SAN FRANCISCO BAY
BIRD OBSERVATORY

WESTERN SNOWY PLOVER AND CALIFORNIA LEAST TERN MONITORING IN THE SAN FRANCISCO BAY ANNUAL REPORT 2023

Prepared By:
Maddy Schwarz, Plover Program Director
Katie LaBarbera, Landbird Program Director
Josh Scullen, Senior Biologist
San Francisco Bay Bird Observatory
524 Valley Way, Milpitas, CA 95035

For:
Rachel Tertes, Don Edwards San Francisco Bay National Wildlife Refuge
Carly White & Karen Taylor, California Department of Fish and Wildlife
Laura Cholodenko & Dave Halsing, California State Coastal Conservancy
Donna Ball, San Francisco Estuary Institute
Amy Larson, California Wildlife Foundation
Renee Spenst, Ducks Unlimited

January 24, 2024

CONTENTS

Executive Summary 1
Introduction and Background 5
Snowy Plovers 5
Least Terns 6
Methods 6
Study Area 6
United States Fish and Wildlife Service 6
California Department of Fish and Wildlife 7
Hayward Area Recreation and Parks District and East Bay Regional Parks District 7
Other South Bay Landowners 7
Other North Bay Landowners 7
Field Surveys 8
Survey Frequency and Timing 8
Survey Protocol 8
Nest Monitoring 9
Snowy Plover Color Banding 10
Chick Banding 10
Adult Banding 10
Calculated Metrics 10
Snowy Plover Nest Densities 10
Hatch Rate 10
Fledge Rate 10
Number of Males 11
Chicks Fledged per Male 11
Snowy Plover Return Rates 11
Oyster Shell Habitat 11
E14 Large Scale Enhancement 11
Other Shelled Sites 12
Predator Surveys 12
Camera Traps 13
Habitat Availability 13
Habitat Enhancement 13

Volunteer Events....13
Predator Fence....13
Rehabilitation....14
Results....14
Field Surveys....14
Survey Frequency and Timing....14
Weekly Adult Counts....15
Early and Late Season Trends....16
Interspecies and Intraspecies Aggression....16
Pacific Coast Snowy Plover Window Surveys....17
Band Re-Sight Surveys....17
Nest Abundance and Success....17
Snowy Plovers....17
Least Terns....19
Snowy Plover Color Banding....20
Chick Banding....20
Adult Banding....20
Calculated Metrics....20
Breeding Chronology and Density....20
Fledge Rate and Chicks Fledged per Male....20
Return Rates....21
Oyster Shell Habitat....21
Nest Site Selection....21
Nest Survival....21
Predators....21
Camera Traps....21
Avian Predators....22
Mammalian Predators....23
Human Disturbance....24
Habitat Enhancement....24
Volunteer Events....24
Predator Fence Efficacy....25
Rehabilitation....25

Overall....25
Dicussion....26
Population Size....26
Pacific Coast Breeding Season Window Survey: RU3 Overall....26
Snowy Plover Nest Abundance, Success, and Timing....27
Least Tern Nest Abundance and Success....34
Snowy Plover Chick Fledging Success....35
Oyster Shell Habitat Enhancement....37
Large Scale Enhancement Study....37
Nest Site Selection and Nest Survival....38
Predators....38
Avian Predators....39
Mammalian Predators....40
Restoration and Snowy Plover Nesting....41
Recommendations....41
Management Recommendations....41
Research Recommendations....43
Monitoring Recommendations....44
Acknowledgements....45
References....45

EXECUTIVE 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), East Bay Regional Parks District (EBRPD), United States Fish and Wildlife Service (USFWS) Bay Delta Fish and Wildlife Office, USDA-Wildlife Services, HT Harvey and Associates, Vollmar Natural Lands Consulting, Novato Baylands Stewards, and Avocet Research Associates form the Western Snowy Plover (*Anarhynchus nivosus nivosus*; Snowy Plover) Recovery Unit 3 (RU3) 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 estuary. During the 2023 breeding season, SFBBO monitored Snowy Plover population size, nesting and fledging success, the use of experimental habitat enhancement sites, and potential predators at eight historical salt production pond complexes in the South San Francisco Bay.

During the Pacific Coast rangewide winter window survey (January 26 – 30, 2023) SFBBO and other organizations counted a total of 262 adult Snowy Plovers within RU3, while during the breeding season window survey (May 20 – 27, 2023), SFBBO and other organizations counted a total of 368 adult Snowy Plovers within RU3. Over the course of the breeding season (March – September), SFBBO staff determined and documented the fates of 304 Snowy Plover nests in the South San Francisco Bay. Of the 304 nests monitored by SFBBO, 64% hatched, 31% were depredated, 2% were flooded, 1% fell to miscellaneous other fates[1] and 2% were unknown. An additional 39 nests were detected at the brood stage.

Other members of RU3 documented a total of 23 nests. Among these 23 nests, 43% hatched, 35% were depredated, 13% fell to miscellaneous other fates, and 9% were unknown. An additional eight nests were documented at the brood stage.

A summary of 2023 nesting activity by pond complex or management unit follows:

On Refuge property, SFBBO monitored 41 nests in the Alviso Complex, seven nests in the Mountain View Complex, 69 nests in the Ravenswood Complex, and 11 nests in the Warm Springs Unit. Apparent nest success was 37% at Alviso, 71% at Mountain View, 70% at Ravenswood, and 36% at Warm Springs. Four, 17, and two nests were detected at the brood stage at Alviso, Ravenswood, and Warm Springs, respectively. HT Harvey and Associates monitored an additional four nests at Alviso, none of which hatched.

On Cargill managed property, an independent biologist reported one undetected brood at the Newark Production Facility. SFBBO monitored 63 nests on Refuge owned, Cargill managed ponds in the Dumbarton Complex and found an additional four nests at the brood stage. Apparent nest success in this complex was 73%.

On ACFCD property, SFBBO documented the fate of two nests at Patterson Pond, both of which hatched for an apparent 100% success rate.

[1] Other fates include collected, failed to hatch, failed – unknown cause, and lost at hatch.

On Midpeninsula Regional Open Space District (MROSD)/National Aeronautics Space Administration (NASA) property, SFBBO did not monitor any nests or detect any nests at the brood stage.

At Hayward Regional Shoreline, EBRPD reported five Snowy Plover nests on Least Tern Island, with a hatch rate of 100% (D. Riensche, pers. comm.). SFBBO documented one nest at the Oliver Brother's North (OBN) ponds, which hatched for an apparent 100% success rate. One additional nest was detected at the brood stage at Frank's Dump West (FDW).

On CDFW property, SFBBO documented 109 nests at Eden Landing Ecological Reserve (ELER), finding that apparent nest success was 66%. Eight nests were detected at the brood stage.

At San Pablo Bay National Wildlife Refuge, USFWS was able to confirm the presence of one nest at Cullinan Ranch Each, but was unable to confirm its fate (M. Marriott, pers. comm.).

At Montezuma Wetlands in Solano County, Vollmar Natural Lands Consulting biologists documented three nests with at least one hatching and at least one failing. They detected an additional four nests at the brood stage (M. Yonashiro, pers. comm.).

At Hamilton Wetlands, Avocet Research Associates and Novato Baylands Stewards documented the presence of ten nests, finding that four hatched. An additional four nests were documented at the brood stage at Hamilton Wetlands (C. Eyster, pers. comm.).

SFBBO banded 194 Snowy Plover chicks from nests that successfully hatched within Alviso, Dumbarton, ELER, Ravenswood, and Warm Springs nesting ponds, representing 38 percent of all chicks known to have hatched from SFBBO monitored sites in the South Bay. From band re-sighting surveys and reports from other scientists and birders across the species' range, we determined that at least 64 of these chicks survived to fledge (fully flight capable, at least 28 days post-hatching) as of December 12, 2023, resulting in an estimated apparent fledging success of 33 percent. Due to concerns regarding highly pathogenic avian influenza (HPAI), we limited our adult banding efforts. We recaptured and re-banded three adults whose bands had been damaged. Comparing adult band re-sighting and fledged juvenile data from 2022, we found return rates of 58% (n=63) for adults banded in or before 2022 and 60% (n=62) for 2022 fledges.

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. Common Ravens (*Corvus corax*), American Crows (*Corvus brachyrhynchos*), Snowy Egrets (*Egretta thula*), and Great Egrets (*Ardea alba*) were the next most commonly observed predator species. Two avian species and one mammalian species were confirmed as predators of Snowy Plovers in 2023 due to the following observations: a Northern Harrier depredating an incubating female Snowy Plover at A12, as reported by HT Harvey and Associates; a California Gull depredating a Snowy Plover chick at PP1; and red fox scat with Snowy Plover color bands embedded in it at E14.

We continued to monitor Snowy Plover use of oyster shell plots, which were spread in September 2014 in two areas of ELER pond E14 (Western = 6.47 ha; Eastern = 13.76 ha) as a large scale habitat enhancement project. We monitored 39 Snowy Plover nests in E14 and found an additional three nests at the brood stage; at least 24 nests were found within one of the shell plots. Chi-square analyses indicated that based upon available habitat, breeding Snowy Plovers preferred to nest in shelled plots. Nest survival analyses found the daily nest survival (DSR) to be 98.3% with a 60.9% chance that a nest would survive to hatch (33 days).

2023 marked the seventh consecutive year that California Least Terns (*Sternula antillarum browni;* Least Terns) nested at pond E14. This year Least Terns also nested on the levee between ponds E12 and E13, on a constructed island on E13, and for the first time on pond E6B. On March 4, 2023, we led a volunteer event to remove encroaching vegetation, spread oyster shells, and place 15 wooden chick shelters within the Western Shell Plot of E14. Least Terns were first observed at ELER on May 2, when an unknown number of adults were heard flying over E14. The maximum number of adults recorded on-site was 55 on July 11. A total of 77 nests were monitored between ponds E6B, E12, E13, and E14. In E14, a total of 22 nests were monitored, with two confirmed to have hatched. Eighteen failed (did not hatch due to depredation, abandonment, or flooded out), and the fate of two nests could not be determined. No fledglings were produced from E14. At E12 and E13, a total of 25 nests were monitored, with three confirmed to have hatched and three more presumed to have hatched. Sixteen nests failed and the fate of three nests could not be determined. Between three and four fledglings are estimated to have been produced from E13. At E6B, a total of 30 nests were monitored, with seven confirmed to have hatched and an additional eight presumed to have hatched. The other 15 nests failed. Based on scat and prints, SFBBO suspects that red foxes depredated the majority of the Least Tern nests in ELER.

In 2023, SFBBO continued to interface with the various land and project managers throughout the South Bay, including the South Bay Salt Pond Restoration Project (SBSPRP), whose actions are reshaping the Bay's ecosystems and seriously impacting Snowy Plovers and Least Terns. During Phase 1 of the SBSPRP, 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. To account for the decline in available habitat, new water control structures were installed in many ponds at Don Edwards SFBNWR and ELER to allow for better management of habitat. In 2022 and 2023 respectively, we recorded the second highest (288) and highest (368) breeding population sizes ever recorded in RU3, suggesting a growing population size. However, since 2020, the proportion of breeding adult Snowy Plovers found on SBSPRP lands compared to all of RU3 has consistently been under 80 percent, when the lowest it had previously dropped between 2003 and 2019 was 83 percent in 2018. Some of this lower ratio can be attributed to expanded survey efforts across RU3, but the recent movement of Snowy Plovers away from high density nesting at E14, and instead diversifying to sites across RU3 is also relevant. In order to reach the SBSPRP and RU3 goals of 250 and 500 breeding birds, respectively, it will likely be necessary to provide multiple enhanced breeding ponds, both locally and throughout RU3, in conjunction with targeted predator control efforts to reduce predation pressure on any one pond.

Phase 2 restoration on Refuge lands includes restoration activities at the Ravenswood Complex (R3, R4, R5/S5), Alviso Complex (A8 Ponds: A8, Mountain View Ponds: A1, A2W and the Island Ponds: A19, A20). Pond R3 has been enhanced for Snowy Plovers by adding water management capabilities with the addition of a new water control structure. However, overall Phase 2 actions at the Refuge have still resulted in an additional 8% loss of remaining available breeding habitat due to the breaching of R4 in December 2023. It will be critical to enhance remaining Snowy Plover breeding habitat at R1 through R3 and SF2 to account for the higher density of breeding that will likely occur in these areas. Reduced habitat availability could result in increased predation pressure at the Ravenswood Complex. Furthermore, increased development adjacent to these restoration sites artificially inflates human commensal predator populations such as skunks, feral cats, American Crows, and Common Ravens by supplementing food and complicating predator management opportunities in locations with high visitor use. Without additional enhancement and informed predator control efforts, population growth at one of the most important breeding sites in RU3 could be impeded.

Currently, most breeding plovers in RU3 are found in the South Bay, and a large proportion of those plovers breed on SBSPRP lands. We recommend that the SBSPRP plan Phase 2 construction activities to avoid negatively impacting breeding Snowy Plovers, as was done in Phase 1. This includes providing alternative breeding habitats when construction activities impact or eliminate Snowy Plover nesting ponds and scheduling construction activities before or after the Snowy Plover breeding season when possible.

The recovery of the RU3 plover population depends on the continued availability of suitable habitats, which are currently owned and managed by multiple landowners. Providing quality habitat at spatially diverse locations throughout RU3 is a critical strategy to prevent population decline caused by overconcentration of breeding in any one area. Our research over the past nine years at E14 highlights that "placing all the eggs in one basket" is not an effective long-term strategy for meeting recovery goals. Adaptive management strategies on SBSPRP land to balance tidal restoration with Snowy Plover needs, despite the increased cost of managing ponds and future concerns about sea level rise adaptation, could serve as a positive example for other landowners. Aside from the SBSPRP, other RU3 landowners have not adequately accounted for Snowy Plovers when making land management and restoration decisions, particularly in the North Bay where Snowy Plovers were long known to breed in former salt production ponds but have been left with minimal nesting habitat following widespread tidal marsh restoration. Management actions by the SBSPRP to balance tidal marsh and pond dependent species 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, gravel, and/or cobble enhancement to attract Snowy Plovers to appropriate nesting ponds.

