in drained ponds and help to prevent overly high nesting density that could negatively affect breeding success in R3 and RSF2 during the first half of the season.

In addition, identifying and managing suitable habitat outside of the project may benefit both the Projects tidal marsh restoration goals and RU3s goal of 500 adult Snowy Plovers. There are several sites in Santa Clara County, including CMW and the Spreckles Marsh area of NCM that have shown the potential to provide high quality breeding habitat. RU3 should identify solutions that may allow for these areas to be seasonally managed for Snowy Plover breeding while continuing meeting their current functions as flood control basins during the non-breeding season

Since 2010, the average number of Plovers within the Project lands has stayed well above the NEPA Baseline of 113 breeding adults (198.5±39.8; Table 7). This period has been marked by

the two highest breeding population estimates on project lands since the project began (253 adults in 2010, 243 adults in 2017), which may have resulted from the ability to better manage breeding habitat. Yet in each case, the observed population underwent a steep two year decline (138 adults in 2012, 176 adults in 2019). Four of the ponds opened to tidal action or converted to other management regimes during this time frame historically hosted moderate to large numbers of Snowy Plovers (A8, E12-13 and E8A; Figures 23-25). Although the breaching of these ponds did not cause an immediate and sustained population decline, the increased concentration of plovers in remaining ponds may have increased Snowy Plover vulnerability to predation. We recommend that following the breach of R4, the Project carefully monitor the impacts to breeding Snowy Plovers and other ground nesting species in the remaining Ravenswood ponds before determining the future status of these ponds.

Human Disturbance

On several occasions we directly observed or found evidence of humans trespassing in plover habitat closed to the public. At Ravenswood, pedestrians were consistently seen trespassing onto the bay levee on R4 and onto the R5S pond bottom adjacent to Highway 84. At Eden Landing, large tire tracks on the pond at E8 indicated that an all-terrain vehicle had been recently driven over a large section of the pond. The tracks came within approximately 15 meters of running over a nest, and had potential to hit Snowy Plover adults or chicks, though no carcasses were located. In another instance, pedestrians were found walking along E16B. All of these incidents of trespass could have disturbed breeding Snowy Plovers. These incidents were reported to Refuge and Eden Landing staff when appropriate.

Past studies have indicated that human disturbance can significantly impact Snowy Plover nest site selection and behavior (Lafferty et al. 2006). Within the South San Francisco Bay, Trulio et al. (2012) found that Snowy Plovers flushed from their nests when trail walkers were an average of 145m away, regardless of the distance of the nest from the levee. Although Least Terns appear to be less sensitive, prior research in Florida determined that a buffer of 100m is sufficient to prevent terns from flushing (Rodgers et al 1995). In mid-June, numerous Snowy Plover and Least Tern nests were located a short distance from the public trail spur along the E13/E14 levee. In order to protect these nests, as well as chicks from both species, the trail spur was closed for approximately one month. Following closure, the area was used by numerous Snowy Plover broods and Least Tern fledglings, indicating that closure of this spur during peak breeding times may be an important method to reduce disturbance and provide a suitable amount of foraging habitat for both species.

RECOMMENDATIONS

Management Recommendations

1. Refuge and CDFW management should continue to meet Snowy Plover habitat requirements by: a) providing dry 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, disturbance and/or disease, c) discouraging Snowy Plover breeding at ponds with low quality habitat by keeping them flooded

2. Since bulk oyster shells may be hard to come by, Recovery Unit 3 should identify alternative habitat enhancement materials or methods and implement them in areas that will not be flooded on a consistent basis.
3. Refuge and CDFW, in coordination with the South Bay Salt Pond Restoration Project, should identify suitable Snowy Plover breeding habitat in RU3 outside the Project footprint that can be managed for breeding Snowy Plovers. Nearly all documented RU3 Snowy Plover breeding, both historically and within recent years, is within the Project area. A goal of the Project is to support 250 breeding adults, whereas the USFWS RU3 goal is 500 breeding adults. Tidal marsh restoration of current breeding habitat will hamper RU3 goals, therefore in order to reach RU3 goals additional habitat must be identified and managed for Snowy Plovers.
4. Construction activities on Snowy Plover nesting ponds should occur outside of the breeding season whenever possible, per applicable Biological Opinions and associated BMPs and minimization measures.
    - If construction activities occur on ponds where Snowy Plovers are nesting, or on levees in between breeding and/or foraging ponds, there should be a trained biologist onsite during working hours to minimize impacts to Snowy Plovers.
    - Actions should be taken to deter Snowy Plover nesting on ponds where heavy equipment will be operating. Focusing the construction in a small footprint and keeping human disturbance constant (5-7 days a week during daylight hours) may reduce the number of Snowy Plovers attempting to nest in the vicinity of construction.
    - 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.
5. The predator management and gull hazing programs should continue in 2020 in the South Bay, with increased focus on removing mammals and implementing a tiered approach to manage specific problem Northern Harriers in high density breeding areas and preventing gulls from roosting near plover breeding and foraging habitat.
6. At the north end of pond E8 and RSF2 cell U3, efforts should continue to remove vegetation on the pond bottom that are reducing available nesting habitat. This may be achieved through flooding ponds, applying salt or gypsum, direct removal with mechanical and/or hand tools, or a combination of these methods.
7. At E16B, repair or replacement of the water control structure would allow for better management of the pond, including the prevention of Snowy Plovers nest inundation in low lying areas that are prone to flooding. This action, along with adding interior channels, should be implemented to increase the amount of foraging habitat in the pond.
8. Addition of oyster shell or other materials such as gravel at RSF2 cell 3, R3, and R1-2 could partially mitigate against depredation related to potential high-density Snowy

Plover breeding following breaching of R4. Raising water levels and increasing water connectivity between the borrow ditch and interior channels will create more foraging habitat.

9. Recovery Unit 3 should continue to work with PG&E to remove predator nests from the towers, with special focus on locations adjacent to or near high priority sensitive species habitat. Tower design modifications should be researched to discourage Common 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 bird spikes to discourage predator perching.
10. Recovery Unit 3 should continue to develop a Snowy Plover Outreach Program. Increased outreach and interaction with the public is necessary as more trails near Snowy Plover breeding habitat are opened to the public.
    - Continue to station trained docents at public areas adjacent to nesting sites, to provide information on Snowy Plover conservation and disturbance issues and viewing opportunities of nesting birds. This would create public awareness and support for Snowy Plovers, thereby reducing the human disturbance.
    - Additional interpretive panels should be placed on public trails at Eden Landing and Ravenswood to provide information on Snowy Plover habitat needs, disturbances, and conservation issues.
    - Law enforcement patrols should be increased in areas with Snowy Plover breeding habitat to minimize human disturbance. This will become progressively more important as overall habitat is reduced and additional trails are opened to the public as part of the Project.

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 GPS tags or radio 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. Impacts of corvids, raptors, and gulls on nesting Snowy Plovers.
    a. Efficacy of avian predator management on Snowy Plover breeding success.
    b. Relationship between number of predators observed and breeding success
3. Changing Northern Harrier population size, territory size and habitat use and impacts on nesting Snowy Plovers as tidal marsh nesting habitat increases for harriers.
4. Potential impacts to nesting Snowy Plovers of human disturbance from recreational trail use.
5. Positive and negative impacts of Least Terns and Snowy Plovers nesting in close proximity within Recovery Unit 3 and how that related to similar co-nesting within other RUs.
6. Long-term use of E14 large-scale oyster shell enhancement by breeding and wintering Snowy Plovers.

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 tidal marsh restoration.
2. Monthly surveys should include scouting areas that are not consistently used by breeding Snowy Plovers, including Patterson Pond in Coyote Hills, Frank's Dump 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.
3. Monthly surveys in the North Bay should be conducted to better document Snowy Plover breeding effort.

ACKNOWLEDGEMENTS

In 2019, Western Snowy Plover monitoring was supported by California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Facebook Inc., Santa Clara County Fish and Game Commission, and SFBBO donors. California Least Tern monitoring was supported by Alameda County Fish and Game Commission. We are especially grateful to Cheryl Strong and Rachel Tertes of the Don Edwards San Francisco Bay National Wildlife Refuge and John Krause of CDFW for logistical support at the Refuge and Eden Landing, respectively. We thank SFBBO Biologists Jessica Gonzalez, Anjou Kato, Alex Rinkert, Gabbie Burns, Cole Jower, Josh Scullen, SFBBO intern Illianna Termuehlen, and Refuge intern Aurelie Muckhirn for their hard work throughout the season. We also thank our dedicated volunteers, Diane and Tom Bennett, Bill and Tanya Hoppes, Richard Jeffers, Mike Mammoser, Mike Rogers, Ethel Murphy, Sue Morgan, Jing Zhu, Debbie Ottman, Kayla Ferron, and Analicia Hawkins for conducting Snowy Plover surveys, Least Tern Surveys, docent surveys, and/or data entry. We also thank Karen Taylor of CDFW, Ann Graham of HARD and David Riensche of EBRPD, Anne Wallace of EcoBridges Environmental Consulting, and Jules Evens of Avocet Research Associates for contributing information about Snowy Plover nesting activity in Napa Sonoma Marsh Wildlife Area, Hayward Shoreline, Montezuma Wetlands Restoration area and Hamilton Wetland Restoration area, respectively.

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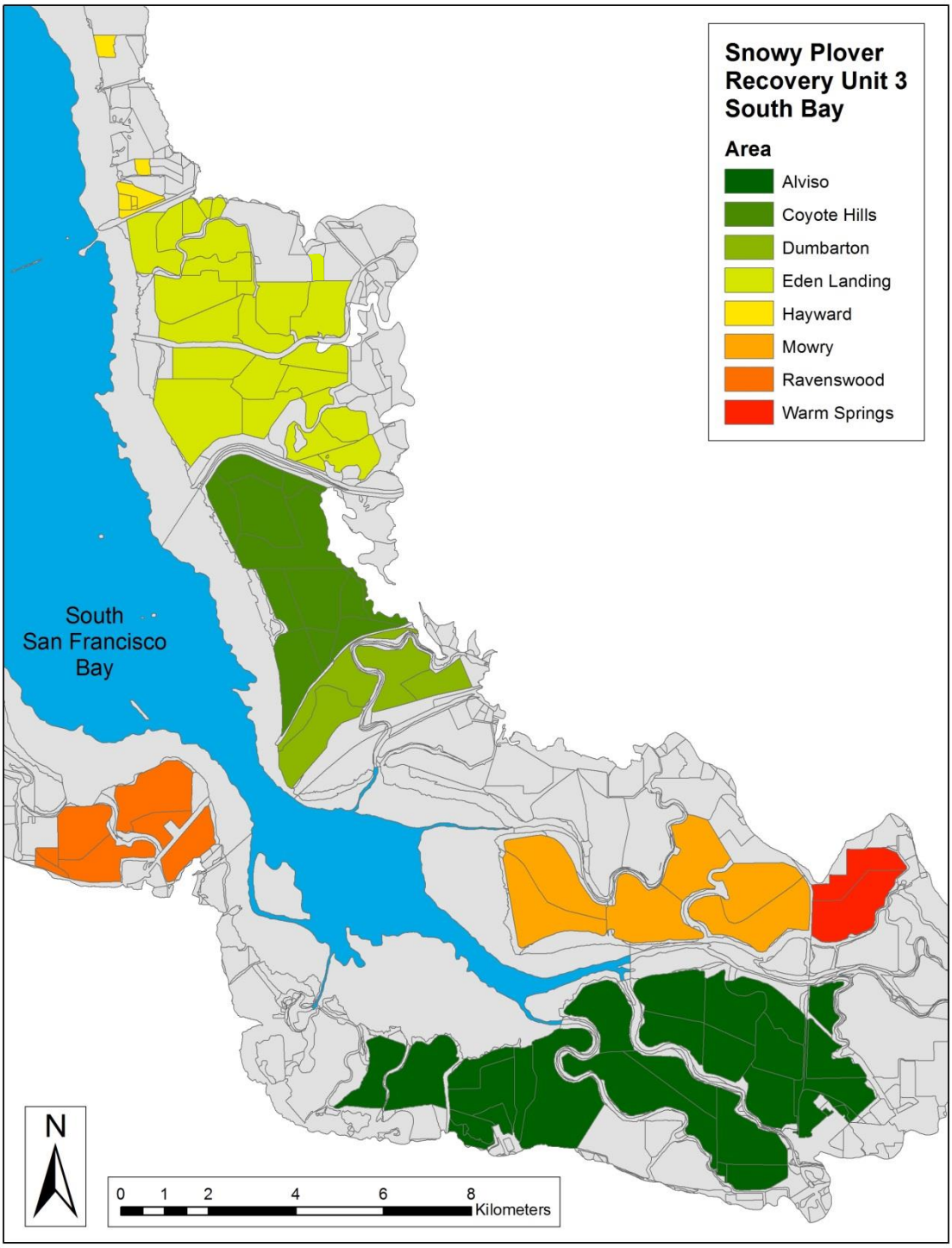

Figure 1. The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's Eden Landing Ecological Reserve, East Bay Regional Park District and Hayward Area Recreation and Park District lands in the South San Francisco Bay, California.