Thus we recommend that Refuge biologists and USFWS Snowy Plover Recovery Leads continue to promote enhancement, management, and maintenance of Snowy Plover habitat on SBSPRP land, and encourage the Bay Delta Fish and Wildlife Office and landowners to increase efforts to identify suitable habitat in the rest of RU3 that can be enhanced or managed for breeding Snowy Plovers and maintain existing Snowy Plover habitat when feasible as outlined in the Recovery Plan (USFWS 2007). In addition, we recommend that all managers communicate

and coordinate tidal marsh restoration activities to ensure that adequate Snowy Plover breeding habitat will remain to support recovery throughout RU3.

INTRODUCTION AND BACKGROUND

SNOWY PLOVERS

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). In 2007, the USFWS wrote the Recovery Plan for the Western Snowy Plover, which split the subspecies' range into six different Recovery Units and specified metrics and goals for each Recovery Unit to achieve for de-listing to occur (USFWS 2007). 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. They are listed as a species of special concern in California (CDFW 1998).

Western Snowy Plover RU3 consists of the San Francisco Bay and includes Alameda, Contra Costa, Napa, Santa Clara, and Solano counties, and the eastern portions 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 dry salt panne in diked marshes. In 1992, the Refuge began surveying for Snowy Plovers.

From 2003-2023, SFBBO has conducted annual Snowy Plover monitoring and research within the South San Francisco Bay in support of the goals set forth for RU3. Specifically, we: 1) identify areas used by Snowy Plovers through regular surveys of all potential nesting habitat from March through September, 2) participate in the USFWS-coordinated range-wide breeding and winter window counts to estimate RU3 numbers, 3) record nest fates, nest densities, and chick fledging rates through nest-monitoring and chick banding, 4) survey for potential avian predators, 5) identify areas of potential disturbance from predators, trespass, construction, and other human activities, and 6) provide management recommendations to landowners and project managers on how they can best support Snowy Plovers in the Bay Area.

When the SBSPRP began active restoration in 2006, SBSPRP lands supported approximately 62 Snowy Plover breeding pairs. Despite the loss of Snowy Plover breeding habitat (dry panne) expected overall through the SBSPRP's actions, the project set a management target of maintaining 125 breeding pairs (250 birds) of Snowy Plovers within its footprint (USFWS and CDFW 2007). To aid in achieving this goal, SFBBO and the SBSPRP initiated a large-scale oyster shell habitat enhancement project, informed by the success of previous pilot studies from 2008-2013, on ELER pond E14. Enhancements were made in September and October 2014, and 2023 marked the ninth year of monitoring the enhancement.

In this report, we summarize results from the 2023 breeding season; this includes Snowy Plover nest distribution and habitat use, RU3 Breeding and Winter Window Survey results, nest (hatching) success, fledging success, use and effect of oyster shell plots, and avian predator abundance and distribution. Although we report Snowy Plover numbers in other areas of RU3, this report focuses on our research in the South San Francisco Bay, from just north of the San Mateo Bridge to the southern terminus of the Bay.

LEAST TERNS

California least terns (*Sterna antillarum browni;* Least Terns) are small, ground nesting seabirds whose breeding range is restricted to sandy beaches, bays, and lagoons on the Pacific Coast from the San Francisco Bay Area south to Baja California. Least terns were once widespread and abundant, but increasing human disturbance on sandy beaches, hunting for the millinery trade, and increasing predator populations caused the population to undergo a major decline in the early 1900s (USFWS 2006). Least Terns were federally listed as endangered in 1970 and state listed as endangered in 1971 (USFWS 2006). In 2017, they began breeding at pond E14 in ELER, discussed above. As SFBBO was already involved in long-term monitoring and recovery efforts for plovers at that pond, we immediately began monitoring the reproductive success of the Least Terns as well.

Since 2017, a small Least Tern colony has consistently nested at ELER, which SFBBO monitors. Each year we determine 1) the number and location of all nests, 2) the fate of each nest when possible, 3) the estimated number of fledges produced from the colony, and 4) any predators that may impact Least Terns and their nests and chicks.

METHODS

STUDY AREA

From March 6 to September 25, 2023, SFBBO staff and volunteers conducted Snowy Plover and avian predator surveys at all known Snowy Plover breeding sites throughout the South Bay, as shown in Figure 1 and Table 3. In the North Bay, other organizations including USFWS, CDFW, Avocet Research Associates, and Vollmar Natural Lands Consulting along with various volunteers conducted surveys at Hamilton Wetlands, Montezuma Wetlands, the Wingo Unit of Napa-Sonoma Marshes Wildlife Area (NSMWA), and Cullinan Ranch East Unit of San Pablo Bay National Wildlife Refuge (San Pablo Bay NWR), as shown in Figure 2 and Table 3. Many different organizations and agencies manage Snowy Plover habitat throughout RU3. SFBBO categorizes each breeding site into a complex that is based on its location and land manager. The following sections describe each complex by landowner. Full descriptions of each complex and site within them can be found in Attachment A.

United States Fish and Wildlife Service

The USFWS owns and manages the Refuge, which includes approximately 30,000 acres of former salt ponds, tidal marsh, mudflats, and uplands in the South Bay. SFBBO divides the Refuge into seven geographic complexes: Alviso (

Figure 3), Mountain View (

Figure 3), Ravenswood (Figure 4), Coyote Hills (Figure 5), Warm Springs (Figure 6), Dumbarton (Figure 7), and Mowry (Figure 1). Full descriptions of each of these complexes can be found in Attachment A.

In the North Bay, USFWS also owns and manages the San Pablo Bay NWR, where beneficial use placement of sand inadvertently created Snowy Plover habitat within the eastern side of the Cullinan Ranch Unit (Figure 2).

California Department of Fish and Wildlife

The CDFW owns and manages ELER (formerly known as Baumberg), which includes approximately 6,400 acres of former salt ponds, marsh, and tidal habitat (Figure 1, Figure 5). The reserve lies west of Hayward and Union City, between these urban areas and the San Francisco Bay, extending from the Alameda Creek Flood Control Channel in the south to Highway 92 in the north. For the purposes of surveying, SFBBO divides ELER into 5 sections or loops: Mount Eden Creek (MEC), Whale's Tail (WT), Old Alameda Creek (OAC), E6/E6C, and the C-System. Full descriptions of these sites can be found in Attachment A.

In the North Bay, CDFW also owns and manages the NSMWA, including ponds 7 and 7A, the Wingo Unit, and the Green Island Unit/Napa Plant Site (Figure 2).

Hayward Area Recreation and Parks District and East Bay Regional Parks District

HARD and EBRPD co-own Hayward Regional Shoreline (Hayward Shoreline), which includes 1,841 acres of former salt production ponds and tidal marsh located directly north of Highway 92 on the east side of the San Francisco Bay (Figure 1, Figure 8). Hayward Shoreline is managed by EBRPD, and includes Snowy Plover foraging and nesting habitat in the (OBN ponds), FDW, and an island constructed for California Least Terns (Least Tern Island) within treatment ponds that are also used by nesting Snowy Plovers. This island and treatment ponds are monitored by EBRPD. Full descriptions of the sites SFBBO monitors can be found in Attachment A.

Other South Bay Landowners

Various other landowners including MROSD, the NASA, Alameda County Flood Control District (ACFCD), and Cargill Incorporated (Cargill) own various other parcels throughout the South Bay with suitable habitat for Snowy Plovers. Full descriptions of each of these sites can be found in Attachment A.

In addition to one pond in ELER, Cargill owns two large tracts of land used for salt production in Redwood City and Newark (Figure 9). 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.

Other North Bay Landowners

In the North Bay, the Hamilton Wetlands and Bel Marin Keys Restoration site is located in Novato at the former Hamilton Army Airfield and former agricultural lands, and is owned by the

State Coastal Conservancy (Figure 2). Despite some portions of the site being opened to tidal action and no active management for Snowy Plovers, the site still provides suitable nesting and foraging habitat in the North Seasonal Wetlands, South Seasonal Wetlands, former agricultural ponds, and Bel Marin Keys Seasonal Wetlands (Figure 10).

Snowy Plovers were first observed breeding at Montezuma Wetlands (Figure 2, Figure 11) by Napa-Solano Audubon Society members conducting surveys for the Solano County Breeding Bird Atlas in 2006. This is a privately owned dredge placement site within the Montezuma Wetlands Restoration Project footprint.

FIELD SURVEYS

Survey Frequency and Timing

To document areas used by Snowy Plovers and to estimate the number of Snowy Plovers in the South Bay, SFBBO identifies ponds with potential nesting habitat and surveys those ponds weekly from March 1 to September 15. Select ponds where unfledged broods are still present after September 15 are surveyed until the last brood fledges. Ponds that are known to support Snowy Plover breeding, but are completely flooded at the beginning of the season are surveyed fortnightly until the first plover is observed. Thereafter, the pond is surveyed weekly.

Least Tern surveys are conducted biweekly from the date the first tern is observed at each site until no more are present. This is typically from late April to the end of August.

Survey Protocol

SFBBO biologists and volunteers survey potential Snowy Plover breeding ponds by driving slowly on the levees or walking levees without vehicle access. We stop approximately every 0.3 miles to scan for Snowy Plovers with spotting scopes. During each survey, we record the number and behavior of all Snowy Plovers present, identify the sex and age class of each individual using plumage characteristics (Page et al. 1991), and mark the approximate location of sightings on a geo-referenced paper map. We also record the color-band status and combination, if applicable, of any banded Snowy Plovers observed.

Least Tern surveys are also conducted by driving slowly along levees and stopping to scan for terns. We collect data using CDFW's standard data sheet, which includes fields for recording the high count of adult terns seen during the survey, the total number of nests observed, and the total number of chicks and fledges at each age class observed.

Interspecies and Intraspecies Aggression

Any instances of interspecies or intraspecies aggression between Snowy Plovers, Least Terns, and other nesting shorebirds and/or seabirds are also recorded. Although we record all instances of aggression during surveys, the only type of aggression discussed in this report is aggression between incubating birds. Snowy Plovers will regularly display aggression towards each other at the beginning of the breeding season when males are defining their territory and at the end of the breeding season when males are defending their broods. However, it is less common to see aggression between incubating birds, since Snowy Plovers usually nest in low densities far away

from other nests of any species. Therefore, because it is atypical, we feel it is important to call out aggression during incubation when observed.

Pacific Coast Snowy Plover Window Surveys

Each year SFBBO participates in the Pacific Coast Snowy Plover breeding and wintering window surveys. These surveys are coordinated by the USFWS as part of a bi-annual, regional effort to census all coastal Snowy Plovers during the same time period. In RU3, the surveys cover all potential breeding habitat at all publicly owned and some privately owned sites. Surveyors at all sites use the same methods for sighting and counting Snowy Plovers as described above.

Band Re-Sight Surveys

Band re-sighting is a crucial aspect of assessing Snowy Plover fledging and survival rates. SFBBO always opportunistically records the band combinations of any Snowy Plovers we see during every breeding survey. However, at the end of the season when breeding activity at a site is fully completed, we will also perform specialized band re-sight surveys with the specific goal of reading as many color bands as possible.

During these surveys, biologists first locate a large flock of roosting or foraging birds. After reading as many band combinations as possible from the levee, the biologists will walk onto the pond bottom and strategically flush the flock just enough for the birds to stand up and reveal their color bands. This is accomplished by slowly and quietly walking several steps at a time and pausing whenever the birds start to move. Band re-sight surveys are best done in pairs where one person walks toward the flock at a time while the other person watches through a scope.

NEST MONITORING

We locate Snowy Plover and Least Tern nests by scanning for incubating adults during weekly surveys. We then search for nests on foot and record nest locations with personal smartphones equipped with Field Maps by Esri software.

We monitor nests weekly until we determine the fate of the nest. On each survey, we record 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 to a Snowy Plover nest, we float the eggs (Hays and LeCroy 1971) to estimate egg age if incubation was observed (typically three-egg clutches throughout most of season, sometimes one or two eggs later in the 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). Using the egg age estimated from the egg float, we then calculate the nest initiation date and predicted hatch date for all nests monitored.

SFBBO does not float Least Tern eggs due to permit limitations. When walking through the Least Tern colony, we record the location and number of eggs at each nest, but do not interact with the eggs or chicks directly.

When there are no longer eggs in the nest, we assign each nest a fate based on evidence seen at the nest (Mabee 1997). For Snowy Plovers, nest fates include: hatched, depredated, flooded,

abandoned, unknown, or other[2]. For Least Terns, nest fates include: hatched, probable hatch, failed, and unknown. In addition, where relevant, we record whether the nest is located in an oyster shell enhancement or non-shelled plot, as described in Oyster Shell Habitat

SNOWY PLOVER COLOR BANDING

Chick Banding

Since 2008, SFBBO biologists have banded Snowy Plover chicks to study their movements and to estimate fledging success rates in the South Bay. To band chicks, biologists check nests daily, starting four days before the estimated hatch date. Due to the precocial nature of chicks, biologists try to arrive during the brief period when all chicks have hatched, but before they begin moving away from the nest, which is typically a several hour window. We band each chick with a unique four-color combination by placing two bands on each leg below the tibiotarsal joint. Each combination consists of three darvic (XCLA Darvic Leg Bands I/D 3.1 mm n.d.) or acetal (XCLA Acetal Leg Bands I/D 3.1 mm n.d.) color bands and one silver U.S. Geological Survey band. All bands are then wrapped in colored auto pin-striping tape. Both darvic and acetal color bands are used depending on availability and best fit for each chick.

Adult Banding

Due to concerns regarding HPAI at the beginning of the season, SFBBO made the decision not to band any new adult Snowy Plovers in 2023. Instead, we would only opportunistically recapture adults when we observed something wrong with their bands (i.e., a missing band, damaged, band, or missing auto pin striping tape). To accomplish this, we placed walk-in traps over the nests of incubating females or brooding males and sheltered in a blind, watching the trap until an adult entered. As soon as a bird entered the trap, we retrieved it and processed it using the same techniques described above in Chick Banding.

CALCULATED METRICS

Snowy Plover Nest Densities

Nest densities are calculated for each pond by dividing the number of nests found within each area by the available habitat. Results are displayed in hectares.

Hatch Rate

We define a nest as successful if it hatches at least one egg. We calculate apparent nest success, or hatch rate, as the percentage of nests that successfully hatched at least one egg out of the total nests monitored.

Fledge Rate

We define a fledged Snowy Plover chick as one that survives to 28 days of age, at which point it is considered to be capable of flight (Warriner et al. 1986). We calculate apparent fledging success as the percentage of fledged, banded chicks out of the total chicks banded. Since re-

[2] Other fates include collected, failed to hatch, failed – unknown cause, and lost at hatch.

sighting banded chicks on salt panne habitat can be extremely difficult, this method of estimating fledging success has limitations and is a conservative estimate.

We define a fledged Least Tern chick as one that survives to 20 days of age, at which point it is capable of flight (USFWS 1980). Since SFBBO does not band Least Tern chicks, it is very difficult to estimate fledge rate. Therefore, we use the 3WD method outlined by CDFW to estimate the number of fledges produced from our colonies. This method involves counting the number of fledges present every three weeks after the first fledge is seen, which generates an estimate for each cohort of chicks that fledge out of the colony every 21 days.

Number of Males

Estimating the number of breeding male plovers within any given system is notoriously difficult, particularly in RU3, where we typically band under 50% of the chicks hatched in any given year. At other sites that have banded nearly all of their chicks for many years, almost every male is banded, making it relatively easy to determine the number of males that tended broods for that breeding season (Colwell et al. 2018). However, since only a fraction of the males we observe tending broods each season are banded, we must use another way of estimating the number of males in the system.

For sites monitored by SFBBO in RU3, we count one male for every nest we band chicks from. We recognize that this method does not account for males that re-nest multiple times throughout the season, since they are double-counted using this method. In addition, our estimated number of males is only a proxy for the total number of males, since it is generated from only a subset of males tending broods in RU3 (i.e., the broods we band). However, we feel that given our limited banding efforts, this is the simplest and most logical way to calculate the number of males.

Chicks Fledged per Male

Chicks fledged per male is calculated by dividing the number of juveniles we have confirmed as fledged, by the estimated number of males. This metric is an estimate for two main reasons. First, many juveniles disperse out of the areas we regularly survey, meaning we can only confirm them as fledged if someone else observes them and reports the band combination to us. In addition, re-sighting banded birds is difficult, so there is no guarantee that we confirm all of the juveniles that stay. Second, as discussed above, our number of males metric is only an estimate, not a definitive value. For these reasons, our chicks fledged per male metric is also an estimate.

Snowy Plover Return Rates

In an effort to track survival of color banded birds, we analyze our band re-sighting data to calculate how many plovers we re-sighted this year that were banded the previous year. We then calculate the proportion of birds that were only seen in the previous year versus birds seen in both years. These comparisons are made for each age class.

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 carried out a large scale habitat enhancement project in September 2014 at ELER pond E14 by treating 20.23 ha with oyster shells at the previously tested density. As shown in Figure 12, two distinct plots were created within the pond – a western plot totaling 9.47 hectares (referred to as the Western Shell Plot), and an eastern plot totaling 13.76 hectares (referred to as the Eastern Shell Plot). Three hectares of the Western Shell Plot are made up of the one-hectare pilot plots that were joined together into one larger plot when the large-scale enhancement was performed. Henceforth, the pilot plots have been fully incorporated into the Western Shell Plot and are no longer termed pilots. The remaining untreated areas without shells are termed Control in this report.

Analytical Methods at the E14 Large Scale Enhancement

Nest Site Selection

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

Nest Survival

To analyze the effects of time, location, and oyster shell supplementation on 2023 nest survival at E14, we ran a Cox proportional hazards model (coxph in the R package "survival") of the number of days each nest was observed and that nest's fate (hatched or depredated), with nest initiation date, distance from nearest levee, and treatment (Western Shell Plot, Eastern Shell Plot, or Control) as fixed effects.

Other Shelled Sites

Several other sites across the South Bay have had varying quantities of oyster shells spread on them by various organizations. Most of these efforts have been opportunistic without targeted data being collected or analyzed about the shells' effects. Descriptions of each site containing oyster shells are provided in Attachment A.

PREDATOR SURVEYS

To identify avian predators that might affect Snowy Plovers, SFBBO biologists and interns conduct predator surveys concurrently when surveying ponds for Snowy Plovers (Table 6 and Table 7). Observers choose survey points that provide a clear view of the pond. At each survey point, the location, start time, and stop time are recorded. Observers record the number, species, behavior, and habitat type at the time of sighting any predators present. The approximate locations of the predators are marked on a map. In addition, observers document any predator nests in the area and their fates when possible. We calculate 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 feel it meaningful to present indices of predator abundance at the pond scale since both predator and Snowy Plover surveys are conducted at this level.

We define avian predators as any species that could potentially prey on a Snowy Plover egg, chick, or adult. This includes most raptors, gulls, corvids, herons, and egrets (Table 6) found within Snowy Plover breeding habitat in RU3. While potential mammalian predators (Table 7) and their signs (e.g., tracks) are noted, these surveys were not designed to detect mammals, particularly since many are nocturnal. Among all predators, we consider corvids, raptors, gulls, and mammals (especially coyote, red fox and striped skunk), to be the most critical potential predators of Snowy Plover adults, eggs, and chicks due to previous predation captured on camera and consistent with previous documentation of predation.

Camera Traps

SFBBO will also opportunistically place camera traps at Snowy Plover nests when the camera is presumed to not increase predation risk. Cameras are placed directly on the ground between 2-3 meters from the nest; this method was adopted after testing other further away, but unsuccessful placements in the past. Cameras are 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 are taken whenever motion is detected, in color by day and monochrome infrared by night. Cameras are checked and serviced each time a nest is visited, typically once per week.

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, we conduct habitat availability surveys every other week throughout the breeding season.

Maps for each pond are overlaid with a grid composed of 50-meter by 50-meter squares. During each survey, the approximate location of available habitat within each pond is marked on the corresponding map. Available habitat types include dry pond bottom, dry levees, and sparse vegetation cover; unavailable habitat types include standing water, saturated pond bottom or mud, and full vegetation cover. Each square is considered available or unavailable for breeding based on which type constitutes more than 50 percent of its space. Habitat availability surveys are conducted fortnightly on the same day as the corresponding 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.

HABITAT ENHANCEMENT

Volunteer Events

Each year SFBBO hosts one to two habitat enhancement events at ELER that are open to the general public. During these events, volunteers help SFBBO staff remove encroaching vegetation, spread additional oyster shells, place chick shelters for the Least Tern colony, and stomp in the mud to create artificial scrapes that Snowy Plovers or Least Terns may choose to nest in. These events typically happen at E14, but have also occurred at E6B and E8.

Predator Fence

Following the 2021 breeding season, SFBBO contracted ABC Fencing to construct a series of fences and gates at all corners of E14 in an effort to prevent mammalian predators from accessing the pond and to reduce human trespass. The fences extended across the entire width of the levee, down to the pond waterline on either side to make it impossible to walk around without getting wet. During the 2022 season, biologists noted that small mammals appeared to be burrowing underneath the fence. Therefore, at the end of the 2022 season, the contractors installed concrete pads underneath each fence to prevent digging.

REHABILITATION

SFBBO does not participate in rehabilitating any wild birds directly, but will transport imperiled birds to wildlife rescues across the greater Bay Area when appropriate. For rescued Snowy Plovers specifically, SFBBO partners with International Bird Rescue (IBR) in Fairfield, California, which specializes in rehabilitating shorebirds and seabirds.

SFBBO will only collect Snowy Plover eggs, chicks, or adults if there is a strong indication that the bird will die without intervention. The most common situation SFBBO encounters that warrants collection is the complete abandonment of eggs or chicks by the breeding pair, whether due to predation or rapidly rising water levels. In 2023, SFBBO made the decision not to collect any obviously sick birds due to the risk of transmitting HPAI.

RESULTS

FIELD SURVEYS

Survey Frequency and Timing

Snowy Plovers

Snowy Plover surveys for 2023 began a week late due to rain on the week of March 6, 2023 and ran through the week of September 11, 2023 at all sites. Due to the continued presence of unfledged broods, sites E6B, R1, R2, and R4 were surveyed through the week of September 18 and sites R3 and OBN were surveyed through the week of September 25.

Due to extremely heavy rain during the first three months of 2023, several sites which usually provide habitat for Snowy Plovers were completely flooded for much of the season. These sites consisted of Crittenden Marsh West (CMW), Crittenden Marsh East (CME), Patterson Pond,

FDW, Frank's Dump East (FDE), and OBN. Patterson Pond and Frank's Dump were surveyed fortnightly until May 15. OBN was surveyed fortnightly until July 3. Crittenden Marsh was surveyed fortnightly until August 21 (Table 4).

Ponds A3N, A3W, AB1, and AB2 were subject to fluctuating water control regimes throughout the season. Therefore, they were surveyed weekly when habitat was available and fortnightly when no habitat was available (Table 4).

All other sites were surveyed weekly (Table 3).

Least Terns

Least Terns were first recorded at ELER on May 2, 2023, but only heard calling as flyovers. Occasional flyovers were recorded during Snowy Plover surveys for the next two weeks, but dedicated Least Tern surveys did not begin until May 18 when adults began being observed roosting on ponds E12, E13 and E14. Least Terns were observed for the first time ever at E6B on May 23. Surveys continued biweekly at all four ponds until August 24 at E12 and E13 and until August 29 at E14 and E6B.

Weekly Adult Counts

Snowy Plovers

We observed a mean of 380±88 Snowy Plover adults per week over all sites that we surveyed (Figure 13). Over the course of the season, ELER and Ravenswood supported the greatest number of Snowy Plovers in the South Bay (Figure 13). Mountain View and Coyote Hills supported the least number of Snowy Plovers in the South Bay (Figure 13). The following sections detail the average weekly counts at each complex.

Alviso

We observed a mean of 47±24 Snowy Plovers per week in the Alviso complex (Figure 14).

Coyote Hills

We observed a mean of 3±5 Snowy Plovers per survey at Patterson Pond (Figure 14).

Dumbarton

We observed a mean of 36±12 Snowy Plovers per week at PP1 and Hickory (Figure 14).

Eden Landing

We observed a mean of 179±66 birds per week at ELER (Figure 13). E14 once again supported the greatest number of Snowy Plovers with 67±40 birds observed per week. This is followed by E6B with 35±25 birds observed per week and E16B with 23±15 birds observed per week.

Hayward

We observed a mean of 14±24 Snowy Plovers per survey at FDW and OBN ponds (Figure 14).

Mountain View

We observed a mean of 0.3±0.8 Snowy Plovers per survey at CMW, CME, A3N, A3W, AB1, and AB2 (Figure 14).

Ravenswood

We observed a mean of 87±33 Snowy Plovers per week in the Ravenswood complex (Figure 14).

Warm Springs

We observed a mean of 14±16 Snowy Plovers per week in the Warm Springs complex (Figure 14).

Least Terns

We observed a mean of 14±10 adult Least Terns per survey at E12 and E13 (surveyed together), 5±6 adults per survey at E14, and 21±19 adults per survey at E6B.

Early and Late Season Trends

Snowy Plovers

Across all sites, we observed the highest numbers of birds in August and September (503±63 birds compared to 380±88 for the entire season). ELER was the biggest contributor to this statistic, with an average of 266±45 birds for those six weeks compared to an average of 179±66 birds for the entire season. Other complexes such as Hayward and Warm Springs finally drying down enough to provide substantial habitat also contributed to the higher numbers late in the season.

At the beginning of the season we also observed higher numbers of birds in April (409±43 for the month compared to 380±88 for the entire season), largely due to Ravenswood. This complex saw 115±15 birds during April compared to 87±33 birds for the entire season. Alviso also supported more birds at the beginning of the season and appeared to experience a gradual decline in numbers from the beginning of the season to the end (61±30 birds for the first four weeks of the season versus 10±10 birds for the last four weeks of the season).

Higher numbers at both the beginning and end of the season suggests that many of the birds observed may have been staging for migration to other sites, arriving for the breeding season (in March and April), or early arriving wintering birds (in August and September).

The lowest weekly counts of the year when theoretically no migrants were present appeared to be centered around the end of June. From the week of June 12 to the week of July 10, we observed an average of 301±15 birds across all sites, compared to 380±88 birds for the entire season. This is largely due to ELER, which experienced an average weekly count of 123±11 birds during this period compared to 179±66 birds for the entire season. Interestingly, the Dumbarton complex maintained a very consistent number of birds throughout the whole season, with some of that complex's highest weekly counts being recorded during the June 12 to July 10 period.

Least Terns

Least Terns were present at E14 in the beginning of the season, then sharply declined around the end of June. From the week of May 14 to the week of June 25, we observed an average of 10±5 Least Terns at E14. However, following the week of June 25, only 1±2 adults were seen per survey. This coincided with the collapse of the breeding colony on E14

Least Tern activity at E13 was much more consistent throughout the season. This is likely due to the persistent breeding colony on an island in E13, which was active for the entire season and successfully fledged chicks.

Pond E6B became active later in the season and remained active until the end of August. It is possible that Least Terns whose nests on E14 failed at the beginning of the season re-nested at E6B in the second half of the season.

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 early months of the breeding season. Although there was limited habitat available at the beginning of the breeding season in 2023 due to heavy winter rains, we observed very minimal aggression. Two instances of interspecies aggression were observed at nests on E12 and Patterson Pond, both of which were in close proximity to American avocet (*Recurvirostra americana*) nests. The avocets were observed repeatedly chasing the incubating plovers off of their nests. However, both of these nests hatched, so the aggression did not appear severe enough to negatively impact incubation.

No instances of intraspecies aggression were observed, which is notable considering the incredibly high density of Snowy Plovers nesting on PP1 (0.827 nests/hectare), with simultaneously active nests located as close as 12 meters apart.