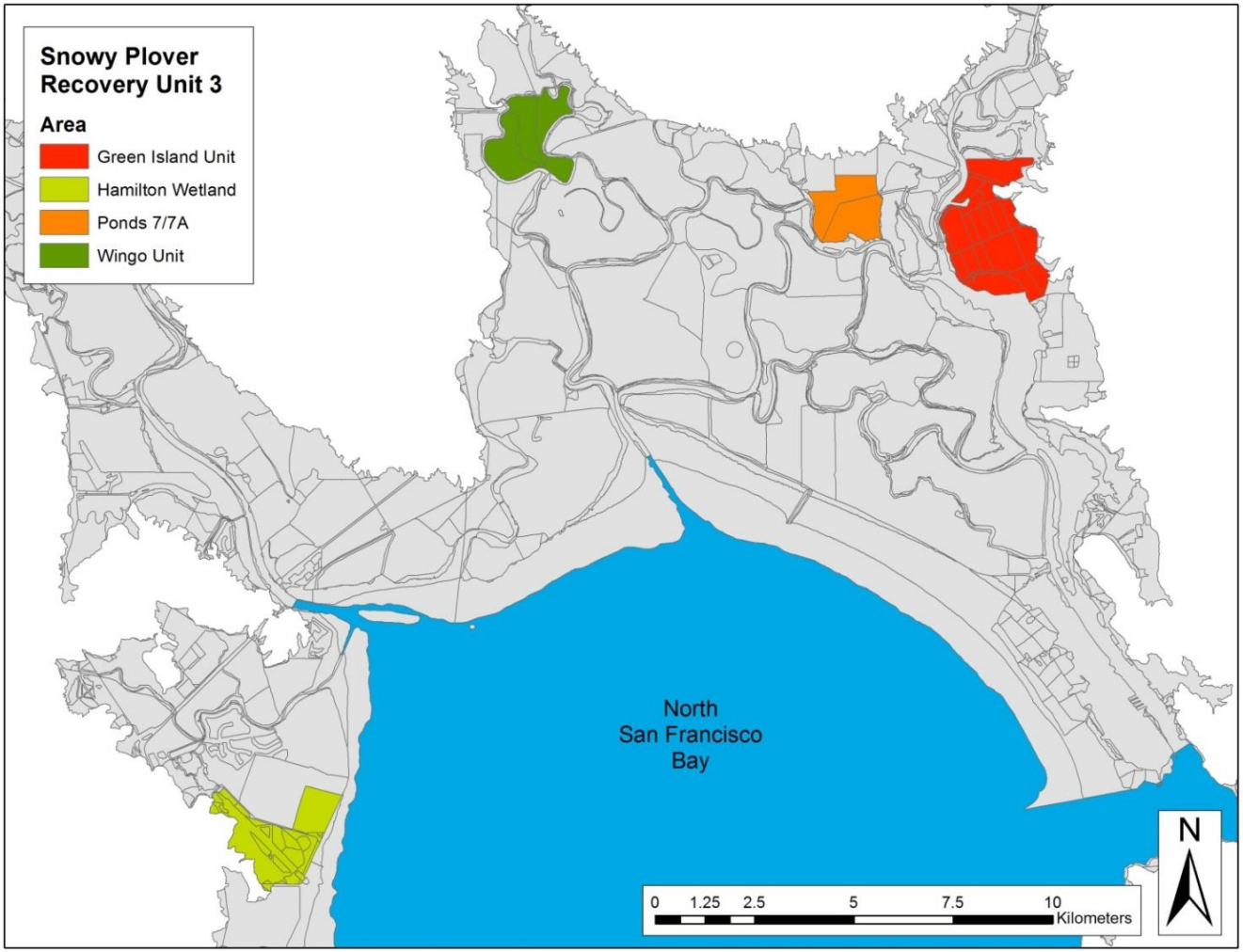

Figure 2. Snowy Plover nesting areas in the CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site); Coastal Conservancy's Hamilton Wetlands, North San Francisco Bay, California.

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

Figure 4. Ponds in the Refuge's Alviso Complex, including Mountain View (A1-A3N) and NASA-ARC/Mid-Peninsula Regional open Space District property (Crittenden Marsh), at the southern end of the South San Francisco Bay, California. See Figure 1 for location of Alviso within South San Francisco Bay.

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

Figure 6. Ponds in the Refuge's Dumbarton Complex, at the east end of the Dumbarton Bridge, South San Francisco Bay, California. Note that this complex includes Wildlands Inc. property (Newark Slough Mitigation Bank, termed Hickory in this report). See Figure 1 for location of Dumbarton within South San Francisco Bay.

Figure 7. Ponds in the Refuge's Mowry Complex, near Fremont, South San Francisco Bay, California. See Figure 1 for location of Mowry within South San Francisco Bay.

Figure 8. Ponds in the CDFW's Eden Landing Ecological Reserve, near Hayward, South San Francisco Bay, California. See Figure 1 for location of Eden Landing Ecological Reserve within South San Francisco Bay.

Figure 9. Close-up of Hamilton Wetlands, Novato, CA. The northern seasonal wetlands, which may remain suitable for Snowy Plover breeding, are outlined in red.

Figure 10. Montezuma Wetlands Project Site location in Suisun County, CA.

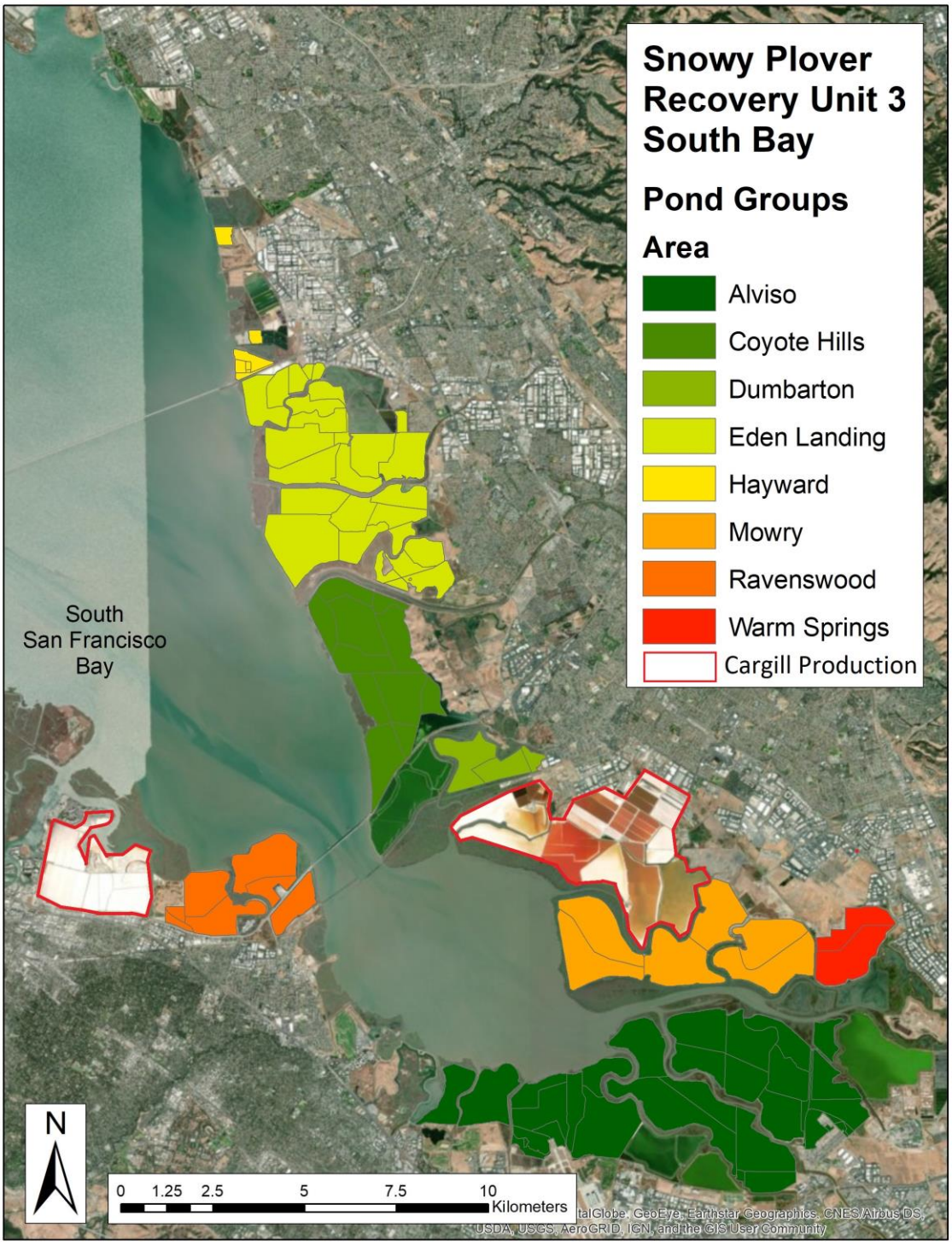

Figure 11. Cargill salt production ponds in relation to other pond groups, South San Francisco Bay, CA. The Redwood City plant is located west of the Ravenswood ponds, while the Newark plant is located north of the Mowry ponds.

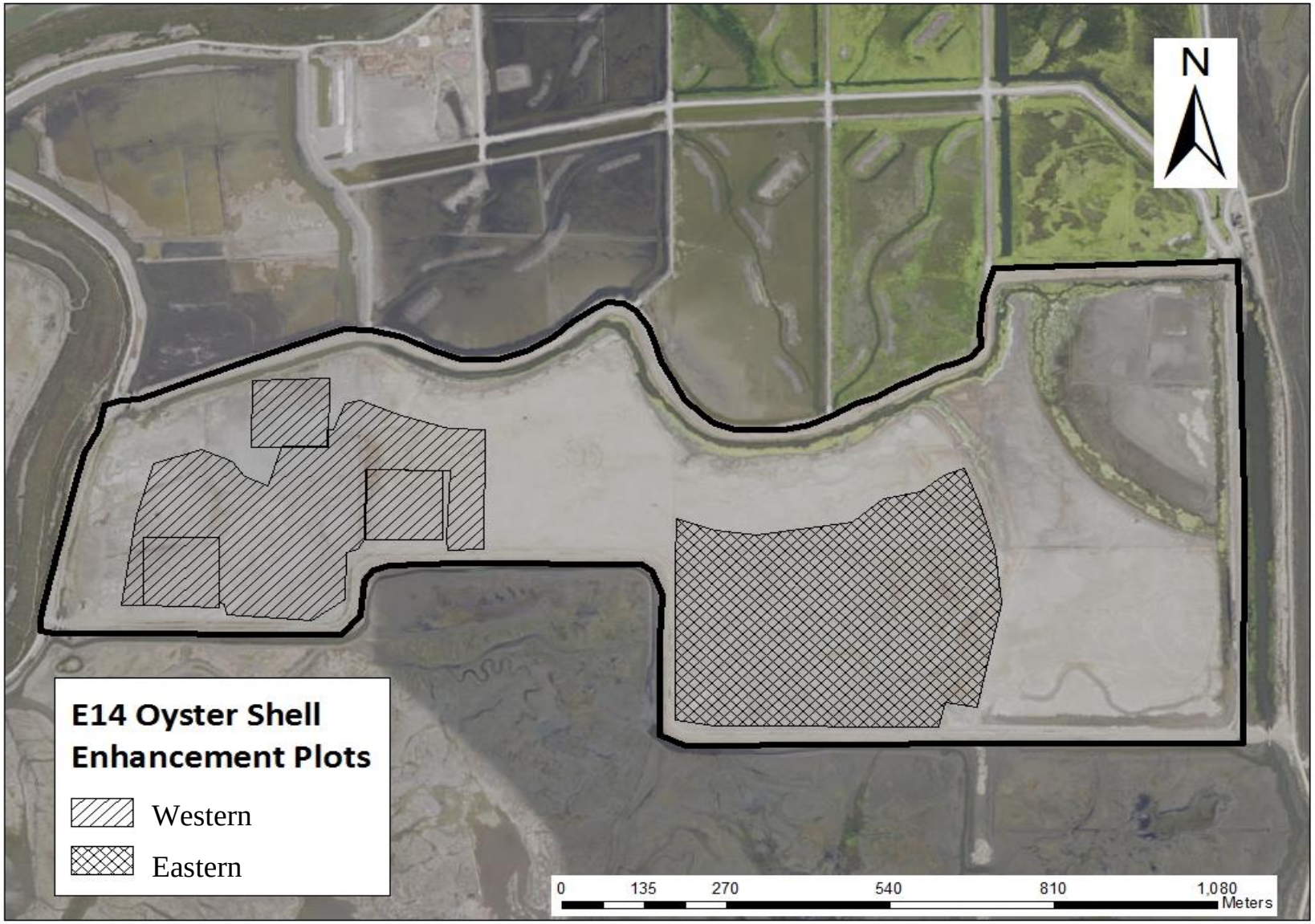

Figure 12. Oyster shell enhancement plots at Pond E14, Eden Landing Ecological Reserve, Hayward, CA.

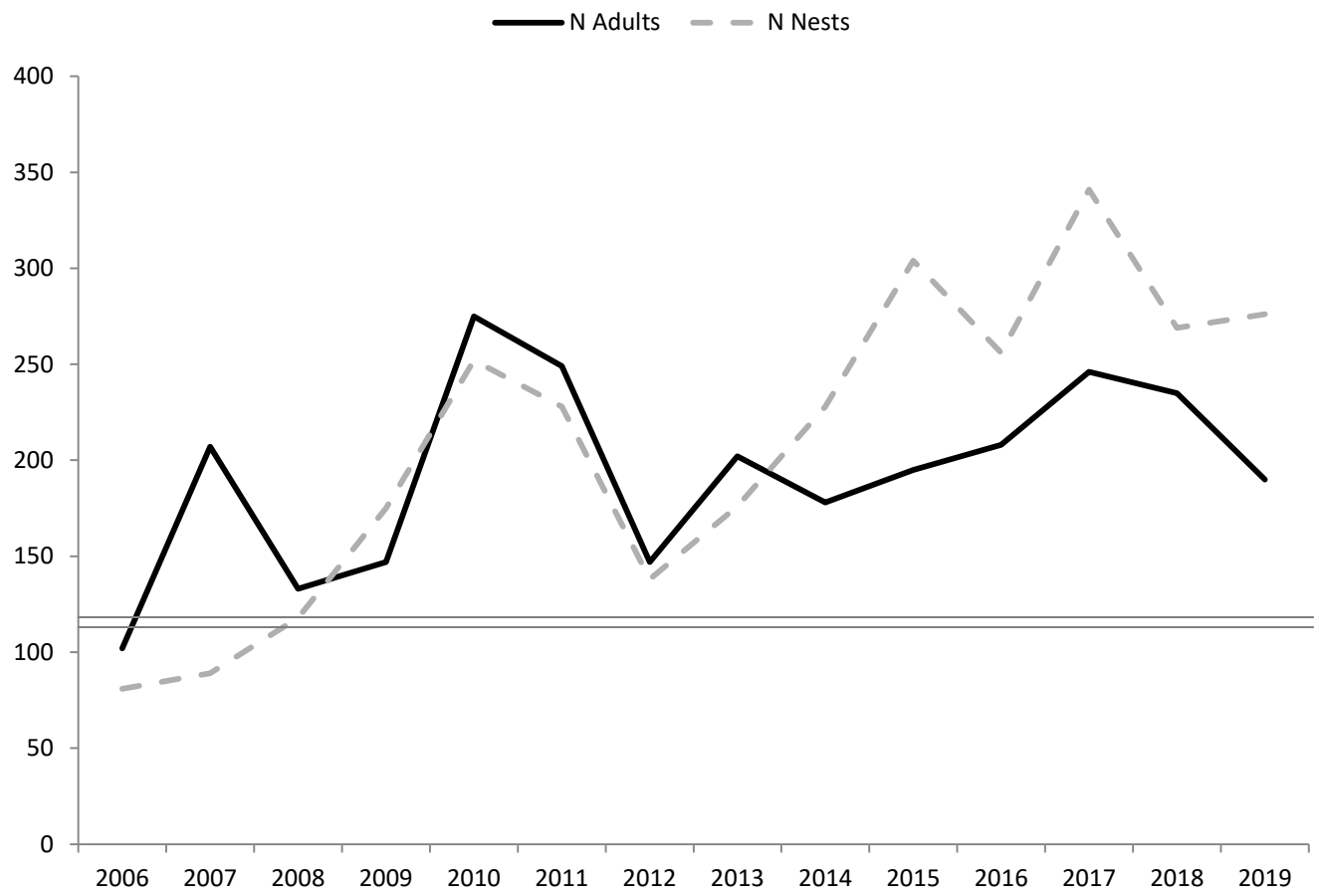

Figure 13. The total number of Snowy Plover adults counted during the breeding window survey and the total number of Snowy Plover nests counted during the season in all regularly monitored Recovery Unit 3 (RU3) areas, San Francisco Bay, from 2006-2019. The double line indicates the South Bay Salt Pond Restoration Project NEPA/CEQA baseline of 113 breeding adults on project lands, established from the average number of breeding birds from 2004-2006.

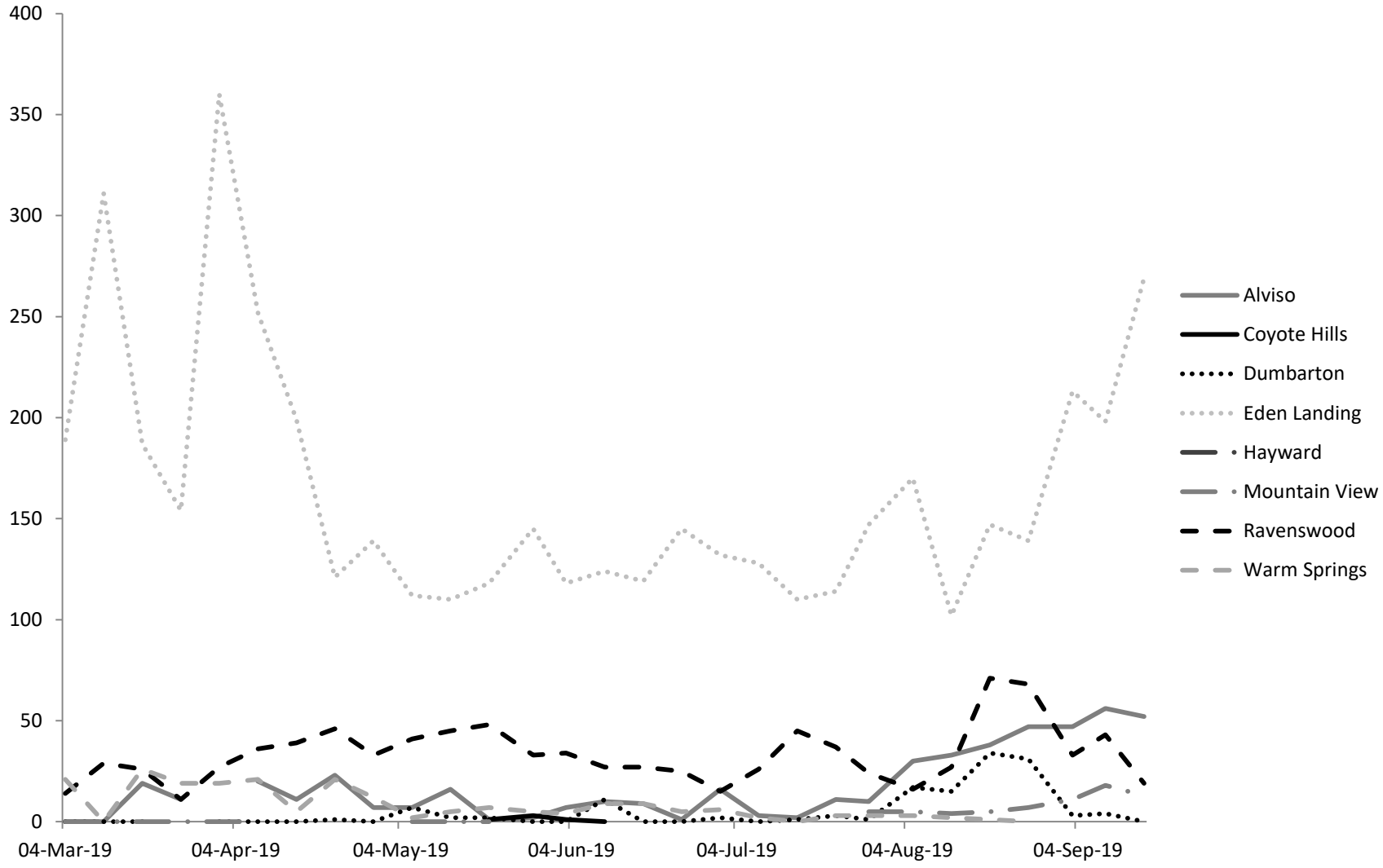

Figure 14a. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2019. Data are presented here for all locations monitored where Snowy Plovers were observed. Note the high number of Snowy Plovers observed in April and September are presumed to be migrating and not breeding in the San Francisco Bay.

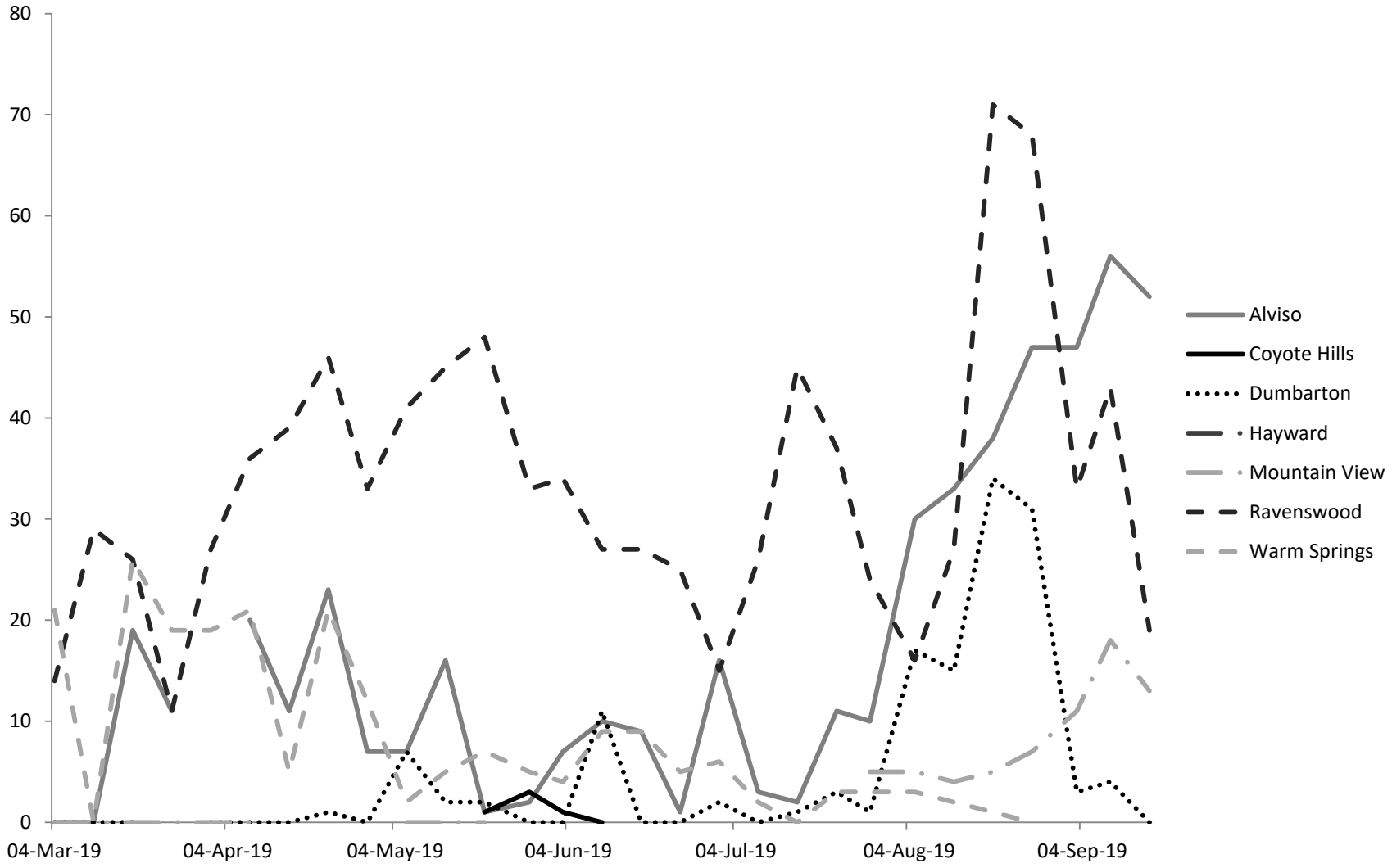

Figure 14b. Weekly counts of adult Snowy Plovers by week and area, San Francisco Bay, California, 2019. To facilitate interpretation, data are presented for all locations monitored excluding Eden Landing. Note the high number of Snowy Plovers observed in April and September are presumed to be migrating and not breeding in the San Francisco Bay.

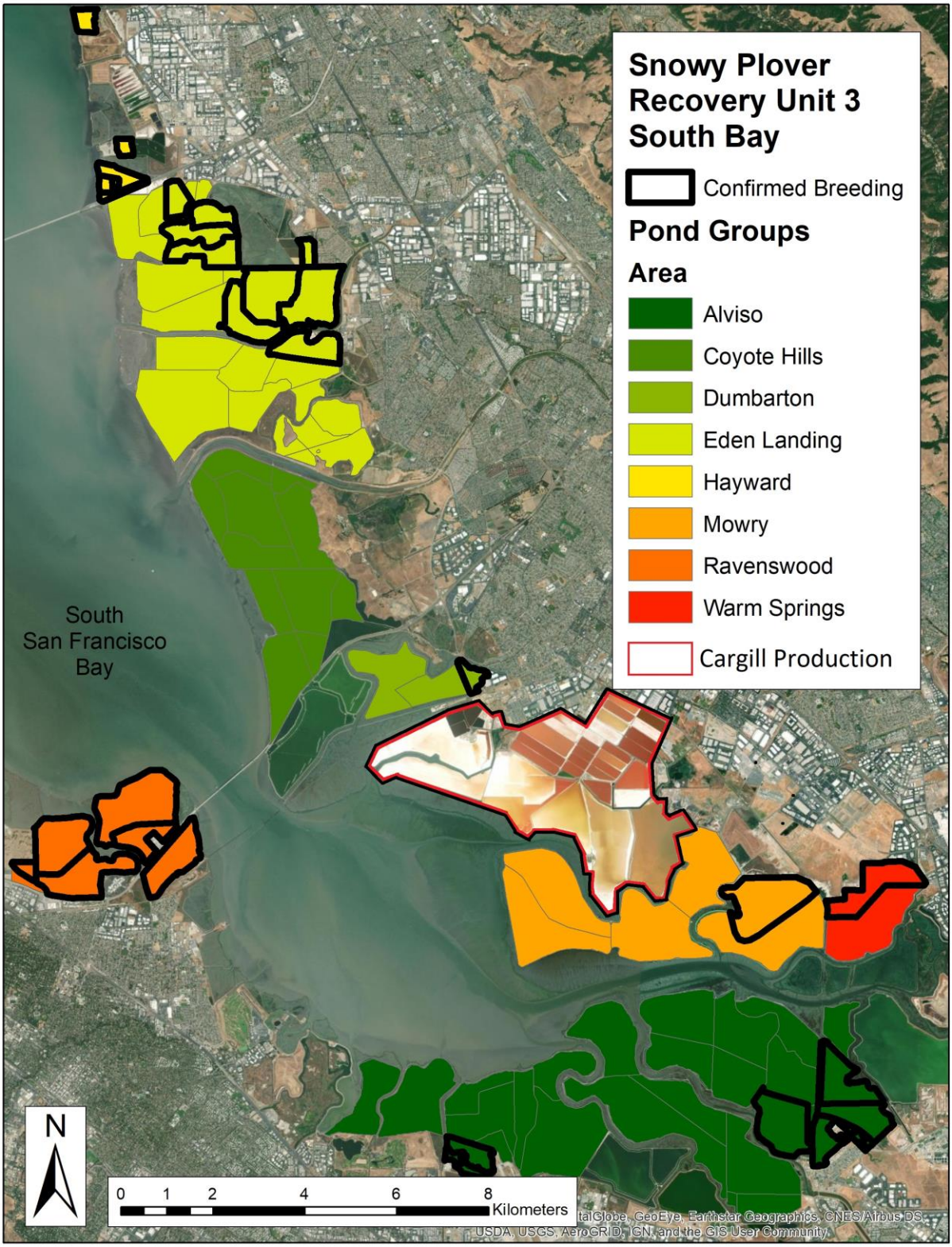

Figure 15. Areas (black outline) with documented Snowy Plover nesting activity during the 2019 breeding season, South San Francisco Bay, California.