Pacific Coast Snowy Plover Window Surveys

Winter Window Survey

During the 2023 Pacific Coast winter window survey (January 26 – 30, 2023), a total of 282 adult Snowy Plovers were counted in RU3 (Table 2).

Breeding Window Survey

During the 2023 Pacific Coast breeding season window survey (May 20 – 27, 2023), a total of 368 adult Snowy Plovers were counted in RU3 (Table 1, Figure 13).

Band Re-Sight Surveys

SFBBO conducted six dedicated band re-sight surveys between September 18 and September 28. During these surveys we confirmed a total of thirteen fledges at FDW, E14, E3C, E4C, and R2. FDW was the most popular site for fledges, with six fledges confirmed on it on September 21. The next most popular pond was E4C, with three fledges confirmed on it on September 28.

NEST ABUNDANCE AND SUCCESS

Snowy Plovers

South San Francisco Bay Overall

SFBBO determined the fates of 304 Snowy Plover nests, EBRPD determined the fates of five nests, and HT Harvey and Associates determined the fates of four nests (Table 8). Of these, 199 nests hatched (65.5%), 94 nests were depredated (30.9%), six were flooded (2.0%), and one was

abandoned (0.3%). Three fell to miscellaneous other fates[3] (1.0%) and the fate of six nests was unknown (2.0%), as shown in Table 8 and Figure 19. Across all surveyed areas, we documented 39 broods from undetected nests, indicating that despite our best efforts, some breeding went undetected (Table 8). We documented the greatest amount of breeding activity at ELER (109 nests monitored, eight found at brood stage), followed by Ravenswood (70 nests monitored, 17 found at brood stage), Dumbarton (63 nests monitored, four found at brood stage), Alviso (45 nests monitored, four found at brood stage), Warm Springs (11 nests monitored, two found at brood stage), Mountain View (seven nests monitored, three found at brood stage), Hayward (six nests monitored, one found at brood stage), and Coyote Hills (2 nests monitored) (Table 8).

Refuge

SFBBO determined the fate of 122 Snowy Plover nests on Refuge lands (Table 8). HT Harvey and Associates reported an additional four nests at pond A12 in Alviso. At the Ravenswood Complex (R1, R3, R4, R5, and SF2), 49 nests hatched (70%) and 19 were depredated (27%). The fate of one nest was unknown (1%) and one nest fell to a miscellaneous other fate. A total of 17 nests were detected as broods, including seven in R1, five in R4, three in R3, and one each in R2 and SF2. The Ravenswood Complex contained 23% of all nests found in the South Bay (Figure 20), and we found the most nests in the Ravenswood Complex on pond R3 (32 monitored), as shown in Figure 22. No nests were monitored on R5 in 2023.

In the Alviso Complex (A12, A13, and A15), 15 nests hatched (33%), 28 nests were depredated (62%), and two nests fell to miscellaneous other fates (4%). Four nests were detected as broods, including three at A13 and one at A15 (Table 8). The Alviso Complex contained 15% of all nests found in the South Bay (Figure 20), and 62% of all Alviso nests were found in A15.

At the Warm Springs Unit (A22 and A23), four nests hatched (36%) and seven were depredated (64%). An additional two nests were detected at A22 as broods (Table 8). The Warm Springs Unit contained 4% of all nests found in the South Bay (Figure 20) and 91% of all Warm Springs nests were found in A22.

In the Mountain View Complex, we determined the fates of seven nests, finding that five nests hatched (71%), one was depredated (14%), and one was flooded (14%). An additional three nests were detected at the brood stage on A3W (Table 8). Nests in the Mountain View Complex accounted for 2% of all nests in the South Bay. No nests were monitored in Crittenden Marsh in 2023.

Coyote Hills

At Patterson Pond within the Coyote Hills Complex, we determined the fates of two nests, finding that both hatched (100%). No nests were detected as broods (Table 8). Nests in Patterson accounted for less than 1% of all nests found in the South Bay (Figure 20).

Eden Landing

We determined the fates of 109 Snowy Plover nests at ELER, comprising 36% of all nests found in the South Bay (Figure 20). Of these, 72 hatched (66%), 28 were depredated (26%), four nests

[3] Other fates include collected, failed to hatch, failed – unknown cause, and lost at hatch.

were flooded (4%), one nest was abandoned (1%), one fell to a miscellaneous other fate (1%), and the fates of three nests were unknown (3%; Table 8). An additional eight nests were detected as broods across ELER (Table 8). E14 supported the most breeding activity (42 nests), followed by E6B (27 nests), E16B (17 nests), E13 and E6A (eight nests each), E4C (seven nests), E8 (four nests), the North Creek Managed Ponds (NCMP) (two nests), and E12 (one nest). E14 alone comprised 39% of the nests found in ELER (Figure 21) and 14% of the nests found in the entire South Bay in 2023 (Table 8). No nests were monitored on E14B, E15B, E8XN, E6, E6C, E1C, E2C, E3C, or E5C in 2023.

Hayward

EBRPD reported five Snowy Plover nests on Island Five (Least Tern Island) at Hayward Shoreline, of which 100% hatched (D. Riensche, pers. comm.; Table 8). SFBBO monitored one nest this season at the OBN, which hatched (100%). One nest was detected at the brood stage at FDW. LETE Island accounted for 83% of all monitored nests at Hayward Shoreline in 2023 (Figure 25). No nests were monitored on FDE in 2023.

Dumbarton and Cargill Salt Evaporation Ponds

At the Dumbarton production ponds, we determined the fates of 63 nests at PP1, finding that 46 hatched (73%), 13 were depredated (26%), and one was flooded (2%). One nest fell to a miscellaneous other fate and the fates of two nests were unknown (3%; Table 8). An additional four nests were detected as broods on PP1 (Table 8). Nests in PP1 supported 21% of all nests found in the South Bay in 2023 (Figure 20). No nests were monitored on Hickory in 2023.

At Cargill's Newark Plant Site, one brood was reported. Due to the size of the Newark Plant Site and lack of targeted surveys, it is possible that additional Snowy plover breeding occurred there in 2023. No Snowy Plover breeding activity was reported at the Redwood City Plant Site.

North Bay Overall

Avocet Research and Associates, Vollmar Natural Lands Consulting, and the USFWS determined the fates of 14 Snowy Plover nests in the North Bay, including ten at Hamilton Wetlands, three at Montezuma Wetlands, and one at San Pablo Bay NWR. Of these, five nests hatched (35%), six were depredated (43%), one fell to a miscellaneous other fate (7%) and the fate of two nest was unknown (14%). Four additional nests were found at the brood stage at both Hamilton Wetlands and Montezuma Wetlands. No Snowy Plover breeding was observed at NSMWA in 2023.

San Pablo Bay National Wildlife Refuge

At the Cullinan Ranch East Unit, the USFWS confirmed the existence of one nest, but was unable to confirm its final fate. The USFWS did not conduct regular surveys at this site.

Montezuma Wetlands

At Montezuma Wetlands, Vollmar Natural Lands Consulting monitored three nests, of which at least one hatched and at least one failed. The fate of the third nest could not be determined. An additional four nests were detected at the brood stage, for a total of at least seven nests at the site. The 2023 breeding season marked the third year in which targeted Snowy Plover surveys were conducted at this site, increasing the confidence in overall breeding effort reported at this site.

Hamilton Wetlands

Avocet Research Associates determined the fates of ten nests, finding that 40% hatched, 50% were depredated, and 10% fell to a miscellaneous other fate. An additional four nests were detected at the brood stage.

Least Terns

Across ELER, we determined the fates of 77 Least Tern nests (Table 9). At E14 we monitored 22 nests, two of which hatched (9%), 18 of which failed (82%), and two of which the final fate could not be determined (9%). At E13 we monitored 25 nests, three of which hatched (12%), three of which probably hatched (12%), 13 of which failed (52%), and six of which the final fate could not be determined (24%). For the first time since Least Terns began breeding at ELER in 2017, Least Terns nested on E6B. On that pond we monitored 30 nests, seven of which hatched (23%), eight of which probably hatched (27%), and 15 of which failed (50%).

SNOWY PLOVER COLOR BANDING

Chick Banding

As part of our efforts to document breeding success within the South San Francisco Bay, we banded 194 Snowy Plover chicks from 79 broods in 2023 (Table 12). This represents 38.0% of all chicks that hatched from the nests SFBBO monitored in 2023.

Adult Banding

In 2023, SFBBO recaptured and processed three adults, all at ELER. This included two females from two nests at E14 and one male from a nest at E13. All three were selected for recapture because they were missing tape on at least one band in their combination.

CALCULATED METRICS

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 0.27 nests per hectare (Table 27). The highest apparent nest density was observed at PP1 (0.83 nests per hectare), followed by Patterson Pond (0.60 nests per hectare), and E13 (0.35 nests per hectare) (Table 27).

We observed an extended period of moderate nest initiation throughout the breeding season. Three very slight peaks of nest initiation were observed, including during the weeks of May 7 – May 21 (23.3±0.5), June 11 – June 18 (27.0±1.0), and July 2 (21). For the seventh year in a row, we observed one extended period of active nests across the season rather than two distinct periods. Between the weeks of May 21 and July 9, a mean of 106.6±5.7 nests were active, with a high of 114 nests active during the week of June 18 (Figure 26).

Fledge Rate and Chicks Fledged per Male

Of the 194 chicks that SFBBO banded in 2023, at least 65 chicks survived to fledge (34%) (Table 10). These chicks originated from 79 distinct broods, making our number of males

estimate for this calculation 80 males. This resulted in a chicks fledged per male rate of 0.82 (Table 11).

SFBBO monitors the SNPL Band Reporting Google Group, periodically checks eBird for photos of banded Snowy Plovers, and puts considerable effort was into finding fledglings during band re-sighting surveys. However, due to juvenile dispersal and the difficulties in finding and reading banded Snowy Plovers, it is expected that additional chicks fledged and our fledge rate and number of chicks fledged per male metrics are conservative estimates.

Return Rates

We observed a total of 62 out of 103 banded 2022 juveniles, resulting in an apparent return rate of 60% (Table 12). Of 108 previously banded adults observed in 2022, 63 were observed in 2023, resulting in a return rate of 58% (Table 14).

OYSTER SHELL HABITAT

During the ninth season following large scale enhancement at E14, we located and monitored 39 Snowy Plover nests; 10 nests in the Western Shell Plot (which includes the three 1-ha pilot plots and additional shells spread by volunteers), 14 nests in the Eastern Shell Plot, and 15 nests in the unshelled areas of the pond (Control) (Figure 12, Table 28).

Examining the treatments individually, apparent nest success was highest in the Control areas (87%), followed by the Eastern Shell Plot areas (64%), and the Western Shell Plot had the lowest apparent nest success (40%) (Table 28). Depredation was the most significant cause of nest failure in all areas of E14 (Western=50%, Eastern=36%, and Control=13%). The fate of one nest in the Western Shell Plot is unknown (10%).

Nest Site Selection

Our chi-squared analysis showed that Snowy Plovers continued to prefer nesting in oyster shell plots (P = 0.0058) in 2023 (Table 29). While Western and Eastern shell plots accounted for 42% of available nesting area in E14 during 2023, these areas accounted for 62% (n=39) of all nests found in E14 during that time. However, most of this significance is attributed to the Eastern Shell Plot, where the expected number of nests was 6.74 and we observed 14. At the Western Shell Plot, the expected number of nests was 9.79 and we observed 10 nests.

Nest Survival

DSR at E14 in 2023 was 98%, which led to a 61% chance that a nest would survive until hatch. None of the variables included in the model (i.e., nest initiation date, distance nearest levee, or treatment area) were found to have a significant effect on nest survival, although a lower survival rate in the western shell plot treatment was nearly significant (P=0.090). The power of this test was relatively small due to the limited sample size; we only had complete data for 34 nests. Because of the trend towards lowered survival in the western shell plot, we ran an additional analysis similar to the previous one except that we grouped both shell-supplemented plots into one category to compare them to the non-shell-supplemented area, giving the test less locational specificity but greater power to detect any effect of shell supplementation on survival. This analysis found no significant effect of shell supplementation on nest survival. In sum, there is no

evidence that nest initiation date, distance from levee, or oyster shell supplementation impacted nest survival in 2023; however, these results should be interpreted with caution, as the power of the analysis was low.

PREDATORS

Camera Traps

Due to personnel constraints, SFBBO did not deploy any camera traps in 2023.

Avian Predators

Ravenswood

Unidentified Gulls (174.8/survey) were the most abundant avian predators at Ravenswood, followed by California Gulls (107.3/survey)(Table 15). Excluding gulls, American crows (*Corvus brachyrhynchos*) (20.0/survey), Snowy Egrets (16.5/survey), Great Egrets (5.8/survey), and Common Ravens (3.8/survey) were the most abundant predators observed. We frequently observed American Crows and Common Ravens flying low over and walking on ponds R3 and R5 (Table 15). Northern Harriers (1.04/survey) and Red-tailed Hawks (0.6/survey) were the two most frequently sighted raptor at Ravenswood.

Alviso

Unidentified gulls (447.6/survey) and California Gulls (85.4/survey) were the most numerous predators observed at Alviso (Table 16). Excluding gulls, Common Ravens (10.1/survey), Great Egrets (1.3/survey), American Crows (0.9/survey), and Peregrine Falcons (0.5/survey) were the most frequently observed predators in the complex. Ravens were frequently observed hunting on A13 and A15 using a combination of perching, flying, and walking on the pond. Peregrine Falcons were the most frequently observed raptors in the complex, where they were typically observed perched on posts in A15.

Warm Springs

Unidentified gulls (296.1/survey) and California Gulls (118.2/survey) were the most numerous predators observed at Warm Springs (Table 17). Common Ravens (9.5/survey) and American Crows (2.7/survey) were the next two most frequently observed predators, with most found in A22. Northern Harriers (0.5/survey) were the most frequently observed raptor in the unit, where they were often observed hunting over the marsh along the railroad tracks. Other raptors including Red-tailed Hawks (0.3/survey) and Bald Eagles (0.3/survey) were observed in the adjacent upland habitat perched on power towers.

Dumbarton

California Gulls (49.3/survey) were the most numerous predator observed at the Dumbarton Complex, followed by Unidentified Gulls (28.4/survey) (Table 18). In July and August, an SFBBO biologist observed California Gulls eating a Snowy Plover chick and a Least Sandpiper. American Crows (3.0/survey) and Red-tailed Hawks (0.6/survey) were the next most frequently observed predators, with most of the Red-tailed Hawk observations recorded in Hickory.

Mountain View

California Gulls (1,332.0/survey) were the most numerous predators at Mountain View (Table 18). This is due to the large California Gull colony that was active in AB1. Unidentified gulls (172.5/survey) and Snowy Egrets (20.2/survey) were the next most frequently observed predators at Crittenden Marsh. Osprey was the most common raptor observed at Mountain View (1.3/survey) because of an Osprey nest that was established on a power tower just north of A3N. This same tower hosted a Great Blue Heron nest (4.6/survey) and the next tower south on the pond itself contained a Common Raven nest (5.8/survey).

Eden Landing

Unidentified gulls (229.8/survey) and California Gulls (187.8/survey) were the most numerous predators at ELER (Table 20, Table 21, Table 22, and Table 23). Snowy Egrets (43.0/survey) and Great Egrets (23.6/survey) were the next most numerous species observed. Egrets and herons were especially numerous at ponds E3C (Table 20), E6A (Table 22), and E13 (Table 21), all of which provide large amounts of open water habitat that these species often hunt in. Common Ravens (4.1/survey) were most frequently observed at E14 (Table 21). Northern Harriers (2.4/survey) and Red-tailed Hawks (2.0/survey) were the most commonly observed raptors at ELER. Harriers were most active at E14 (Table 21), and Red-tailed Hawks were most active at E6A (Table 22).

In January of 2016, hunting blinds in adjacent pond E9 that were within 100 meters from E14 were demolished or wrapped in landscape cloth. This was done in an attempt to reduce predation risk for adults, chicks, and nests. During the 2023 breeding season, the landscape cloth was still intact, resulting in no observed raptor nesting or perching on these blinds.

Hayward Shoreline

Unidentified Gulls were the most frequently observed predators at Hayward Shoreline (13.3/survey) (Table 24). California Gulls (2.2/survey) and Ring-billed Gulls (1.6/survey) were the next most frequently observed predators. Red-tailed Hawks were the most frequently observed raptor at Hayward Shoreline (0.3/survey), but were only seen at FDE.

Coyote Hills

California Gulls were the most frequently observed predator at Patterson Pond (11.5/survey) (Table 25). Common Ravens were seen with moderate frequency (0.2/survey).

Mammalian Predators

SFBBO did not conduct targeted surveys for mammalian predators. However, opportunistic data collected during avian predator surveys, other visual observations, and tracks are reported to aid in analyses of predator threats. Pond E14 saw the most mammalian predator activity with five red fox sightings and one coyote sighting (Table 21). Pond E6A had the next highest mammalian predator activity with three coyote sightings, one feral cat sighting, and one skunk sighting (Table 22). Mammals were also present at the C-System in ELER with feral cats and coyotes being observed at those ponds (Table 20). Skunks were present at Ravenswood (two sightings on R4) and Warm Springs (one sighting on A23) (Table 15, Table 17). Off-leash domestic dogs are a known problem at every complex, although this has mostly been observed through tracks on

ponds and trail camera observations, rather than direct observations, suggesting that it is a persistent, but low volume issue.

In 2023, USDA-Wildlife Services provided predator management for endangered species protection at the Refuge and ELER, including mammal trapping and targeted removal of problematic species, including Common Ravens.

Human Disturbance

Since there are many public trails adjacent to Snowy Plover nesting habitat, there are lots of opportunities for pedestrians to leave the public areas and cross into restricted areas. This year at ELER, the fences around E14 prevented any trespass onto that pond, but trespassers were observed on E12, E13, and E14B. A trespasser was also observed in the C-System.

Ravenswood's proximity to Bedwell Bayfront Park contributes to trespass at ponds R3 through R5, especially because of poor signage around R5. Biologists frequently intercepted hikers who had wandered off of the public trail onto restricted levees and politely redirected them.

At Warm Springs, bicycle tracks were observed in the mud on A22 at the beginning of the season. In July, biologists observed a collection of vandalized signs on the pond that had been shot through with pellets.

Patterson Pond is located along a busy section of the San Francisco Bay Trail along the Alameda Flood Control Channel, and although we did not record pedestrians using the trail, on one occasion we observed trespass from Coyote Hills Regional Park onto the western levee of Patterson Pond where access is restricted. After tall vegetation was mowed near the fence and gate on the northwest corner of the pond, human footprints were found going around the fence and onto the west and southern levees.

At Hayward Shoreline we also observed signs of human disturbance. At OBN we found footprints on both OBN11 and OBN12, as well as the northern and western levees. At FDW we directly observed trespassers and unleashed dogs on the pond as well as finding tracks from both. The recently erected fence on the northern levee of FDW was found to have been cut through before the breeding season began. Multiple people and unleashed dogs were observed going through this hole in the fence on at least two separate occasions.

The only complex where we did not record any human trespass in 2023 was the Mountain View complex. Although the Bay Trail runs along the south end of these ponds, there was no dry habitat adjacent to any public trails that made it possible for pedestrians to access the pond bottom.

HABITAT AVAILABILITY

Habitat availability surveys showed that the amount of available habitat in the South Bay steadily increased throughout the season (Figure 26). The lowest total available hectares was recorded the week of March 21 at 279 hectares, while the highest total available hectares was recorded the week of August 22 at 1,279 hectares, for an increase of 1,000 hectares across the season.

HABITAT ENHANCEMENT

Volunteer Events

SFBBO hosted two volunteer events at ELER in 2023. The first one occurred on March 4 at E14, which 28 members of the public attended, including ten youths from local high schools. This event was primarily focused on setting up for the Least Tern season. Volunteers placed numbered wooden A-frame chick shelters in the Western Shell Plot, spread supplementary oyster shells in the Western Shell Plot, and removed encroaching pickleweed along the northwest side of E14.

The second event occurred on April 8 at E6B, which 30 members of the public attended, including 12 youths from local high schools. This event focused on enhancing Snowy Plover habitat on this pond by stomping in the mud to create additional texture, which increases camouflage, and to create depressions that mimic scrapes, which Snowy Plovers have been documented using.

Predator Fence Efficacy

Unfortunately, all of the fox and coyote sightings on E14 were within the area that should have been protected by the fence. In February 2023, contractors installed concrete pads underneath each of the fences, which successfully eliminated the issue of mammals digging underneath the fences. However, the issue of water levels dropping low enough to expose land around the distal ends of the fences at low tide persisted. Despite staff efforts at the end of the 2022 season to dig trenches around the end of the fences, water fluctuations quickly eroded them and land bridges occasionally formed, which would allow mammalian predators to easily access E14.

REHABILITATION

Overall

SFBBO and biologists from the Refuge brought a total of one chick and six eggs to IBR for rehabilitation and successfully released a total of five banded juveniles in 2023. Four juveniles were released together on August 11 at E14 in ELER, while a fifth juvenile was released at E14 on September 1.

Alviso

All six eggs taken to IBR came from two different nests in Alviso that were being monitored by HT Harvey and Associates as part of the ongoing South San Francisco Bay Shoreline Project (Shoreline Project), described in Attachment A. At the request of the Army Corps of Engineers and with approval from the Bay Delta Fish and Wildlife Office, Rachel Tertes, USFWS Wildlife Biologist and 10(a)(1)(A) permit holder, collected three snowy plover eggs from one nest on June 8, 0223 and transported them to International Bird Rescue to be reared. All three eggs successfully hatched and fledged. SFBBO banded the juveniles and then released them at E14 on August 11. Two of these birds have been seen again since release.

On June 21, an independent contractor biologist on the Shoreline Project observed a Northern Harrier depredate an incubating female, leaving the eggs behind. HT Harvey biologist, Ben Pearl collected these eggs and transported them to IBR. All three chicks from this nest hatched, but

unfortunately two chicks were euthanized soon after hatching. One broke its leg in the incubator immediately after hatching and one immediately displayed signs of metabolic bone disease. SFBBO banded the third chick on August 11 and it was released at E14 on September 1, but has not been seen since.

Ravenswood

On June 8 we collected one chick from a nest at R1 that appeared to have been abandoned by both adults. The first two chicks hatched on June 6 and had already moved away from the nest with the male. The third egg hatched sometime in the early morning of June 8, but had been abandoned and was cold and barely alive when SFBBO arrived to begin banding. The chick was transported to IBR where it was successfully reared and banded on August 11. It was released at E14 on August 11 and was re-sighted on August 22.

DICUSSION

POPULATION SIZE

Pacific Coast Breeding Season Window Survey: RU3 Overall

During the May breeding window survey, we counted 368 breeding adult Snowy Plovers, representing the largest breeding window survey count in RU3 since surveys began in 2003. We are encouraged to see a second consecutive year of population growth after observing a slight decline from 2017-2019 (the 2020 survey was incomplete and thus can't be compared), but will continue to strive to reach the RU goal of 500 breeding adults. The proportion of RU3 adults found on SBSPRP lands continued to increase as well from 72% in 2022 to 77% in 2023. This is still lower compared to pre-2019, when the percentage was consistently in the high 80s to low 90s, but is improved compared to the sudden dip to 53% in 2021 (the 2020 survey was incomplete and thus cannot be compared). The average proportion of RU3 adults found on Project lands from 2003-2023 is 87±12%, indicating that the vast majority of RU3 Snowy Plovers utilize SBSPRP land, but have also expanded into other sites. In order to sustain population growth, habitat on both SBSPRP lands and other areas must be managed specifically to support breeding Snowy Plovers.

In the South Bay, we observed the largest change in window survey count at Dumbarton, where we counted 55 adults in 2023 compared to 11 in 2022, a five-fold increase. We attribute this high count to the novel water management continuing since 2021 on pond PP1. This pond, which is owned by the Refuge but managed by Cargill, is typically managed at very high water levels with minimal exposed habitat. However, unintentional drops in water level for the last three years have led to drastically increased available habitat. This also contributed to a record-high number of nests on PP1 in 2023.

Increases were also observed at ELER and Alviso, particularly Alviso, which jumped from 39 birds in 2022 to 70 birds in 2023. As discussed in Early and Late Season Trends, it appears that RU3 did not reach average low numbers when no migrants are present until the end of June. Alviso may have especially contributed to this, since on average, this complex experienced a gradual negative trend-line throughout the season (Figure 15). The week of the window survey,

we counted 70 birds, which is approximately one standard deviation above that complex's overall average for the year, showing that the window survey occurred when Alviso was still experiencing high numbers of plovers, compared to the second half of the season. High counts at Alviso in the beginning of the season were likely possible due to how quickly A13 dried compared to previous years when it remained largely flooded. By the week of the window survey, it was approximately 38% exposed, giving plovers much more space to utilize.

At Hayward Shoreline and Crittenden Marsh, we observed a large decline in adults counted during the window survey, decreasing from 26 at Hayward and eight at Crittenden Marsh in 2022 to five at Hayward and zero at Crittenden Marsh in 2023. This is entirely due to the record-breaking winter rain the Bay Area received over the winter. Because of the extreme rain and lack of active water control capabilities, FDW, OBN and all of Crittenden Marsh were completely flooded during the window survey, with no habitat for plovers to utilize. The only plovers observed at either of these two complexes during the window survey were at Least Tern Island, which has active water management. In years without as much rainfall, these sites can support moderate numbers of Snowy Plovers and should be considered priority areas for maintaining suitable Snowy Plover breeding habitat outside of the SBSPRP area.

In the North Bay, nine adults were observed at Hamilton Wetlands, five were observed at Cullinan Ranch East, and four were observed at Montezuma Wetlands. No plovers were observed at NSMWA. This total count of 18 adults in these areas represents the largest window survey count since 2015, when 24 adults were counted between Hamilton Wetlands and Montezuma Wetlands. It is important to note that other potentially suitable habitat exists in San Pablo Bay and Suisun Bay, but was not surveyed during the window survey. Therefore it is possible that additional Snowy Plover adults were missed.

Snowy Plover Nest Abundance, Success, and Timing

In 2023, we monitored 304 nests in the South Bay, EBRPD monitored five nests in the South Bay, and a variety of other researchers monitored 23 nests in the North Bay. Nest totals should be viewed as an index rather than a precise total since not all successful nests were detected and unsuccessful nests were even less likely to be detected (Mayfield 1975). This is exemplified by our observation of at least 39 broods in the South Bay and eight in the North Bay that were detected at the brood stage.

Apparent nest success varied greatly by pond. Across the South Bay, the ponds with the highest hatch rates (minimum 10 nests) were R1 (88%; n=17), R4 (82%; n=17), PP1 (73%; n=63), E6B (71%; n=24), and E14 (67%; n=39), while the lowest hatch rates were observed at A22 (30%; n=10), A13 (31%; n=13), A15 (39%, n=28), R3 50%; n=32), and E16B (53%; n=15). Depredation was again the primary cause of nest failure and primary limiting factor in the recovery of Snowy Plovers in the South Bay and across the Pacific Coast (USFWS 2007, USFWS and CDFW 2007).

South Bay

Ravenswood

For the third year in a row, the Ravenswood ponds appeared to provide some of the best nesting habitat in the South Bay, with a 70% hatch rate observed across R1-5 and SF2. It was also the

second most productive complex, with 70 nests total monitored, including the first two nests ever monitored on R5. R3 had the highest number of nests at 32, but also the lowest hatch rate at 50%. We suggest that the high number of nests on R3 can be attributed to the lack of available habitat on R4 for much of the season due to the heavy winter rains. The first nest on R4 was not initiated until May 17, while the first nest on R3 was initiated on April 4, which was the first initiated nest of the season across the entire South Bay. Due to this lack of available habitat, R4 had much less nesting on it compared to 2022 (n=35 in 2022, n=17 in 2023). However, it had a much better hatch rate than R3, coming in at 82%.