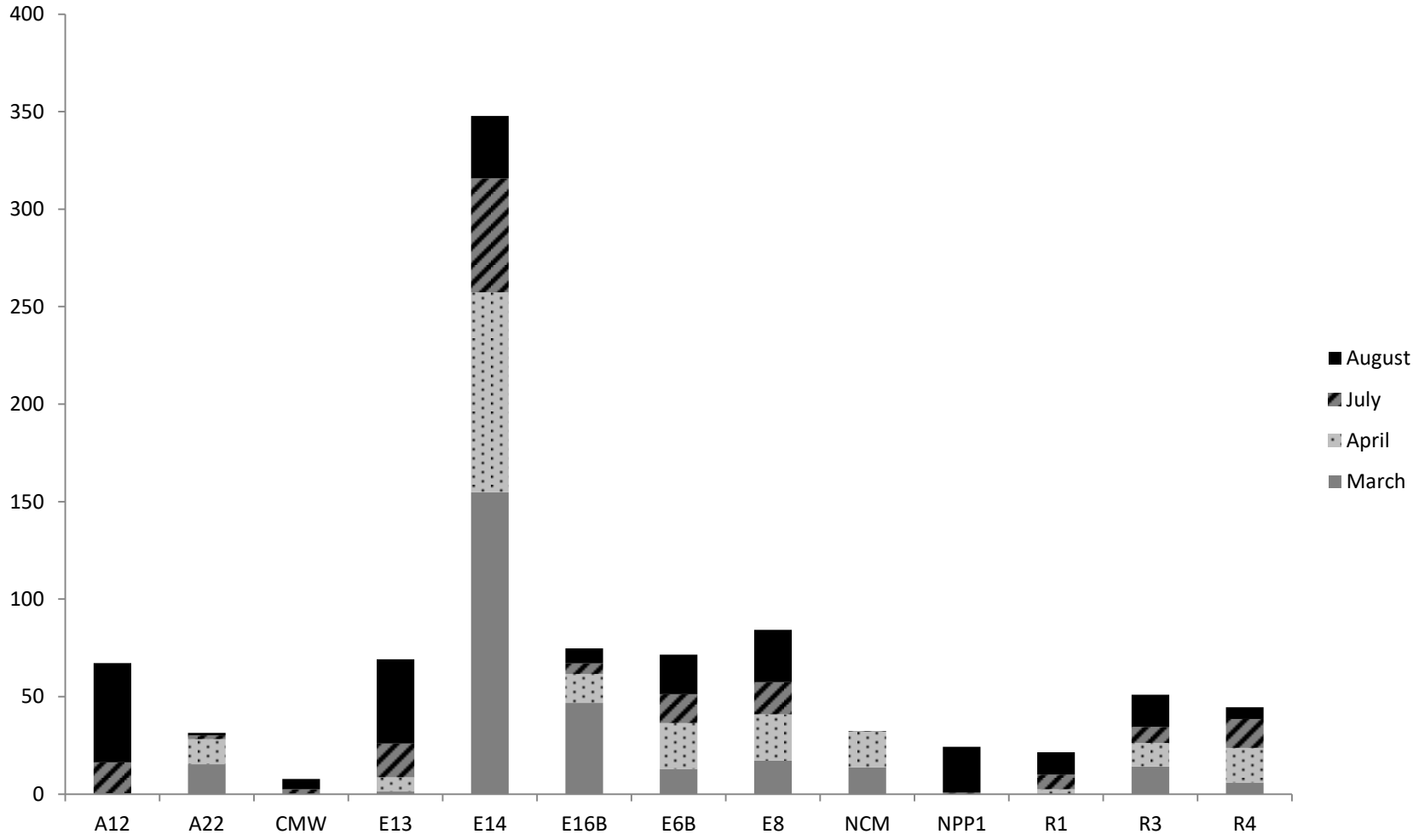

Figure 16. Average number of adult plovers observed per survey at select ponds during March, April, July and August, 2019. The purpose of this figure is to show that ponds are used by Snowy Plovers in varying intensity during the beginning and end of the breeding season.

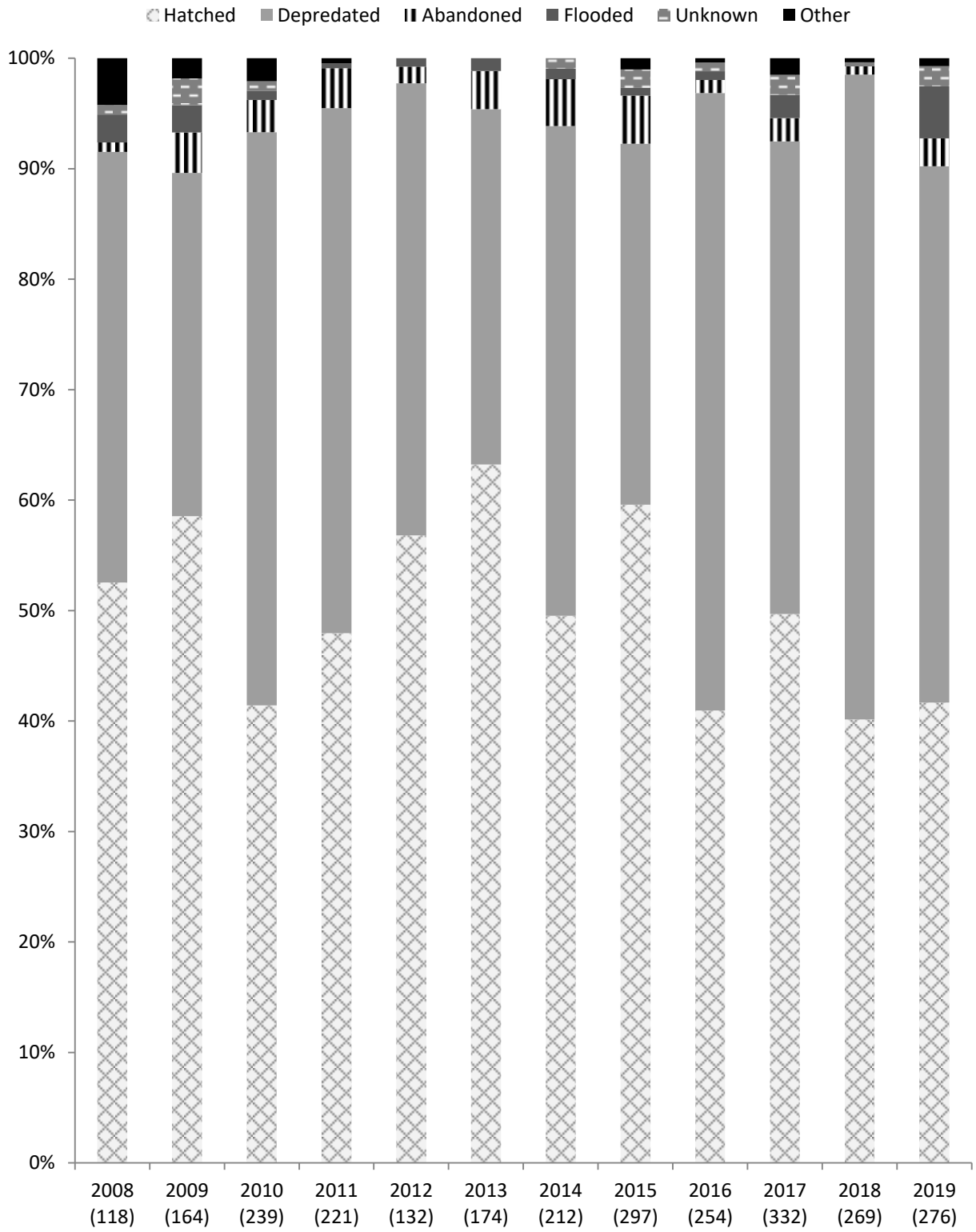

Figure 17. Annual apparent Snowy Plover nest fates in the South San Francisco Bay, California, 2008-2019. The number of nests monitored is indicated in parentheses beneath the year.

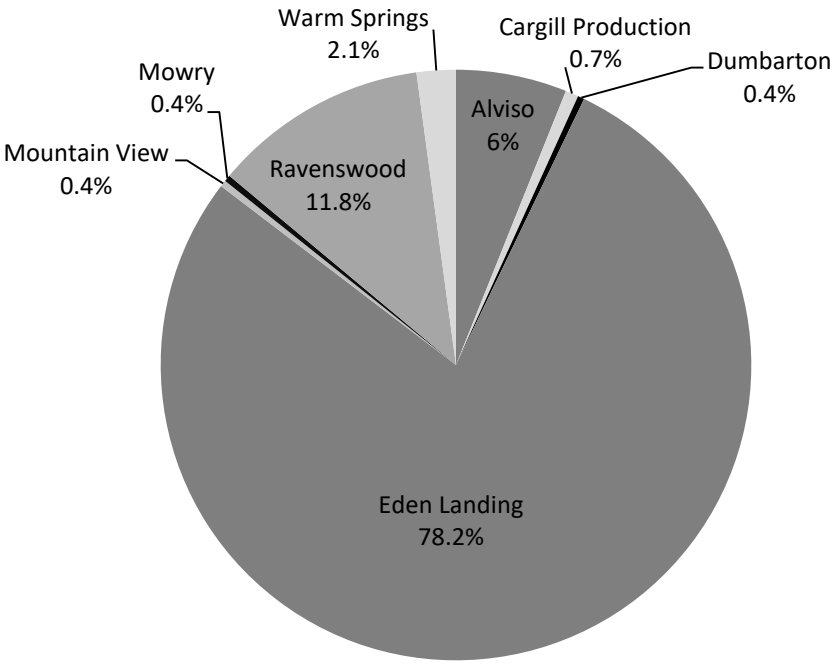

Figure 18. The proportion of Snowy Plover nests found in each pond complex in the South San Francisco Bay, California, 2019.

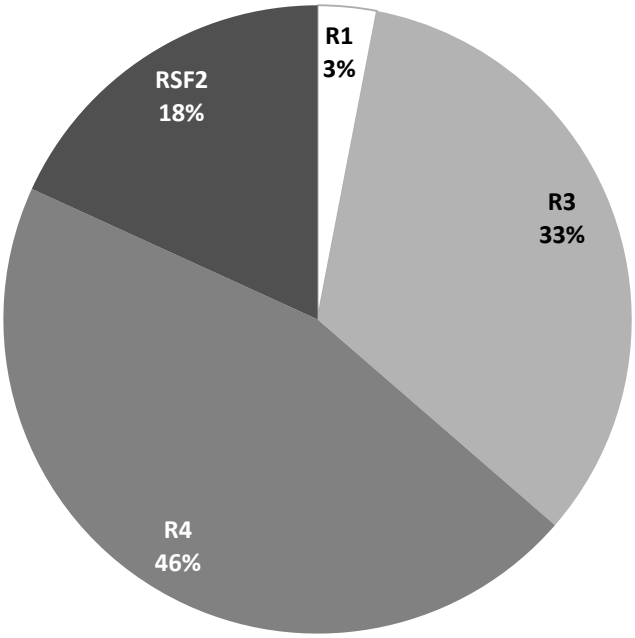

Figure 19. The proportion of Snowy Plover nests found in each Ravenswood pond within the Ravenswood Complex, Menlo Park, California, 2019.

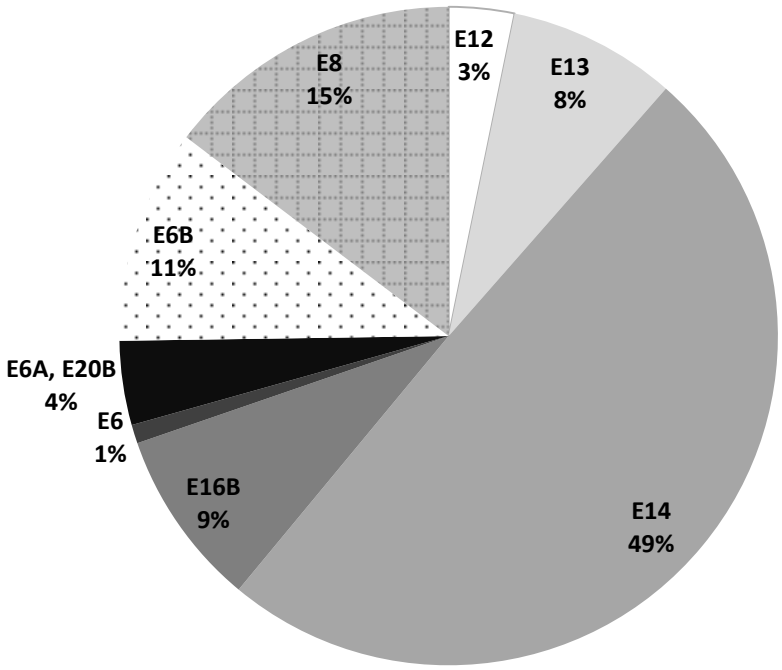

Figure 20. The proportion of Snowy Plover nests found in each Eden Landing pond within the Eden Landing Ecological Reserve in Hayward, California, 2019. Note that 49% of Eden Landing nests were found in pond E14.

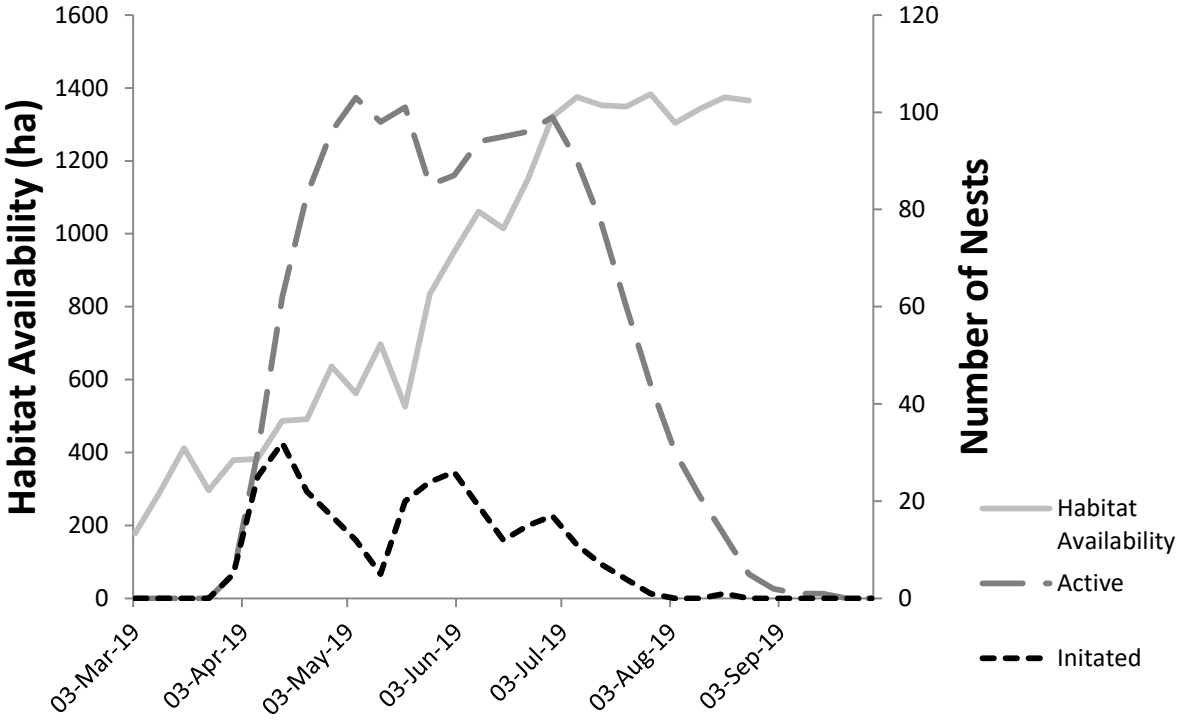

Figure 21. The weekly number of initiated and active Snowy Plover nests and estimated habitat availability in the South San Francisco Bay, California, 2019.