This may be because the habitat quality of R4 is higher than that of R3. In recent years R3 has been overtaken by invasive plants, mostly small-flower iceplant (*Mesembryanthemum nodiflorum*). High vegetation cover reduces the available area for nests and the overall ability for adults to successfully camouflage. Conversely, R4 is completely devoid of vegetation when dry and is very textured, which increases camouflage. To combat this degradation, the Refuge plans to flood R3 in January 2024 in an effort to kill the iceplant and improve the habitat quality of R3. Improving R3 will be especially vital following the breach of R4 on December 13, 2023. Moving forward, R4 will no longer support any Snowy Plover nesting habitat..

Elsewhere in Ravenswood, R1 continued to be a unique pond for Snowy Plover nesting. In 2021 R1 appeared to provide the best nesting habitat in the Complex, with a 100% hatch rate (n=13). However, due to predation and flooding, the pond did not provide similarly high quality habitat in 2022, with only 45% of monitored nests (n=22) determined to have hatched. However, in 2023, it was again very successful, with an 87% hatch rate (n=17), the highest in the complex and the highest in the South Bay overall. For the second year in a row, a leak in the water control structure for the pond allowed water levels to drop, transforming more of the pond into suitable nesting habitat. However, these dry conditions once again proved to be unstable and unsustainable. We were fortunate that that no nests were flooded during a high tide event at the beginning of June, when several nests were dangerously close to channels on the pond that threatened to overtop. These nests hatched before the highest tides and were able to disperse to drier areas of R1.

As mentioned above, with the breach of R4 during Phase 2 of the Project, approximately 27% of Snowy Plover habitat in the complex has been lost and opened to tidal action. Based upon the large amount of breeding activity observed in the Ravenswood Complex in recent years, we expect that beginning in 2024, R3, SF2, and R1-2 will consistently host a larger amount of Snowy Plover breeding. Since it is likely that R1 and/or R2 will also be opened to tidal action in the near future, it is imperative that habitat enhancements are implemented at both R3 and SF2. Spreading oyster shells, gravel, or other materials to increase crypsis in both nesting and foraging areas, as well as attempting to prevent predator perching on structures adjacent to R3 and within SF2, could also result in improved breeding success. At both ponds, it will be imperative that water levels are managed appropriately to prevent extensive vegetative growth and to provide quality foraging habitat throughout the season.

Alviso

SFBBO monitored 41 nests, HT Harvey and Associates monitored four nests, and four nests were detected at the brood stage at Alviso in 2023, which is slightly fewer than 2022, but still

much higher than the historical average at that complex. The majority of Alviso nests were found at A15 (28 nests and one undetected brood), which was drawn down by the Refuge to provide nesting habitat away from the Shoreline Project. A13 was also much drier than usual and provided consistent habitat for a moderate amount of nesting (13 nests and three undetected broods).

A12 was managed wet in 2023 to preclude nesting adjacent to the Shoreline Project. Water in A12 did not begin evaporating until the very end of the season after nest initiation had concluded, so no nests were monitored on the pond itself. Rather, the four nests monitored at A12 were located on and between the levees surrounding the pond within the Shoreline Project's work area, as they build a levee on the landward side of A12, A13 and A16. This project has significantly widened the levees at Alviso, creating suitable open habitat for Snowy Plovers to nest on. However, the consistent active construction throughout this area in 2023 created a high level of disturbance. Therefore, it is somewhat surprising that Snowy Plovers still utilized this habitat. Also interesting to note is that despite an equal habitat distribution across A13, over half (seven out of 13) nests on this pond were established in the far southeastern corner, the side closest to construction.

Despite a high volume of vehicle traffic along the eastern sides of A12 and A13, disturbance was reduced by minimizing the amount of time construction personnel spent outside of their vehicles. SFBBO has consistently documented that vehicles function as blinds during surveys and that incubating adults only flush once the surveyor exits their vehicle. Therefore, it is likely that although the amount of disturbance appeared incredibly high to human senses, the plovers may not have been so impacted by it. Nevertheless, the placement of these nests within disturbed habitat when large areas of undisturbed habitat were readily available is interesting.

Alviso ponds A9-15 will be restored to tidal marsh as part of the Shoreline Project. Once the current levee construction is completed, tidal marsh restoration will be phased in over several years (if feasible). Considering our monitoring of these ponds in recent years, we don't expect the loss of A12 and A13 to tidal marsh restoration in the coming years to negatively impact Snowy Plover recovery as long as A15 is managed to support Snowy Plovers. However, the loss of A15 in conjunction with the breaches at Ravenswood could significantly hamper the ability of Snowy Plovers to meet both SBSPRP and RU3 population goals due to lack of suitable habitat. As such, we highly encourage the Shoreline Project and SBSPRP to consider enhancement and management of A15 to support breeding Snowy Plovers rather than attempting to restore this pond to tidal marsh.

Warm Springs

Overall, Snowy Plovers experienced poor hatching success among monitored nests in A22 and A23 (36%, n=11). However, for the second season in a row we observed a stark difference in hatch success between the first and second halves of the season. The first six nests were initiated in A22 from April 27 to June 12, all of which were depredated. The other five Warm Springs nests were initiated between June 14 and July 26, four of which hatched. This stark difference can likely be attributed to the greater availability of habitat at Warm Springs, especially on A22, later in the season. More exposed habitat leads to a lower nest density and a greater area over which potential predators need to search to find nests.

The specific predators responsible for the depredations at Warm Springs are unknown, but it is highly likely that Common Ravens were the biggest threat. We observed 8.21 Common Ravens per survey at A22, the highest number of ravens at any site across the South Bay in 2023. In addition, a Common Raven nest on a PG&E tower adjacent to A22 was not identified until after the nestlings had fledged. Although these Common Ravens were subsequently removed by USDA, it is possible that the adult pair provisioned their brood with Snowy Plover eggs while they were still in the nest (Harju 2021).

The large discrepancy in hatching success between early and late season nests highlights several issues at Warm Springs that, if addressed, could improve Snowy Plover breeding success in these ponds. Among these, the easiest action to implement is to cut down all remnant hunting blinds, defunct power poles, and salt production infrastructure in both ponds and the native grassland. While doing so won't eliminate the presence of ravens, it is likely to reduce their ability to hunt effectively in many areas. Where perches have been removed, implementing oyster shell and/or gravel enhancement will add needed habitat complexity to the pond and reduce predators' ability to detect incubating adults. In the long-term, the Refuge should consider reconfiguration and enhancement of these ponds in a way that is conducive to supporting breeding plovers. Most importantly, the presence of two rows of large power towers and associated wooden boardwalks that provide perches in the northeast section of both ponds renders approximately 93 hectares of pond poor habitat. Snowy Plovers should be kept from nesting in this area, either by separating it from the rest of the ponds with a new levee and opening it to tidal action, or the elevation of this section of both ponds should be lowered and managed as deep water.

Mountain View

This complex exhibited a very unique nesting pattern in 2023. Beginning in 2014, SFBBO began surveying Crittenden Marsh, which was the only area being managed for plovers in the complex. The Refuge ponds north of Crittenden Marsh are typically kept flooded with only a handful of islands exposed, which are used by Forster's terns (*Sterna forsterii*). However, this year ponds A3N, A3W, AB1, and AB2 dried enough that plovers began foraging on those ponds and nested on A3N and A3W. This is the first ever recorded nesting on A3W and the third year that plovers have nested on A3N (11 nests in 2015 and two in 2018). Conversely, Crittenden Marsh was flooded for the entire season with no available habitat and zero nests, despite that being the only Mountain View site with breeding activity since 2019.

The reason for both of these situations was the heavy winter rains. Since Crittenden Marsh has no water control and acts as a retention basin for the surrounding area, it filled with water over the winter and did not dry enough to expose any habitat until the very end of the season when nest initiation was finished. North of Crittenden Marsh, the Refuge installed a new water control structure at their ponds, but due to the rain, an unexpected quantity of sediment built up and blocked the intake structure. Therefore, AB1, AB2, A3N, and A3W began to dry and the plovers began nesting before the Refuge could bring the water levels back up. Of the seven nests monitored on these ponds, five hatched, one was depredated, and one was flooded. This puts the Mountain View complex in a group with Hayward and Coyote Hills, as three complexes that were heavily affected by the rain and therefore only had small amounts of nesting in 2023.

Barring another record-breaking rainy season, we expect this complex to return to its typical state, where Crittenden Marsh is the only site with Snowy Plover habitat. In December 2022, MROSD began a project to enhance their parcel in CMW for Snowy Plovers by spreading oyster shells. Unfortunately, these shells were immediately covered by water and a thick mat of algae, which completely obscured the shells even after water levels finally dropped in November 2023. This suggests that if MROSD wants to try spreading shells again, they will have to wait for a relatively dry year and then spread the shells in the early spring before nesting season begins, but after the majority of the rain has fallen. As part of this project MROSD also placed camera traps around the perimeter of the marsh to track mammalian predator movements. As of December 2023, these cameras have confirmed that raccoon (*Procyon lotor*), opossum (*Deldiphis virgniana*), red fox, coyote, Common Raven, and feral cat are all present at CMW.

Dumbarton

The Dumbarton ponds and adjacent salt panne Hickory normally provide a small amount of suitable nesting habitat and support between two and four plover nests each year. However, for the last two years, Cargill has allowed PP1 to dry more than usual and SFBBO observed record amounts of nesting in the pond both years (29 in 2022 and 63 in 2023). Although the pond was allowed to dry more than the historical average, the exposed area in 2023 was still not that large (approximately 25 hectares). This means that the density of nesting on PP1 was also incredibly high. This trend was noticed in 2022 (0.57 nests per hectare) and was even more pronounced in 2023 (0.82 nests per hectare). The nest density at PP1 in 2023 is the second highest ever recorded by SFBBO, behind only E12 in 2013 with 1.16 nests per hectare. PP1 supported the largest amount of nesting on any one pond in RU3, the first time since 2015 that a different pond has overtaken E14. Although no nests were documented within Hickory in 2023, this still represents the largest amount of nesting ever documented in the Dumbarton Complex, and highlights the ability of plovers to exploit newly available habitat.

Contrary to our prediction in 2022, the plovers still had a very high hatch rate at PP1 in 2023 (73%). This is lower than 93% in 2022, but is still the fourth highest hatch rate on any pond with more than ten nests in 2023. It doesn't seem that predators, especially Common Ravens have keyed into the large presence of Snowy Plovers at PP1 yet. We do not anticipate mammalian predators having a large effect on nests at PP1 due to the unbroken deep borrow ditch around the exposed area, but ravens could prove problematic if they identify the pond as a high activity area. We observed less than one Common Raven per survey at PP1 this year, but our high raven count at one of the closest complexes (8.21 per survey at Warm Springs) shows that the species is plentiful in the area and could begin hunting on the pond at any time. This year, we suspect the most successful predator was California Gulls, since we observed a California Gull eating a Snowy Plover chick and a Least Sandpiper on two separate occasions.

Unfortunately, Cargill is unlikely to allow PP1 to dry down in the future due to profit concerns. Water management challenges over the past two years have been addressed and it's unlikely that large amounts of plover habitat will persist. However, due to concerns regarding imminent predation pressure, this may be for the best. If PP1 is ever considered for seasonal management to support breeding Snowy Plovers (while still meeting Cargill's salt production needs), rotating

the years when it is available may help to reduce the likelihood that predators will target the pond.

Eden Landing

We monitored 109 Snowy Plover nests at ELER in 2023, making it the most productive complex once again. For the tenth consecutive season, the majority of Snowy Plover breeding activity at ELER was found at E14 (n=39). However, this only represents 36% of all nesting in ELER, which is the lowest percentage of nests on E14 since the large scale enhancement occurred in 2015. Prior to this year, the proportion of nests on E14 has always been above 40%. It is unclear why the proportion of nests on E14 dropped this year. Apparent hatch rate was the fifth highest in the South Bay at 67%, suggesting that predation pressure was relatively moderate.

The next most abundant pond was E6B, with 24 nests, or 22% of nests monitored at ELER. This pond also had a high hatch rate at 71%, the fourth highest hatch rate in the South Bay. With the slow ongoing decline of E14 as the most productive Snowy Plover pond, we are hoping E6B can help make up the difference and will be spreading oyster shells on this pond in early 2024.

We monitored 15 nests on E16B, or 14% of nests at ELER. However, similar to the last two years, E16B had one of the worst hatch rates in ELER at 53%. This pond contains a PG&E transmission power tower that Peregrine Falcons, Red-tailed Hawks, and White-tailed Kites were at times observed perched on, a large amount of remnant salt production infrastructure that provides additional perches, and easy access to the pond bottom for mammals via a wooden bridge. Removal of salt production infrastructure and augmentation of the power towers to reduce perching, as well as alteration of the bridge to restrict mammal access, could help to improve hatching success in these ponds. Although three one-hectare oyster shell plots were spread in E16B in 2009, spreading additional shell or gravel enhancements on the pond could help to increase the efficacy of these plots by increasing the camouflaged area for predators to search.

Hayward

We observed a large decrease in nesting activity from ten nests in 2022 to two nests in 2023. This discrepancy was likely due to the high water levels and lack of habitat availability caused by heavy rain the previous winter. The only nest monitored from the egg stage at Hayward Shoreline, which hatched, was not detected until the last week of July at OBN. The only nest monitored at FDW was detected at the brood stage on August 24, suggesting a nest initiation date near the end of July as well. These observations coincided with the ponds drying out as the season progressed.

Since the majority of Snowy Plover breeding habitat in RU3 occurs on SBSPRP lands, identifying and improving Snowy Plover habitat outside of the SBSPRP footprint will be critical to reaching the RU3 population goal of 500 adults. Hayward is one such area that is capable of supporting moderate Snowy Plover nesting. However, as demonstrated this year, nesting is not possible when habitat is not available. The lack of functioning water control at Hayward, particularly FDW, hampers the ability of this site to provide consistent Snowy Plover breeding habitat. Raising the northern levee and installing a water control structure along Sulphur Creek

would greatly improve FDW for Snowy Plovers, something that EBRPD has stated they are interested in pursuing.

Coyote Hills

Patterson Pond, located directly west of Coyote Hills Regional Park along the Alameda Flood Control Channel, is another area that could provide good quality Snowy Plover habitat. This area supported a moderate amount of Snowy Plover breeding activity in the late 90s and early 2000s, but the last documented breeding activity was in 2003. After not observing Snowy Plovers on-site for several years afterwards, and as other areas became more frequently used by breeding Snowy Plovers, the pond eventually became a lower priority site and was not surveyed regularly. Regular surveys at Patterson Pond resumed in 2021, when we observed a large amount of breeding, and have continued for the last two years. However, this site was another victim of the heavy rain over the winter. In 2023, we only monitored two nests, both of which hatched, at Patterson Pond due to low habitat availability throughout the season.

North Bay

Hamilton Wetlands and Bel Marin Keys

During the 2023 breeding season, the Hamilton Wetlands restoration site supported the greatest amount of Snowy Plover breeding activity ever recorded at this location. Over the course of the season, Avocet Research Associates and Novato Baylands Stewards confirmed the presence of at least ten nests, documented four undetected broods, and observed that between ten and eleven of these chicks survived to fledge (C. Eyster, pers. comm.). Four of the confirmed nests were located in the North Seasonal Wetlands, while three were found in the Eagle Ponds (known as Ag. Ponds in prior SFBBO reports). They were able to collect this data in large part due to the volunteer contributions of plover biologist Carleton Eyster, who was able to lend his expertise obtained from working with snowy plovers for over 30 years to help locate nests, age broods, and determine when chicks had fledged.

Considering that SFBBO biologists located multiple nests and broods during several visits in 2021, we think it is likely that Snowy Plover breeding went undetected in these locations for several years, and given the high natal site fidelity of Snowy Plovers, expect that they will continue to breed on-site. This site represents one of only three confirmed Snowy Plover breeding sites during the 2023 breeding season in the North Bay, and thus holds considerable importance for reaching RU3 population goals. In the future, it is important that consistent and standardized surveys are conducted at Hamilton Wetlands and Bel Marin Keys to document Snowy Plover nesting at this site. In order to accurately assess breeding effort and success, nest monitoring should be conducted, and if possible, color banding of chicks and adults to determine fledging success and movement of adults breeding at this site.

San Pablo Bay NWR

Unlike 2022, SFBBO did not monitor Cullinan Ranch East this year. Instead, San Pablo Bay NWR biologist, Meg Marriott, along with several Audubon Society volunteers performed occasional surveys at the site. Because surveys were inconsistent, no formal nest monitoring was performed, but surveyors were able to confirm the presence of at least one nest. However, the fate of this nest could not be determined.

Cullinan Ranch East is in the construction phases of a tidal marsh restoration project, and both Snowy Plovers and Least Terns nested on a large sand mound that was brought in via beneficial reuse of dredge spoils intended to raise the elevation of the pond. Although their nesting on-site was unexpected, they both have a history of nesting in the North Bay. Snowy Plovers were documented breeding at CDFW's nearby Little Island (which has since been restored to tidal marsh) as early as 1975 (Page & Stenzel 1981), with nesting since documented at several other CDFW ponds since. Although it is unclear whether these birds came from the South Bay or Point Reyes to exploit habitat, or if they represent a breeding population that is often spread out in the North Bay and difficult to detect, Snowy Plovers have been shown to exhibit very high site fidelity, with 64% of first year breeders nesting within 10 kilometers of their natal site and only 16% nesting greater than 50 kilometers from the natal site (Stenzel et al. 2007). Based upon these findings, it seems likely that these breeding birds represent a North Bay breeding population. Due to the vastness and inaccessibility of some marsh and seasonal wetlands habitat in the North Bay, it is possible that Snowy Plovers continue to nest undetected in small numbers across San Pablo and Suisun Bays.

Napa-Sonoma Marshes Wildlife Area

After surveying Napa-Sonoma Marshes Wildlife Area (NSMWA) in 2021 and 2022, SFBBO did not continue surveys at this complex in 2023. Karen Taylor from CDFW performed intermittent Snowy Plover surveys in conjunction with Least Tern surveys, but did not detect any Snowy Plover breeding at any site within NSMWA in 2023. Least Terns also did poorly at NSMWA this year, with only one out of three colony attempts being successful. This may have contributed to the absence of Snowy Plover nesting, since CDFW has observed that plovers at NSMWA seem to rely on nearby colonial nesters, such as Least Terns, to provide nest defense against predators (K. Taylor, pers. comm.).

The Wingo Unit recently had a new water control structure installed, and with proper management during the breeding season to provide dry nesting habitat, could annually support a moderate amount of nesting. Considering the relative lack of suitable nesting habitat in San Pablo Bay, managing this site to support breeding Snowy Plovers is important for CDFW to consider. Doing so will contribute to North Bay plover population growth, which has not occurred to date due to a lack of targeted management, yet must occur if RU3 population goals will ever be met.

Least Tern Nest Abundance and Success

As discussed above, we monitored a total of 77 Least Tern nests across three different ponds: E6B, E13, and E14. Although initially E14 was the only pond where Least Terns nested in ELER, this year it was their least productive site. The first nest on E14 was recorded on June 6 and was depredated two weeks later. Overall, only two nests out of 22 total on E14 were confirmed to have hatched and we never observed any fledges on the pond. The last known nest was established on June 27 and failed by the following week. Following this, we observed a sharp drop in the number of adults seen on E14 during surveys, from an average of nine adults per survey between May 18 and July 4, to an average of one adult per survey between July 6 and

August 29. It is possible that adults from E14 attempted to re-nest on E13 or E6B, since those colonies were active for much longer.

Least Tern nesting at E13 occurred in two main locations: a constructed island in the center of E13 and on the levee between E13 and E12. Nests on the island had a much higher hatch rate, although it is difficult to determine the exact number of nests hatched because we decided to minimize disturbance by ceasing nest checks on the island. However, we know that at least three nests hatched and another three nests probably hatched based on chick observations and length of time birds were observed incubating. We also estimate that at least three fledges were produced from the island using the 3WD method. Meanwhile on the levee, a mammalian predator, presumed to be a red fox based on scat found in a nest bowl, swept through the colony the week of July 11 and wiped out all of the currently active nests. Two new nests were established on the levee the same week, both of which were depredated within two weeks. As a result, all of the levee nests failed and we never observed any signs of hatching or chicks. This contrast demonstrates the value of high quality habitat that is protected by water. Levees are by definition access routes, making it very easy for mammalian predators to enter and decimate colonies formed on them. Conversely, islands are by definition surrounded by water on all sides, thereby deterring mammals from accessing them. Even predominantly dry ponds can function as islands if an unbroken deep borrow ditch is maintained around them.

The most exciting Least Tern colony at ELER in 2023 was the new colony at E6B. Prior to 2017, Least Terns had been documented using ELER (then called Baumberg) intermittently, but specific details on where colonies were located are difficult to pin down (HT Harvey, 2012). Since 2017, the terns have stayed on E14 or E13 and have not expanded to other ponds within ELER. However, in 2023, beginning on May 23, we began observing Least Terns landing on E6B. After initial beliefs that they were only roosting, we confirmed our first ever nest at E6B on June 13, 2023. In total we monitored 30 nests on E6B, the most between all three ponds. E6B also had the lowest percentage of failed nests (50% compared to 52% at E13). We were able to confirm seven nests hatched and another eight nests probably hatched. We also estimate that at least one fledge was produced from this colony using the 3WD method.

As discussed in the Snowy Plover sections above and as also demonstrated by Least Tern breeding success in this section, it appears that the era of E14 being the most productive pond for Least Terns and Snowy Plovers is gradually coming to an end, making way for new sites like E6B and PP1. To this end, SFBBO plans to enhance areas of E6B with oyster shells in early 2024 to increase habitat quality and hopefully attract Least Terns to nest on the pond again since they had better success there in 2023 compared to E14.

Snowy Plover Chick Fledging Success

Due to personnel and budget constraints, we were only able to band 194 Snowy Plover chicks (38% of all chicks hatched) in the field in 2023, which is fewer than the 304 in 2022, but still well above pre-2021 numbers. Banded Snowy Plover chicks collectively experienced moderate fledging success, with 33.0% (64 chicks) confirmed to have fledged, resulting in an estimate of 0.81 chicks fledged per male. These numbers are quite similar to the previous two years' data, over which we observed an average fledge rate of 32.6% and an average 0.84 chicks fledged per male. These data suggest that Snowy Plover reproductive success in the South Bay for the last

three years has fallen short of the USFWS goal of 1.0 chicks fledged per male that is needed to achieve population growth. In order to reach the benchmark of 1.0 chicks fledged per males, it is critical that that habitat enhancement, management, and predator control are all maximized to improve the number of chicks that hatch, and that high quality brood rearing habitat be provided for them to successfully fledge.

Eden Landing

We banded 64 chicks across ELER, the highest number at any complex. We focused our banding efforts on E14, which hosted 35% of all hatched chicks at ELER. We banded 30 chicks from 12 different broods, accounting for 45% of all chicks hatched in E14. Fledge rate at E14 was relatively high at 40%, or 1.0 chick fledged per male. This is lower than in 2022 when 55% of chicks on E14 fledged. The reason for this may have been the high number of mammalian predators detected on the pond despite the installation of the predator fence in 2022. We observed a red fox five separate times on E14 and witnessed meso-carnivore scat in multiple nest bowls. In addition, the bands from one chick, brown over brown, black over blue (nn:kb) were observed in scat the following survey after the chick was banded.

Between E6A and E6B, we banded 21 chicks, accounting for 34% of all chicks that hatched in these ponds. However, there was a stark contrast in fledge rate between E6A and E6B. Six out of nine chicks banded at E6B fledged for a 67% fledge rate and 1.5 chicks fledged per male. Meanwhile, as of December 2023, zero out of nine banded birds from E6A have been confirmed as fledged. It is unclear what caused this disparity, but E6A did experience a much higher predator abundance and diversity than E6B. Feral cat, coyote, skunk, American kestrel (*Falco sparverius*), peregrine falcon, and American crow were all observed on E6A, but not E6B.

Elsewhere in ELER we banded 13 other chicks from six broods on E16B, E13, E4C, and NCMP. Nine of these chicks fledged for an apparent 69% fledge rate. E4C in particular appeared to be a beneficial pond for chicks and juveniles, since we observed large flocks at that pond during band re-sight surveys and confirmed three fledges during one survey. This is likely due to the abundant foraging habitat and relatively low predator abundance at the site. Although E4C is scheduled for tidal marsh restoration in the near future, enhancement of nearby E6C and management to provide good quality habitat could serve a similar function, as this pond has in the past.

Ravenswood

We banded the second greatest amount of chicks in the South Bay in 2023 at Ravenswood: 63 chicks representing 57% of all chicks known to have hatched in the complex. The majority of chicks were banded in ponds R3 and R1, where we were able to band a total of 55 chicks representing 63% of all chicks that hatched in these ponds. Although we observed high apparent hatching success in these ponds, we observed low fledging success, at only 22% in R3 (n=37) and 11% at R1 (n=18). Aside from gulls, American Crows were the most abundant predator on R3, with almost 10 crows observed per survey. We frequently observed crows flying low over the pond and sweeping areas of the pond clean by walking across the pond bottom in large flocks. Although no corvid nests were identified in nearby Bedwell Bayfront Park this year, R3

is directly adjacent to highly developed Menlo Park, which likely supports an American Crow colony.

Since minimal habitat was available on R4 for the majority of the season, we only banded nine chicks on that pond, representing 23% of the chicks hatched. For the first half of the season, the only exposed habitat was a collection of mounds built from dredge spoils meant to serve as temporary high tide refugia on R4 following the impending breach. The Refuge did not anticipate that Snowy Plovers would use these mounds, and so did not construct them or treat them to prevent large cracks from opening in their mud as they dried. However, after reports of potential plover nesting at this location by the public, SFBBO confirmed the first active Snowy Plover nest on the mounds on May 22. Over the course of the season, we located and monitored an additional four nests on these spoils piles. During our banding efforts, we quickly identified that large cracks had indeed formed and were wide enough for chicks to fall into and become trapped. After freeing several chicks who had become wedged, we made the decision to stop banding at this location to reduce the amount of disturbance and hopefully prevent chicks from flushing into a trap. However, chicks may have still fallen into these cracks because only one of the nine chicks we banded on R4 has been confirmed as fledged, for an 11% fledge rate.

Dumbarton

We banded the third largest amount of Snowy Plover chicks in the South Bay at PP1, with 61 chicks representing 55% of all chicks that hatched on the pond. Banded chicks at PP1 experienced relatively high fledging success (41%). In most cases we are unable to identify chick predators and instead rely upon avian predator survey data to infer potential predators. However, as mentioned above, we did observe a California Gull eat a Snowy Plover chick on July 13. Directly after this event, approximately 40 adult plovers rushed towards the California Gull and began alarm calling. Although this display was not aggressive enough to flush the gull, it was a unique behavior that is not often observed.

Other Complexes

Elsewhere in the South Bay we banded chicks from two other complexes, one nest each at Alviso and Warm Springs. This is the second time since 2008 we banded chicks in the A9-A16 loop. These ponds are typically a low priority for banding efforts because the pond bottoms in this complex are very soft and can be dangerous to work in. In addition, access this year was difficult due to levee closures from the Shoreline Project. Therefore, only one nest on A15 was banded. One chick from this brood has been confirmed as fledged through the SNPL Band Reporting Google Group. Orange over brown, pink over pink (on:pp) was photographed at Dillon Beach in Sonoma County on August 23, 2023. At Warm Springs, we banded all three chicks from a nest on A22, but unfortunately have not confirmed any of them as fledged.

The low sample sizes from each of these complexes make it impossible to draw any meaningful conclusions about their respective fledge rates, but given the high egg depredation rates at these complexes, it feels relatively safe to infer that chick fledging rates were similarly poor.