Figure 22. Individual cells within reconfigured Pond RSF2, Menlo Park, CA. Cell U3 is designated as Snowy Plover breeding habitat.

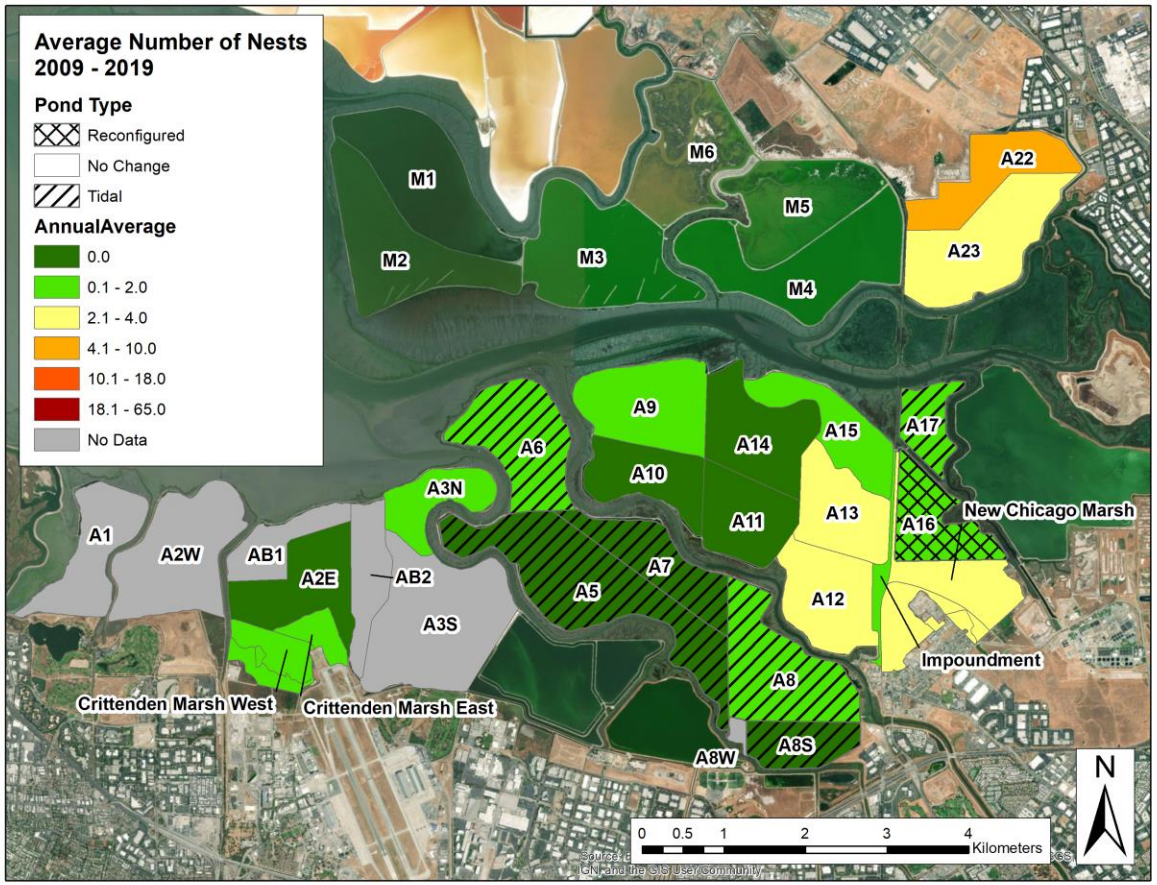

Figure 23. Average number of Snowy Plover nests initiated by pond in the Alviso Complex, South San Francisco Bay, California from 2009-2019. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds were included in Phase 1 actions 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 were enhanced for multiple species and the amount of habitat available to Snowy Plovers was reduced (not A16), and solid colors denote ponds that were not directly affected by Phase 1 actions. The gradient shading denotes the average number of Snowy 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.

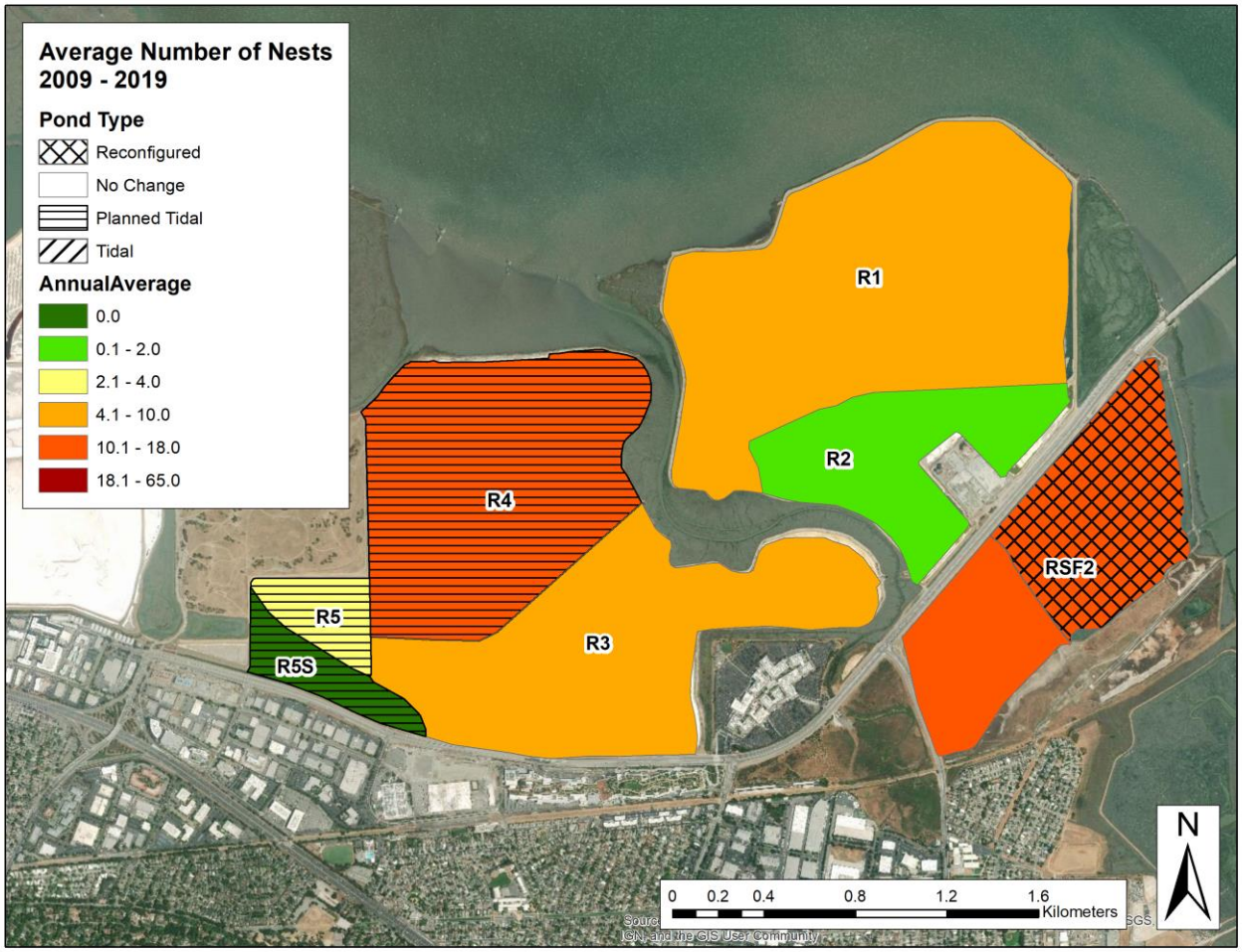

Figure 24. Average number of Snowy Plover nests initiated by pond in the Ravenswood Complex, South San Francisco Bay, California from 2009-2019. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds are included in Phase 2 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 2 actions. The gradient shading denotes the average number of Snowy Plover nests on the pond.

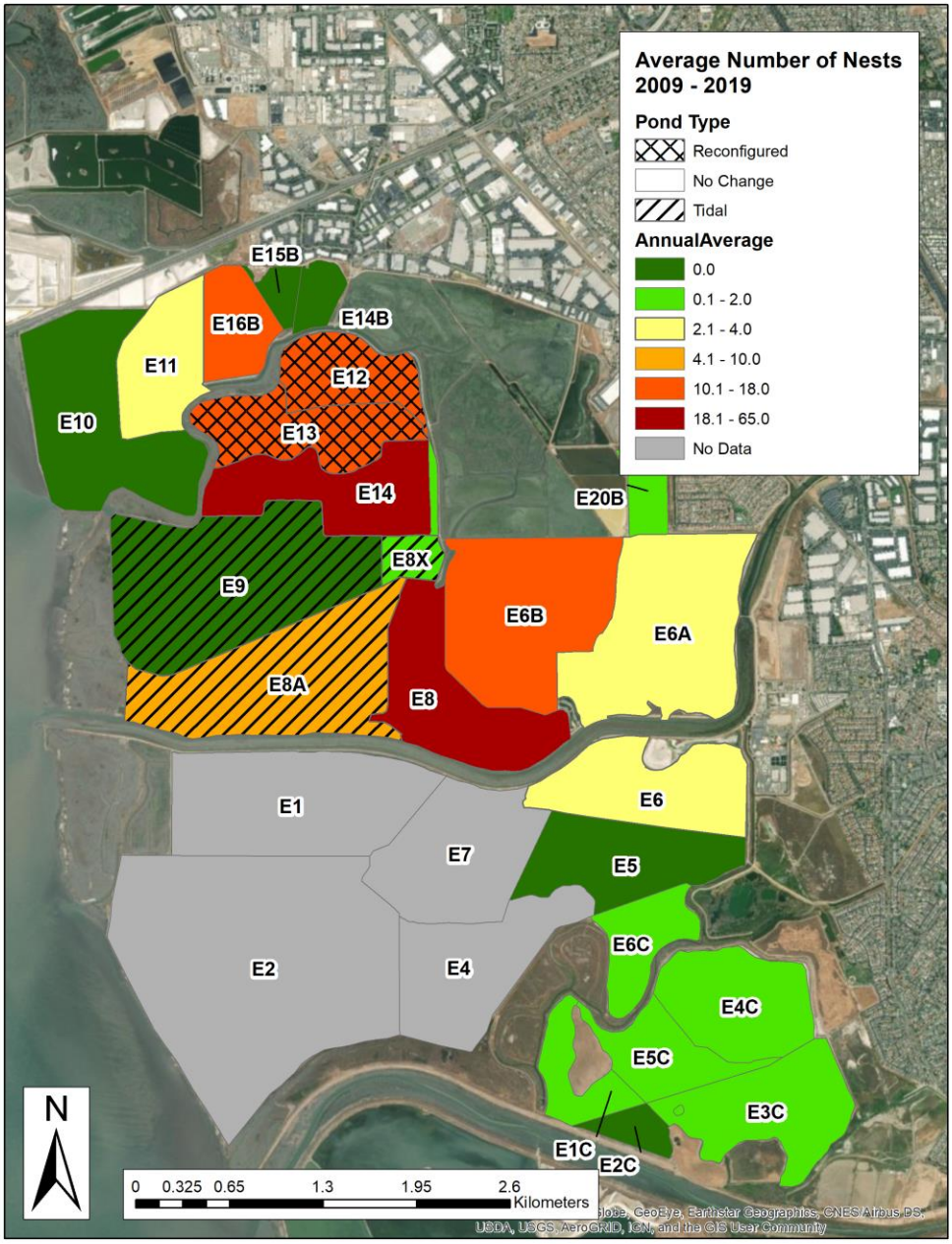

Figure 25. Average number of Snowy Plover nests initiated by pond in the Eden Landing Ecological Reserve, South San Francisco Bay, California from 2009-2019. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds were included in Phase 1 actions 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 was reduced, and solid colors denote ponds that will not be directly affected by Phase 2 actions. The gradient shading denotes the average number of Snowy Plover nests on the pond. Note that pond E3C is owned by Cargill and managed largely as open water.

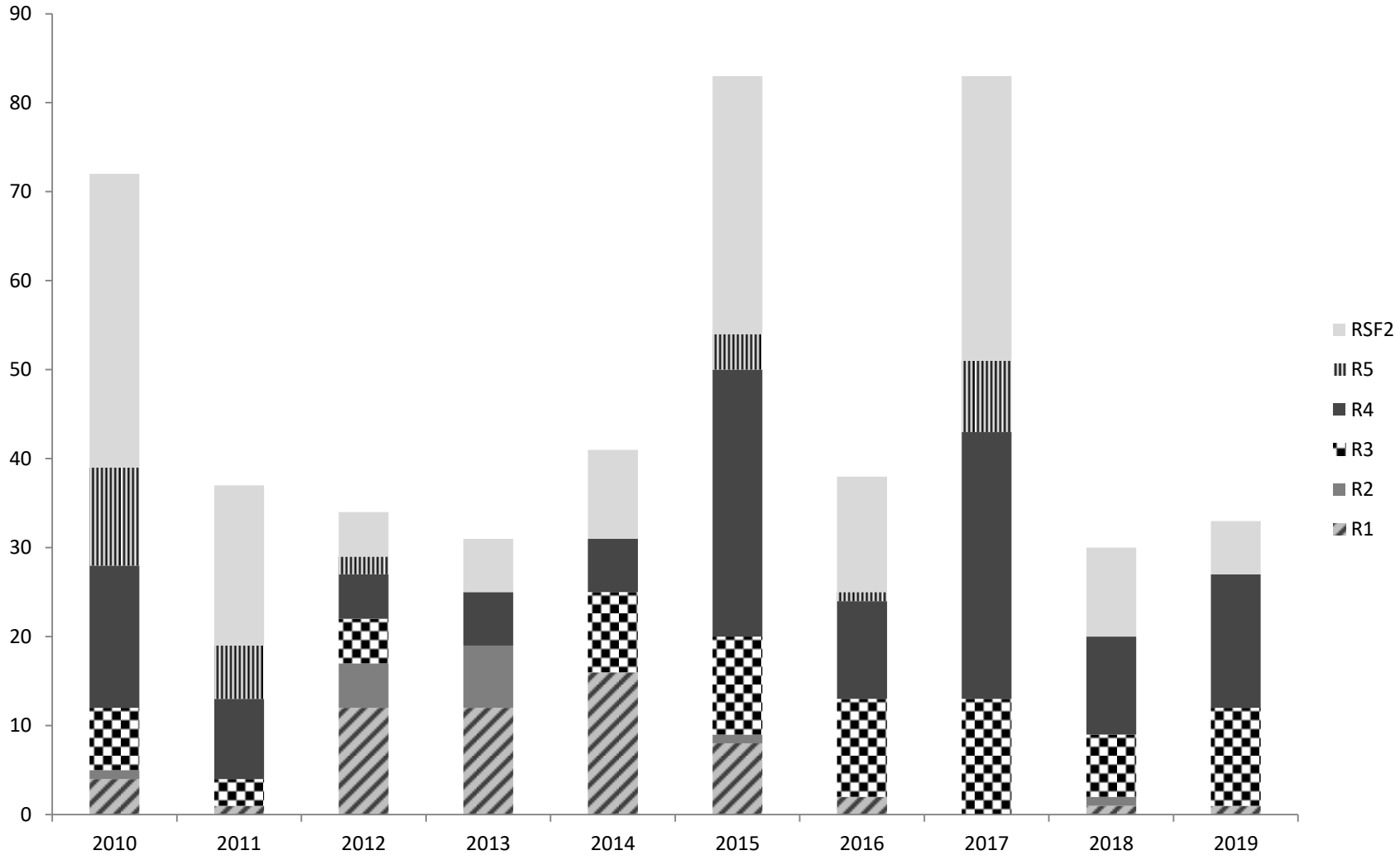

Figure 26. The number of snowy plover nests in the Ravenswood Complex (ponds R1-5, RSF2) in Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, California, from 2010-2019. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years.

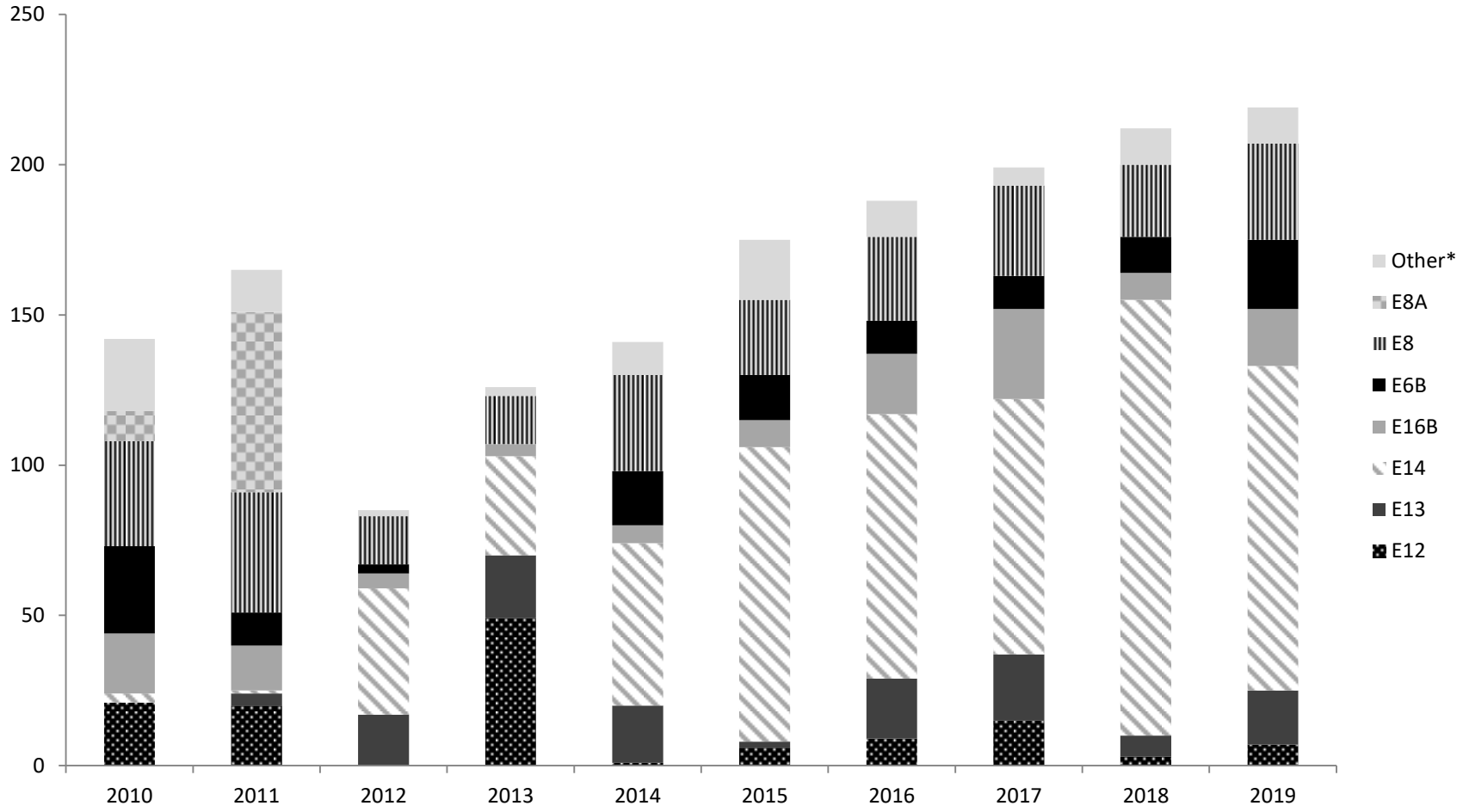

Figure 27. The number of Snowy Plover nests in Eden Landing Ecological Reserve, South San Francisco Bay, California, from 2010-2019. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years. It also shows an apparent positive trend in number of nests from 2012-2019. 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, E20B

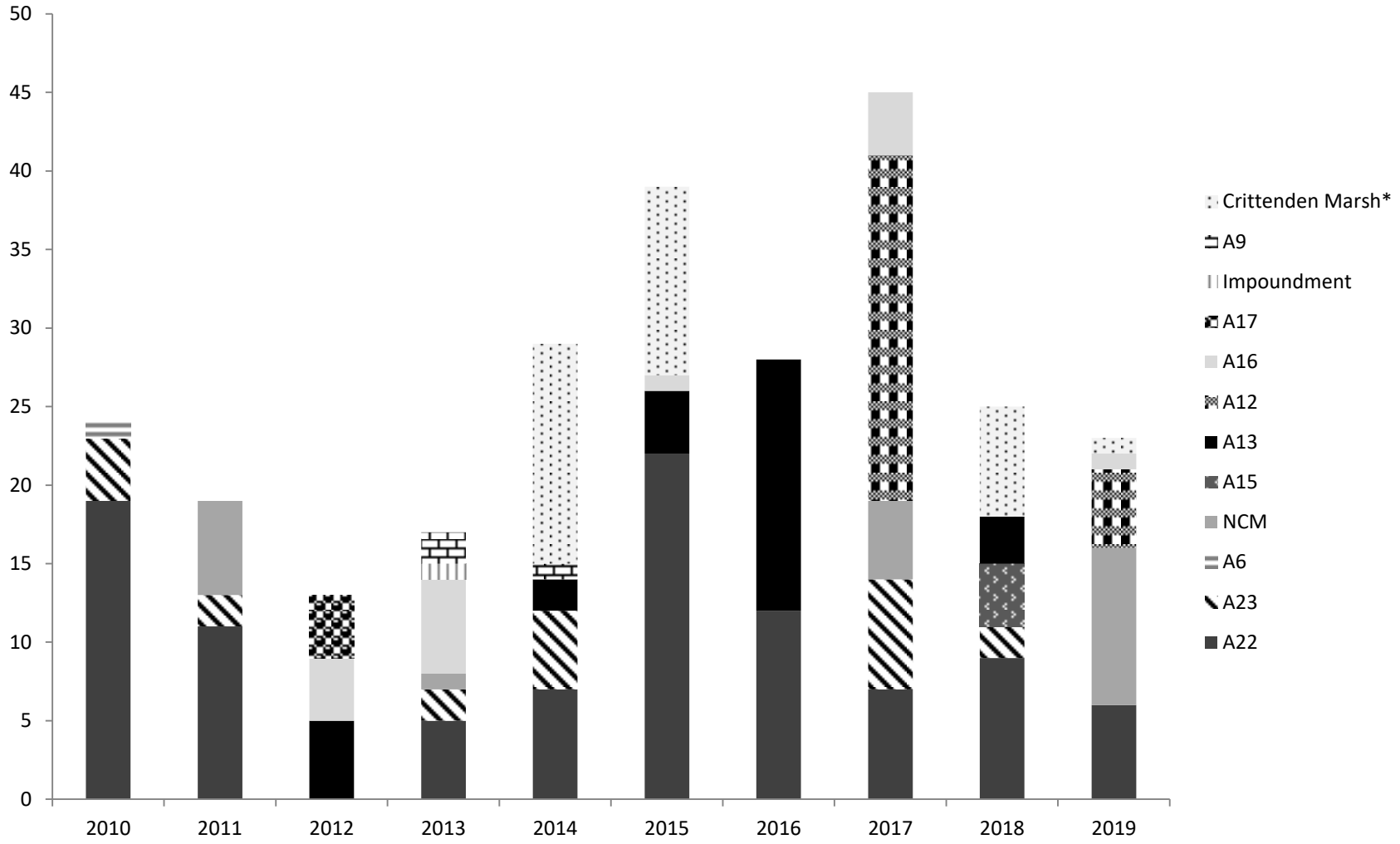

Figure 28. The number of Snowy Plover nests in the Alviso Complex in Don Edwards National Wildlife Refuge, South San Francisco Bay, California, from 2010-2019. Each year is subdivided into individual ponds where the nests were located. The purpose of this figure is to show the variability in use of these ponds for nesting between years.
*Includes ponds CMW, CME, and A3N

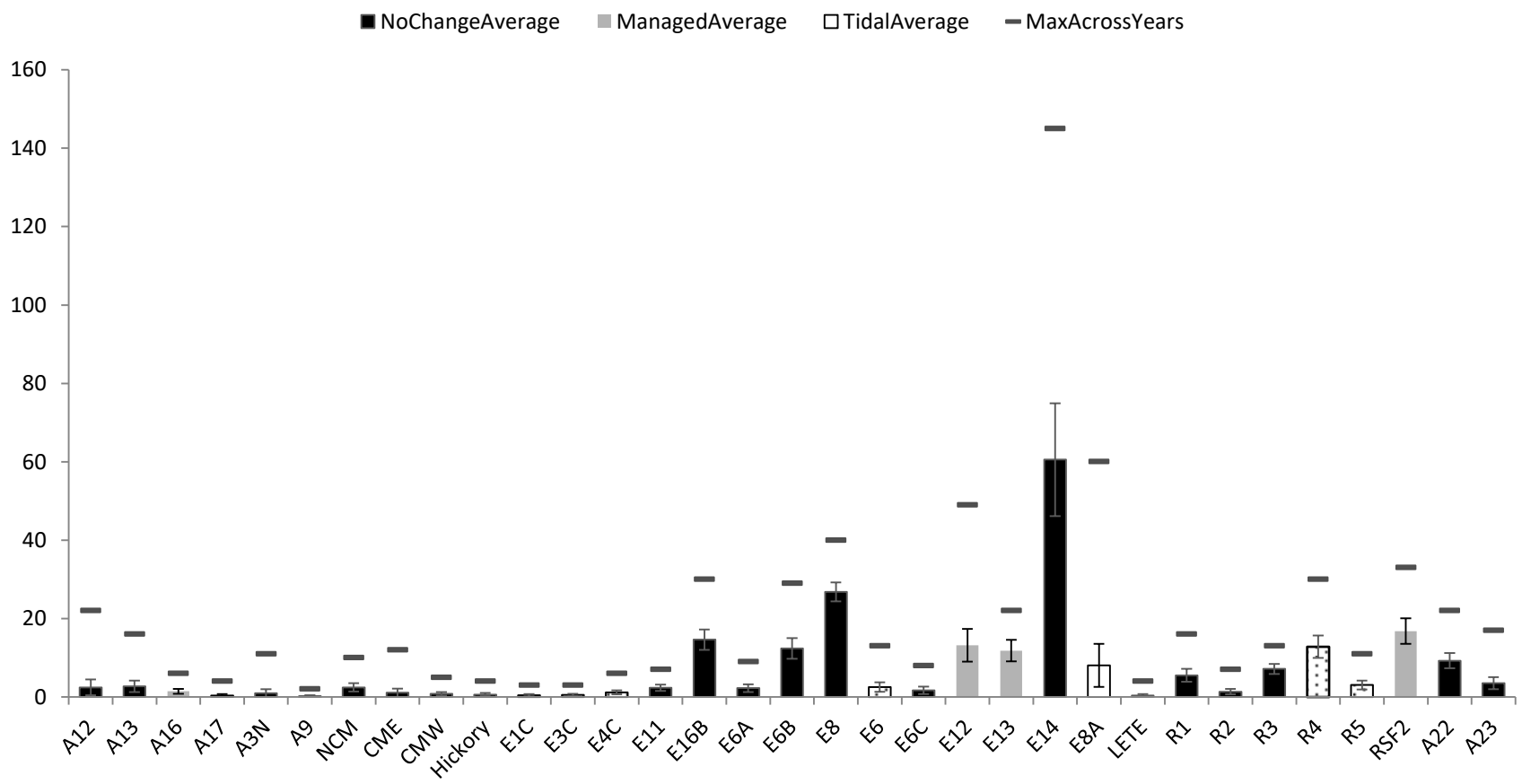

Figure 29. Average number of Snowy Plover nests initiated by pond in South SF Bay, CA from 2009-2019. Data are shown as mean + 1SD. The purpose of this figure is to illustrate which ponds have supported Snowy Plover nesting activity in recent years, and of these, which ponds were/are included in restoration plans of the South Bay Salt Pond Restoration Project. White bars denote ponds that were returned to tidal influence during Phase 1, dotted bars denote ponds that will be returned to tidal influence during Phase II, gray bars denote ponds that are managed for multiple species (at higher water levels) with reduced Snowy Plover habitat availability, black bars denote ponds that were not/will not be directly affected by Phase 1/2 actions, and black dashes denote the maximum number of nests at each pond across all years. Note that "NCM" = New Chicago Marsh, "CME" = Crittenden Marsh East, "CMW" = Crittenden Marsh West, and "LETE" = Hayward Least Tern Island; refer to Figs. 3-10 for other pond names and locations.

Table 1. Number of Western Snowy Plovers observed at Recovery Unit 3 sites during annual breeding window surveys in May, 2005-2019.

REGION	SITE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Alameda	Eden Landing	91	84	162	94	88	184	185	82	97	94	76	120	144	142	117
	Coyote Hills	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Crown Beach	-	-	-	-	-	-	-	-	-	0	0	0	-	-	-
	Dumbarton	0	0	2	0	0	0	0	0	0	0	0	0	2	7	2
	Hayward	0	0	0	1	4	12	8	9	32	7	2	4	0	7	12
	Warm Springs	23	7	0	3	14	27	17	3	1	11	24	14	2	20	7
Marin	Hamilton Wetlands	-	-	-	-	-	-	-	-	-	-	-	0	-	0	0
Napa	Napa	0			0	12	10	1	0	3	10	10	0	-	2	2
San Mateo	Ravenswood	3	3	23	24	21	42	27	33	59	45	68	42	76	51	48
Santa Clara	Alviso	7	8	20	11	8	0	11	20	10	0	1	21	19	4	1
	Mountain View	-	-	-	-	-	-	-	-	-	11	0	0	0	2	0
North Bay Delta	Montezuma Wetlands	-	-	-	-	-	-	-	-	-	-	14	6	3	0	0
Total Unit 3		**124**	**102**	**207**	**133**	**147**	**275**	**249**	**147**	**202**	**178**	**195**	**208**	**246**	**235**	**190**

Table 2. Ponds surveyed weekly within the Don Edwards San Francisco Bay National Wildlife Refuge, South San Francisco Bay, California, 2019.

Location	Ponds
Alviso	A12, A13, A15, A16, Impoundment, NCM
Dumbarton	NPP1, Hickory
Mountain View	CME, CMW, A2E, A3N
Ravenswood	R1, R2, R3, R4, R5, R5S, RSF2
Warm Springs	A22, A23

Table 3. Ponds surveyed weekly within California Department of Fish and Wildlife's Eden Landing Ecological Reserve, San Francisco Bay, California, 2019.

Location	Ponds
Eden Landing Ecological Reserve	E6, E6A, E6B, E8, E8XN, E10, E11, E12, E13, E14, E14B, E15B, E16B, E1C, E2C, E3C, E4C, E5C, E6C

Table 4. Additional areas surveyed in the San Francisco Bay, California, 2019. 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	N1, N2, N3
Eden Landing Ecological Reserve	CDFW	E1C-5C, E20B, North Creek Managed Pond

Table 5. Docent survey results at Alviso, Eden Landing, and Mountain View ponds.

Date	Location	Public Contact #	Group Size	Type	Info. Shared	Nature of Contact
3/30/19	E12-14	1	2	O	E,C,S	P
4/28/19	E12-14	1	6	P	E,P,C,R,S	P
4/28/19	E12-14	2	1	P		P
5/26/19	E12-14	0				
6/19/19	A12	1	1	P	C	P
6/19/19	A12	2	1	P	P,C,R	P
6/28/19	E12-14	1	2	P	E,C,R	P
6/28/19	E12-14	2	2	P	E,C	P
6/28/19	E12-14	3	2	P	E,P,H	P
6/28/19	E12-14	4	4	P	E,C	P
8/10/19	E12-14	1	3	P	E,R	P
8/9/19	CMW	1	1	B	P,C,S	P

8/9/19	CMW	2	1	P		E
8/16/19	CMW	1	2	P	E,P,C,H,S	P
8/16/19	CMW	2	1	B	E,C,S	P
8/21/19	CMW	1	1	P	E, P, C, H, S	P
8/21/19	CMW	2	2	P	E, C, H, S	P
8/21/19	CMW	3	1	B	E, P, C, H, S	P
8/21/19	CMW	4	1	B	E	P
8/21/19	CMW	5	1	B	E, P, C, H, S	P
8/21/19	CMW	6	1	B	E, C, H, S	P
8/26/19	E12-14	0				
8/28/19	CMW	1	1	P	E, P, C, H, S	P
8/28/19	CMW	2	1	B	E, P, C, H, S	P
8/28/19	CMW	3	1	P	E, P, C, H, S	P
8/28/19	CMW	4	1	B	E, P, C, H, S	P
8/28/19	CMW	5	1	B	E, P, C, H, S	P
8/28/19	CMW	6	1	B	E, P, C, H, S	P
9/6/19	CMW	1	1	B	E, C	E
9/6/19	CMW	2	1	B	E, P, C, H, S	P
9/6/19	CMW	3	1	B	E, P, C, H, S	P
9/6/19	CMW	4	1	B	E, P, C, H, S	P
9/6/19	CMW	5	1	B	E, P, C, R, H, S	P
9/6/19	CMW	6	1	B	C	E
9/6/19	CMW	7	1	B	E, P, C, H, S	P
9/6/19	CMW	8	2	B	E, P, C, H, S	P
9/18/19	CMW	1	1	B	E, P, C, R, H, S	P
9/18/19	CMW	2	1	B	E, P, C, S	P
9/28/19	E12-14	0				
10/26/19	E12-14	1	1	p	E	P

Type of interaction
P = Pedestrian
B = Bicyclist
O = Other

Information Shared
E = Snowy Plover breeding ecology
P = Salt pond history and site info.
C = Conservation status
R = Restoration project
H = How to get involved
S = SFBBO general

Nature of Contact
P = Positive
N = Negative
E = Neutral

Table 6. Potential avian predator species.

Common Name	**Scientific Name**
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrines*
Prairie Falcon	*Falco mexicanus*
Bald Eagle	*Haliaeetus leucocephalus*

Golden Eagle	*Aquila chrysaetos*
Cooper's Hawk	*Accipiter cooperii*
Red-Tailed Hawk	*Buteo jamaicensis*
White-tailed Kite	*Elanus leucurus*
Northern Harrier	*Circus Cyaneus*
California Gull	*Larus californicus*
Western Gull	*Larus occidentalis*
Herring Gull	*Larus argentatus smithsonianus*
Glaucous-winged Gull	*Larus glaucescens*
Mew Gull	*Larus canus*
Ring-Billed Gull	*Larus delawarensis*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Cattle Egret	*Bubulcus ibis*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Loggerhead Shrike	*Lanius ludovicianus*

Table 7. Potential mammalian predator species.

Common Name	**Scientific Name**
Red fox	*Vulpes vulpes*
Grey Fox	*Urocyon cinereoargenteus*
Striped Skunk	*Mephitis mephitis*
Virginia Possum	*Didelphis virginiana*
Domestic Cat	*Felis catus*
Coyote	*Canis latrans*

Table 8. Snowy Plover nest fates by pond in the South San Francisco Bay, California, 2019.

Location	Hatched	Depredated	Abandoned	Flooded	Failed to Hatch	Unknown	Total Nests
Alviso							
NCM	1	1	0	8	0	0	**10**
A12	2	4	0	0	0	0	**6**
A16	1	0	0	0	0	0	**1**
Cargill Prod.	0	0	0	0	0	2	**2**
Dumbarton							
Hickory	1	0	0	0	0	0	**1**
Eden Landing							
E20B	0	1	0	0	0	0	**1**
E6A	4	4	0	0	1	0	**8**
E6B	4	18	1	0	0	0	**23**
E8	11	17	3	0	0	1	**32**
E12	4	3	0	0	0	0	**7**
E13	8	10	0	0	0	0	**18**
E14	44	55	3	2	0	4	**108**
E16B	11	4	0	3	1	0	**19**
E6	1	1	0	0	0	0	**2**
Mountain View							
CMW	1	0	0	0	0	0	**1**
Mowry							
M5	1	0	0	0	0	0	**1**
Ravenswood							
R1	1	0	0	0	0	0	**1**
R3	8	3	0	0	0	0	**11**
R4	9	6	0	0	0	0	**15**
RSF2	1	5	0	0	0	0	**6**
Warm Springs							
A22	2	4	0	0	0	0	**6**
Hayward							
LETE	7	2	0	0	0	0	**9**
OBN1-16	0	0	0	0	0	0	**0**
Total South Bay	**122**	**136**	7	13	2	7	**288**
Montezuma Wet.	0	1	0	0	0	1	**2**
Napa-Sonoma Marsh Wildlife Area	0	0	0	0	0	0	**0**
Total North Bay	**0**	1	**0**	**0**	**0**	1	**2**
RU3 Total	**122**	**137**	**7**	**13**	**2**	**8**	**290**

Table 9. Undetected successful nests in 2019 inferred by presence of unaccounted for broods on ponds.

Pond	# Nests
A12	6
A22	3
Cargill Newark Prod. Ponds	2
CMW	1
E6	1
E13	1
E14	1
Franks Dump	1
Hickory	1
NCM	1
NPP1	2
OBN 1-16	2
R1	2
R2	1
R4	2
R5	1
Total	**28**

Table 10. Snowy Plover averaged apparent nest densities (nest/ha) by pond on Refuge property in the South San Francisco Bay, California, 2019. 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 Nests/Ha
A12	0.007
A16	0.151
A22	0.023
CMW	0.046
Hickory	0.008
NCM	0.430
R1	0.001
R3	0.028
R4	0.032
RSF2	0.039
M5	N/A*

*Habitat data not collected

Table 11. Snowy Plover averaged apparent nest densities (nests/ha) by pond at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2019. 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 Nests/Ha
E12	0.569
E13	0.307
E14	0.390
E16B	0.135
E6	0.181
E6A	0.035
E6B	0.087
E8	0.565
E20B	N/A*

*Habitat data not collected

Table 12. Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, California, 2008-2019. Chicks were considered fledged if they survived to 31 days (2008-2016), and 28 days (2017-2019). *N* is the number of chicks banded.

Year	N	Fledging Success
2019	60	32%
2018	31	19%
2017	55	44%
2016	66	27%
2015	116	34%
2014	52	27%
2013	14	36%
2012	8	50%
2011	36	14%
2010	39	41%
2009	113	25%
2008	83	29%

Table 13. Apparent fledging success of Snowy Plover chicks by pond and chicks fledged per male in the South San Francisco Bay, California, 2019. Chicks were considered fledged if they survived to 28 days. *N* is the number of individuals banded.

Pond	N	Fledged	Fledging Success	Males	Chicks fledged/Male
E14	29	8	28%	11	0.73
E16B	14	10	71%	5	2
E13	6	0	0%	2	0
E8	3	0	0%	1	0

E6B	2	0	0%	1	0
Hickory	3	0	0%	1	0
CMW	3	1	33%	1	1
Total	**60**	**19**	**32%**	**22**	**0.86**

Table 14. Chi-square analyses for nest habitat type selection.

	χ2	***df***	***p-value***
2019	69.68	2	$7.395e^{-16}$

Table 15. Summary of logistic regression models of E14 nest fate tested and associated Akaike information criterion (AIC). The purpose of this table is to explain the decision making process for the model that was selected.

Model	AIC
Adj. Fate ~ Near_Dist *NumNbr_100m * Day. Initiation.Adj*Adj.Treatment2	83.642
Adj. Fate ~ NumNbr_100m * Day. Initiation.Adj	73.145
Adj. Fate ~ NumNbr_100m	83.285
Adj. Fate ~ Day. Initiation.Adj	81.436
Adj. Fate ~ Near_Dist	83.613
Adj.Fate ~ Adj.Treatment2	N/A

Table 16. Summary of logistic regression values of Snowy Plover nest fate by number of nest neighbors within 100m and date of nest initiation transformed in Pond E14, Eden Landing Ecological Reserve, Hayward, California, 2019.

Coefficients	Estimate	SE	z value	Pr(>|z|)
(Intercept)	-12.703	4.322	-2.939	0.003**
NumNbr_100m	3.493	1.247	2.800	0.005**
Day.Initiation.Adj	0.084	0.029	2.946	0.003**
NumNbr_100m .Day.Initiation.Adj	-0.023	0.008	-2.791	0.005**

Table 17. Daily nest survival (DSR) outputs for all plover nests in pond E14 in Eden Landing Ecological Reserve, Alameda County, California in 2019. *indicates significance. Note: confidence intervals containing zero are not significant; negative intervals indicate a decrease in survival; positive intervals indicate an increase in survival.

Model	Parameters	Estimate	SE	Lcl	Ucl	DSR Day 1	DSR Day 182
Dot		3.0825	0.1318	2.8242	3.3407	0.9562	0.9562
Camera		-0.1000	0.0000	-0.1000	-0.1000	0.9562	0.9562
Distance to Levee		-0.0030	0.0028	-0.0084	0.0025	0.9561	0.9561
Nest Age		0.0323	0.0179	-0.0027	0.0673	0.5138	0.9973
Time		0.0039	0.0044	-0.0048	0.0125	0.9385	0.9685

Time by Treatment	Time * Western	0.0016	0.0092	-0.0163	0.0196	0.9297	0.9702
	Time * Eastern	0.0020	0.0092	-0.0160	0.0199	0.9370	0.9748
	Time * Non	-0.0044	0.0105	-0.0250	0.0161	0.9490	0.9527

Table 18. Summary of negative binomial regression values of Snowy Plover brooding behavior by chick status and treatment area in Pond E14, Eden Landing Ecological Reserve, Hayward, California, 2019.

	Estimate	St. Error	z-value	p-value
(Intercept)	6.9745	1.1690	5.966	$2.43e^{-9***}$
ChStatus	-2.0256	0.5339	-3.794	0.000148***
HabType	-1.2909	0.5360	-2.408	0.016020*

Table 19. Summary of negative binomial regression values of Snowy Plover roosting behavior by chick status and treatment area in Pond E14, Eden Landing Ecological Reserve, Hayward, California, 2019.

	Estimate	St. Error	z-value	p-value
(Intercept)	-0.36522	0.3851	5.757	$8.54e^{-9***}$
ChStatus	1.48359	0.1727	0.836	0.403
HabType	-0	0.1768	1.469	0.142

Table 20. Summary of negative binomial regression values of Snowy Plover foraging behavior by chick status and treatment area in Pond E14, Eden Landing Ecological Reserve, Hayward, California, 2019.

	Estimate	St. Error	z-value	p-value
(Intercept)	2.2170	0.3851	5.757	$8.54e^{-9***}$
ChStatus	0.1443	0.1727	0.836	0.403
HabType	0.2597	0.1768	1.469	0.142

Table 21. The average number of predators observed per survey (in parentheses) at the Ravenswood Complex, South San Francisco Bay, California, March-September 2019.

Predator Species	**R1 (21)**	**R2 (21)**	**R3 (28)**	**R4 (28)**	**R5 (28)**	**R5S (28)**	**RSF2 (26)**
Unidentified Gull	49.76	0.24	0.93	4.89	0.04	0.38	46.08
California Gull	24.19	27	2.75	26.25	0.44	1.17	14.04
American Crow	0.10	0.14	9	1.5	2.96	0.67	2.12
Snowy Egret	0.14	0	0.43	0.32	0	0.33	8.54
Great Egret	0.10	0	0.36	0.04	0	0	4.46
Common Raven	0.81	0.67	0.5	0.64	0.63	0	0.08
Ring-billed Gull	0.10	0	0	0.04	0	0.08	2.5
Great Blue Heron	0.14	0	0	0.07	0	0	1.58
Black-crowned Night-Heron	0.05	0	0	0	0	0	1.19
Red-tailed Hawk	0	0	0.04	0	0	0	0.58

White-tailed Kite	0	0	0.14	0.18	0	0	0.08
Herring Gull	0	0	0	0.04	0	0	0.27
Peregrine Falcon	0.14	0.05	0	0.11	0	0	0
Northern Harrier	0	0	0.04	0.18	0	0	0.04
Feral Cat	0	0	0	0	0	0	0.23
Western Gull	0	0	0.04	0.04	0	0	0.08
American Kestrel	0	0	0.04	0	0	0	0.04
Glaucous Gull	0	0	0	0	0	0	0.04
Burrowing Owl	0	0	0	0.04	0	0	0
Merlin	0	0	0.04	0	0	0	0
Red-shouldered Hawk	0	0	0.04	0	0	0	0

Table 22.The average number of predators observed per survey at the Alviso Complex, South San Francisco Bay, California, March-September 2019.

Predator Species	A12 (27)	A13 (19)	A15 (19)	A16 (28)	Impound. (25)	NCM (28)
Unidentified Gull	23.63	38.84	82.63	216.25	0.48	105.46
California Gull	58.22	28.21	50.00	22.11	1.72	6.96
Snowy Egret	0.00	0.00	0.05	9.14	0.04	1.04
Great Egret	0.07	0.05	0.00	4.71	0.00	0.43
Common Raven	0.67	0.21	0.32	1.71	0.04	0.64
Great Blue Heron	0.00	0.00	0.05	1.14	0.00	0.11
American Crow	0.37	0.00	0.00	0.04	0.00	0.82
Ring-billed Gull	0.00	0.00	0.00	0.39	0.24	0.57
Herring Gull	0.04	0.00	0.00	0.25	0.00	0.64
Black-crowned Night-Heron	0.00	0.00	0.00	0.86	0.00	0.00
Mew Gull	0.00	0.00	0.00	0.04	0.00	0.71
Glaucous-winged Gull	0.00	0.00	0.00	0.29	0.00	0.07
Northern Harrier	0.15	0.05	0.11	0.04	0.00	0.00
Peregrine Falcon	0.15	0.00	0.05	0.00	0.00	0.00
Unidentified Predator	0.19	0.00	0.00	0.00	0.00	0.00
Feral Cat	0.04	0.00	0.00	0.00	0.00	0.11
Red-tailed Hawk	0.00	0.00	0.00	0.00	0.00	0.11
Western Gull	0.00	0.00	0.00	0.07	0.00	0.00
Domestic Dog	0.00	0.00	0.00	0.00	0.00	0.04
Glaucous Gull	0.00	0.00	0.00	0.04	0.00	0.00
Sharp-shinned Hawk	0.00	0.00	0.00	0.00	0.00	0.04
White-tailed Kite	0.00	0.00	0.00	0.04	0.00	0.00

Table 23. The average number of predators observed per survey at Mountain View Ponds, South San Francisco Bay, California, March-September 2019.

Predator Species	A2E (8)	CME (19)	CMW (19)
Snowy Egret	0	4.95	29.84
Unidentified Gull	5	1.53	26.63
Great Egret	0.13	0.53	7.32

California Gull	0	0	1.42
Red-tailed Hawk	0	0.05	0.37
Common Raven	0	0	0.26
Great Blue Heron	0	0.05	0.16
White-tailed Kite	0	0	0.16
Northern Harrier	0	0.05	0.05
Black-crowned Night-Heron	0	0	0.05
Ring-billed Gull	0	0.05	0
Sharp-shinned Hawk	0	0	0.05

Table 24. The average number of predators observed per survey at Warm Springs, South San Francisco Bay, California, March-September 2019.

Predator Species	A22 (26)	A23 (26)
Unidentified Gull	16.54	34.46
California Gull	23.12	8.62
Snowy Egret	3.35	0.08
Common Raven	1.69	0.12
Red-tailed Hawk	0.92	0.85
Great Egret	0.92	0.04
Peregrine Falcon	0.15	0.42
Black-crowned Night-Heron	0.35	0.00
Great Blue Heron	0.27	0.04
American Crow	0.23	0.04
Bald Eagle	0.19	0.00
Northern Harrier	0.15	0.04
Ring-billed Gull	0.15	0.00
American Kestrel	0.08	0.04
Herring Gull	0.12	0.00
White-tailed Kite	0.12	0.00

Table 25. The average number of predators observed per survey at Dumbarton Complex, South San Francisco Bay, California, March-September 2019.

Predator Species	Hickory (27)	NPP1 (27)
American Crow	0.07	0.00
California Gull	0.00	1.15
Common Raven	0.11	0.04
Peregrine Falcon	0.04	0.00
Red-tailed Hawk	0.30	0.00
Snowy Egret	0.63	0.00
Unidentified Gull	0.11	0.44
White-tailed Kite	0.04	0.00

Table 26. The average number of predators observed per survey in South Eden Landing Ecological Reserve, South San Francisco Bay, California, March-September 2019.

Predator Species	E1C (20)	E2C (20)	E3C (20)	E4C (20)	E5C (20)	E6 (16)	E6C (12)
Unidentified Gull	6.75	0.15	19.85	16.10	6.30	6.13	0.00
California Gull	2.40	0.85	3.25	9.65	6.30	2.50	2.50
Snowy Egret	2.75	1.30	2.20	0.00	1.60	4.13	0.08
Great Egret	1.25	0.25	1.85	0.10	0.25	2.13	0.00
Mew Gull	0.00	0.00	0.00	0.00	0.00	0.88	0.00
Great Blue Heron	0.15	0.00	0.00	0.05	0.00	0.19	0.00
Ring-billed Gull	0.00	0.00	0.25	0.00	0.00	0.00	0.00
Black-crowned Night-Heron	0.00	0.05	0.00	0.00	0.00	0.19	0.00
White-tailed Kite	0.05	0.00	0.00	0.05	0.00	0.00	0.08
Common Raven	0.00	0.00	0.05	0.05	0.00	0.00	0.00
Western Scrub-Jay	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Northern Harrier	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Red-tailed Hawk	0.05	0.00	0.00	0.00	0.00	0.00	0.00

Table 27. The average number of predators observed per survey at the Whales Tail loop, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-September 2019.

Predator Species	E12 (29)	E13 (29)	E14 (29)	E8XN (29)
California Gull	14.59	47.55	1.55	0.00
Unidentified Gull	10.45	30.83	1.79	0.00
Snowy Egret	5.76	4.86	4.31	0.86
Great Egret	4.35	3.38	1.41	0.39
Western Gull	0.59	0.41	0.07	0.00
Great Blue Heron	0.24	0.35	0.07	0.18
American Crow	0.83	0.00	0.00	0.00
Northern Harrier	0.03	0.00	0.69	0.00
Peregrine Falcon	0.00	0.07	0.52	0.00
Ring-billed Gull	0.21	0.35	0.00	0.00
Black-crowned Night-Heron	0.14	0.31	0.03	0.00
Bonaparte's Gull	0.41	0.00	0.00	0.00
Common Raven	0.00	0.10	0.24	0.00
Red-tailed Hawk	0.10	0.03	0.10	0.07
White-tailed Kite	0.03	0.07	0.17	0.04
Herring Gull	0.07	0.07	0.00	0.00
Burrowing Owl	0.07	0.03	0.00	0.00
Bald Eagle	0.03	0.00	0.03	0.00
Merlin	0.00	0.00	0.03	0.00
Red Fox	0.00	0.00	0.03	0.00

Table 28. The average number of predators observed per survey at the Old Alameda Creek Loops, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-September 2019.

Predator Species	E6A (28)	E6B (28)	E8 (29)
Unidentified Gull	83.54	14.29	0.28
California Gull	50.71	29.43	2.97
Snowy Egret	19.07	13.36	1.55
Great Egret	8.89	4.14	0.48
Black-crowned Night-Heron	2.04	0.04	0.10
Western Gull	0.00	1.64	0.07
Red-tailed Hawk	1.07	0.11	0.03
Great Blue Heron	0.57	0.25	0.10
White-tailed Kite	0.39	0.00	0.45
Peregrine Falcon	0.36	0.29	0.17
Northern Harrier	0.11	0.18	0.24
Common Raven	0.04	0.25	0.00
Herring Gull	0.18	0.00	0.03
American Crow	0.14	0.00	0.00
Ring-billed Gull	0.04	0.04	0.07
Bald Eagle	0.07	0.04	0.00
Cooper's Hawk	0.04	0.00	0.07
Prairie Falcon	0.00	0.00	0.03

Table 29. The average number of predators observed per survey at the Mount Eden Creek Loop, Eden Landing Ecological Reserve, South San Francisco Bay, California, March-September 2019.

Predator Species	E10 (25)	E11 (25)	E14B (26)	E15B (26)	E16B (26)
Unidentified Gull	20.52	22.24	0.00	0.00	0.46
California Gull	1.00	31.60	0.04	0.00	0.04
Snowy Egret	8.48	3.12	1.23	0.15	2.23
Great Egret	3.68	1.88	0.35	0.00	1.00
Western Gull	0.16	1.24	0.00	0.00	0.00
Ring-billed Gull	0.00	1.00	0.00	0.00	0.00
Great Blue Heron	0.40	0.36	0.04	0.00	0.00
Peregrine Falcon	0.00	0.00	0.00	0.04	0.50
Black-crowned Night-Heron	0.32	0.16	0.00	0.00	0.00
White-tailed Kite	0.00	0.00	0.00	0.04	0.27
American Crow	0.00	0.00	0.04	0.04	0.12
Common Raven	0.00	0.00	0.00	0.08	0.00
Northern Harrier	0.00	0.00	0.00	0.00	0.08
Red-tailed Hawk	0.00	0.00	0.00	0.00	0.08

Bald Eagle	0.04	0.00	0.00	0.00	0.00
Glaucous-winged Gull	0.00	0.00	0.00	0.00	0.04
Herring Gull	0.04	0.00	0.00	0.00	0.00
Merlin	0.00	0.00	0.04	0.00	0.00

Table 30. Recorded depredation events determined with nest cameras at Eden Landing Ecological Reserve in the South San Francisco Bay, California, 2009-2011, 2015-2019.

Year	Pond	Predator Spp.	Count
2009	E16B	RTHA	2
2009	E8X	UNID	1
2009	E12	CORA	1
2009	E8	NOHA	1
2009	E8A	NOHA	1
2009	E12	NOHA	1
2010	E6B	RUTU	1
2010	E8	CAGU	1
2010	E6	CAGU	1
2010	E6B	GRFO	1
2011	E12	CAGU	1
2011	E8A	CAGU	1
2011	E13	CAGU	1
2011	E8	RTHA	1
2015	E14	CORA	6[1]
2015	E14	UNID	1
2016	E14	CORA	30[1]
2017	E14	CORA	5
2017	E14	UNID	1
2017	E14	REFO	2[2]
2018	E14	CORA	2
2018	E14	REFO	9
2018	E14	REFO	1[3]
2019	E14	CORA	2
2019	E14	NOHA	1[4]
2019	E14	MEME	1

[1]One nest hatched after partial depredation event
[2]One nest depredated after one chick hatched
[3]At least two of three chicks depredated after hatch
[4]Visual observation of nest depredation

Table 31. Snowy Plover color band combinations deployed in 2019

Color combination
ak:bg
ak:py
ak:wy
ak:yy
gk:ar
gk:rw
gk:ry
ka:gb
ka:gy
ka:oy
ka:pb
ka:ry
ka:bw
kk:ag
kk:gg
kk:oy
kk:pg
kk:pw
kk:py
kk:ry
kk:wy
kk:yb
kk:yy
ko:ab
ko:bw
ko:gb
ko:gw
ko:wr
ko:yb
on:ar
on:gg
on:pb
on:py
on:rg
on:rw
on:yr
on:yw
rk:by
rk:gr

Color combination
rk:gy
rk:oy
rk:py
rk:ww
rk:yg
rk:yy
wn:ag
wn:ar
wn:bb
wn:bg
wn:br
wn:bw
wn:by
wn:gy
wn:or
wn:oy
wn:pr
wn:py
wn:rb
wn:rr
wn:wg

a = aqua, b = blue, g= green, k = black, n = brown, o =orange, p = pink, r = red, v = violet, w = white

Table 32. Snowy Plover color band combinations deployed by SFBBO in prior years observed in 2019

Color combination
ak:bw
ak:ry
ak:yw
gk:py
gk:rg
gk:yb
ka:ag
ka:bb
ka:gr
ka:rb
kk:ab
kk:bg
kk:gr
kk:gy

Color combination
kk:or
kk:rb
kk:wg
kk:wr
kk:yg
ko:gy
ko:or
on:gw
rk:og
rk:wb
rk:wg
rk:yr
wb:ra
wn:yr
ws:wx
yv:gw
yv:or
yv:rw