OYSTER SHELL HABITAT ENHANCEMENT

Large Scale Enhancement Study

The implementation of large-scale oyster shell enhancement at pond E14 in ELER allowed us to test the efficacy of oyster shells as camouflage for nesting Snowy Plovers, and we continued to closely monitor their use in 2023, the ninth year that the enhancement was available. For the third year in a row, overall nest abundance throughout the pond, and nest density in the Western and Eastern Shell Plots were lower in 2023 when compared to the first six years (2015-2020) of the enhancement. Water levels and management in nearby ponds were comparable to recent years, suggesting that habitat conditions did not impact Snowy Plover nest site selection. Therefore, we believe that predation was the primary cause for the decline in nest abundance and density in 2023.

Nest Site Selection and Nest Survival

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 as we have documented since 2016, the shells did not result in high hatching success. In addition, it appears that the Western Shell Plot was particularly unsuccessful and unselected for this year. Based on the expected and actual observed nest numbers, the Western Shell Plot had the expected number of nests (Table 26, meaning that plovers were only preferentially nesting in the Eastern Shell Plot.

Nest survival in the Western Shell Plot was also low, almost significantly so at P=0.090. However, we know that the presence of the oyster shells themselves were not the culprit, since our comparison of DSR in any shelled area versus in the Control, yielded a higher P value of 0.250. Despite this, the lack of nests and comparatively low nest success in the Western Shell Plot in 2023 is disappointing.

Higher density breeding in E14 may increase predation pressure and reduce Snowy Plover nest success. Thus it may be advantageous to spread oyster shells, gravel, or other materials in other ELER ponds 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 moderate nest and fledging success in recent years, as well as E6A, which has hosted a moderate amount of Snowy Plover Breeding, may benefit from habitat enhancement to increase texture on the pond and remove perches.

PREDATORS

Since SFBBO did not use camera traps at nests this year, it is difficult to make any concrete determinations concerning the exact cause of nest failures in the South Bay. However, based on previous camera trap evidence, evidence at the nest (i.e., dried yolk and/or large pieces of egg shell in and around the nest bowl), and lack of other reasonable explanations, we assume that depredation is the dominant reason for nest failure in RU3. As shown in Table 15 through Table 25, we observe a wide variety of predators during our weekly surveys. Any predator observed at a site is capable of depredating a Snowy Plover or Least Tern nest, but there are several species we consider the most problematic, based on field observations and published research. These

include Common Ravens, Northern Harriers, American Crows, California Gulls, and red foxes. Each of these species and our relevant observations of them in 2023 are described in the following sections.

Avian Predators

Common Ravens

SFBBO has consistently documented ravens as one of the most prolific and problematic predators for Least Terns and Snowy Plovers in RU3 based on camera trap footage. In addition, research has shown a negative correlation between raven reproductive success and that of their avian prey (Brussee and Coates 2018), as well as finding that ravens provision their chicks with a higher proportion of other bird's eggs and chicks when close to a high density nesting area (Harju et al. 2021). For these reasons, the Refuge, CDFW, USDA, and PG&E coordinate the removal of raven nests and adults from special-status species habitat when possible.

This year, SFBBO only identified two common raven nests, both on PG&E power towers. The first was at A3N in Mountain View. This nest was deemed too dangerous to try to remove, so was allowed to remain. The other nest was found at A22 in Warm Springs, but not until the chicks had already fledged. Fortunately, USDA was still able to remove these ravens in late June. This removal correlated with the sharp increase in hatch rate at A22. Although causation cannot be proved, this is interesting anecdotal evidence.

Although no raven nests were found at Alviso, we suspect that ravens were the primary reason for the poor hatch rate at that complex. We observed over ten ravens per survey and suspect them of depredating all the active nests on A13 in one week due to their presence on the pond during a nest check on July 26. Usually we try to delay nest checks if we recognize ravens are in the area. However, on this day, two ravens flew onto the pond near the active nests at the end of a nest visit, so we could only finish as quickly as possible and leave the area. When we returned for next week's survey, every nest was depredated.

Given these 2023 observations and similar observations from previous years, it is clear that preventing ravens from nesting near sensitive shoreline habitats, including plover breeding ponds, should be considered a top priority for predator management efforts. It is vital that the Refuge and PG&E continue to limit their impact on these and other sensitive species by preventing them from nesting at sensitive habitat throughout the South Bay, and in conjunction, that landowners ensure that predator control is implemented throughout the breeding season on an annual basis.

American Crows

While we do not have any documented evidence of American Crows depredating Snowy Plover nests in 2023, the large crow flocks at Ravenswood and the extremely poor fledge rate at those ponds feel important to call out. We frequently observed flocks of up to 100 crows foraging as a unit over Snowy Plover breeding habitat on R3 and R5. In the midst of such an organized flock, there would be few places for a chick to hide.

Northern Harriers

Northern Harriers have been previously confirmed as Least Tern chick predators at ELER in 2009, 2019, and 2022 (Robinson-Nilsen and Demers 2009, Pearl et al. 2019, Pearl et al. 2023). This year, they were the most frequently observed raptor at Ravenswood, Warm Springs, and E12-E14. In addition, although they were not the most frequently observed raptor at Alviso, a Shoreline Project biologist observed a harrier depredate an incubating female plover on June 21, leading to the eggs from that nest being collected and raised at IBR. This serves as a reminder that many species are capable of depredating chicks and observed presence on a pond may not accurately reflect a species' impact. At E14 we observed Snowy Plover and Least Tern adults acting agitated and stressed after harriers flew over the pond, indicating that the birds perceived them as a major threat. Considering these observations, we believe that harriers were again a significant predator in the South Bay.

Since Northern Harriers are a marsh-nesting species, ongoing restoration of tidal marsh throughout the South Bay means it is likely that Northern Harriers will continue to be one of the predators that most heavily impacts the breeding success of Snowy Plovers and Least Terns throughout the South Bay. It may be beneficial to identify where they nest in case action needs to be taken to protect these breeding listed species.

Mammalian Predators

Red Fox

Red foxes are an invasive species that SFBBO has repeatedly documented depredating Snowy Plover and Least Tern nests. This year we had a high number of red fox observations during surveys at E12-E14 (five sightings), despite the expectation that the predator fence would prevent trespass onto E14. It is also unclear where the foxes' den was. In previous years, we confirmed the presence of a den at the saltworks on E13. However, after an early sighting of a fox there before the beginning of the season, we didn't see any more foxes on E13. Instead, they were usually observed along the southern levee of E14 towards the east end of the pond. Dense mustard stands along the levee may have been obscuring a fox den in that area.

Three separate times at ELER we observed scat presumed to be from a red fox in a plover or tern nest bowl, leaving little doubt as to the cause of nest failure. This scat was seen at a Least Tern nest on E6B, a Least Tern nest on the levee between E12 and E13, and at a plover nest on the levee between E13 and E14. This last deposition was found with black and blue color bands and a partial Snowy Plover chick head embedded in it. Only one chick with black and blue bands fitting the age of the head found in the scat was present in the area at the time: brown over brown, black over blue (nn:kb). This chick had hatched from the nest where the scat was deposited the week prior.

We did not observe red fox at any other complexes outside of ELER this year, but photographs from MROSD's camera traps at Crittenden Marsh show that they are present in other areas of the South Bay.

HABITAT AVAILABILITY AND SEASONAL TRENDS

Although many sites in the South Bay began the season completely flooded with no available habitat, as the summer progressed, seasonal ponds dried down, resulting in an eventual increase of 1,000 hectares of available nesting and foraging habitat. This corresponds to changing numbers and usage of the South Bay by Snowy Plovers. SFBBO typically records our highest weekly counts of plovers at the end of the season when the most habitat is available. However, some ponds that are kept consistently dry such as E14 and A15 serve as important early-season habitat. When comparing the late- and early-season distribution of the same cohort of plovers, these trends become apparent (Figure 18). This pattern seems likely to continue for the 2023-2024 cohort based on our incredibly high end-of-season counts this year (503±63 birds for the last six weeks of the season).

RESTORATION AND SNOWY PLOVER NESTING

The majority of RU3's Snowy Plover breeding habitat is currently located within the SBSPRP 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. Water control structures have been installed at R3 that will allow for consistently available nesting and foraging habitat. Enhancement of the R3 pond bottom with camouflage enhancing materials (oyster shells, gravel etc.) may help to increase fledging success in the pond, which was extremely poor in 2023 (7.5%; n=40). Further enhancement of SF2 Unit 3 for Snowy Plover breeding, including spreading enhancement materials and removal of remaining predator perches, could also help to offset the loss of R4. R1 and R2 may also provide moderate to good quality habitat in the near future, but these ponds are also likely to be restored to tidal marsh eventually, further necessitating the need to enhance and intensively manage remaining habitat.

Identifying and managing suitable habitat outside of the Project is crucial to allowing RU3 to meet its goal of supporting 500 adult Snowy Plovers, as well as enabling the Project to reach tidal marsh restoration acreage goals. In 2023, RU3 observed a record amount of nesting collectively between San Pablo and Suisun Bays (22 nests). Biologists and volunteers at Hamilton Wetlands documented a record amount of Snowy Plover nesting in that area (at least ten nests), and Montezuma Wetlands also observed a high amount of nesting for the area. With implementation of habitat enhancements, focused management, and where possible, targeted predator management, these areas could collectively support a moderate amount of breeding Snowy Plovers and contribute meaningfully to RU3 goals. In the South Bay, MROSD has begun to enhance habitat at Crittenden Marsh by spreading oyster shells in the pond. There are also opportunities to enhance and manage habitat at ACFCD's Patterson Pond and Hayward Shoreline. In the case of Hayward Shoreline, the Hayward Shoreline Adaptation Master Plan recommends tidal marsh restoration that will result in the loss of breeding habitat at FDW and OBN. This project should account for the loss of Snowy Plover breeding habitat, and to the greatest degree possible, provide suitable alternative habitat. Collectively, all of these sites may allow RU3 to reach population goals.

RECOMMENDATIONS

MANAGEMENT RECOMMENDATIONS

1. USFWS, CDFW, HARD, EBRPD, MROSD, the Coastal Conservancy, and Montezuma Wetlands should continue to meet Snowy Plover habitat requirements by providing dry ponds with nearby high salinity foraging habitat and managing ponds in multiple areas around the South Bay for Snowy Plovers to reduce impacts from predation, flooding, disturbance and/or disease.
2. USFWS Snowy Plover recovery leads should engage and coordinate with landowners whose lands currently or have supported breeding Snowy Plovers outside of the Project footprint. These include Veteran Affairs and USFWS at Alameda Point, USFWS at San Pablo Bay NWR, CDFW at the Napa-Sonoma Marshes WA, MROSD and NASA at Crittenden Marsh, ACFCD at Patterson Pond, HARD and EBRPD at Hayward Shoreline, the Department of Defense and State Coastal Conservancy at the Hamilton Wetlands and Bel Marin Keys Restoration Site, and private owners at Montezuma Wetlands. In order to reach RU3 goals, these aforementioned areas are critical to providing additional habitat.
3. Addition of oyster shell and/or gravel at E6A, E6B, and E8 may improve overall breeding success at ELER by reducing predation in these ponds and simultaneously reducing breeding density in other ponds by attracting more plovers to these ponds.
4. Addition of oyster shell and/or gravel, removal of all remaining perches at SF2 cell 3 and R3 could help to mitigate increased predation risk related to increased Snowy Plover nesting density following breaching of R4.
5. Relocation (and for some species lethal removal) of raptors identified as targeting breeding Snowy Plovers should be considered and implemented when high rates of nest loss, low chick survival, and/or direct predation events are observed.
6. Demolition and removal of non-historical or non-functional structures on ponds should be prioritized. Those that are historical or functional should be treated with a perching deterrent such as bird spikes.
7. USFWS should continue to work with PG&E to remove predator nests from towers at the Refuge and ELER, and coordinate with EBRPD, HARD, and MROSD and NASA to do the same at Hayward Shoreline and Crittenden Marsh, respectively. Special focus should be given to locations adjacent to or near Snowy Plover breeding habitat.
8. Invasive and/or overgrown vegetation (such as black mustard and coyote brush) along levee sides should be removed to reduce the ability of predators to hide and prevent perching. Where water control allows, invasive plant species on ponds should be smothered by creating shallowly flooded high salinity conditions.
9. The predator management and gull hazing programs should continue in 2024 in the South Bay, with increased focus on removing mammals in the early part of the breeding season and preventing gulls from breeding and roosting near Snowy Plover breeding and foraging habitat throughout the breeding season.

10. 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 connecting interior channels to the borrow ditch, should be implemented to increase the amount of foraging habitat in the pond.
11. 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 to clear work areas and during working hours as needed to minimize impacts to Snowy Plovers.
    - If construction occurs adjacent to or within a Snowy Plover nesting area, then weekly or greater communication will be necessary to ensure that all parties understand their roles in regards to minimizing impacts to listed species.
12. Expand Snowy Plover outreach, which will become increasingly important as more trails near Snowy Plover breeding habitat are opened to the public.
    - 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.
    - Interpretive panels should be placed on trails at Crittenden Marsh and Hayward Shoreline, and additional panels added at ELER and Ravenswood to provide information on Snowy Plover ecology and conservation.
    - Law enforcement patrols should be increased at ELER and Ravenswood to reduce high rates of observed trespass.
13. Relocate historical Archimedes screw structures to the trailhead north of Mount Eden Creek away from Snowy Plover and Least Tern breeding habitat to reduce the number of predator perches on E14.

RESEARCH RECOMMENDATIONS

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

1. Expanded color banding, GPS, or Motus tracking of chicks and adults to provide a more reliable dataset on Snowy Plover habitat use and survival rates. This is vital information needed to inform the recovery goal of 500 birds in RU3. SFBBO has been awarded a Traditional Section 6 Grant for 2024 to deploy 20 Motus tags on adult Snowy Plovers.
2. Document changing Northern Harrier population size, territory size and habitat use and impacts on nesting Snowy Plovers as tidal marsh nesting habitat for harriers increases.
3. Examine the recent expansion of coyote populations into ELER and the Refuge; identify their impact on breeding Snowy Plovers.

4. Impacts of corvids, raptors, and gulls on breeding Snowy Plovers.
    a. Efficacy of avian predator management on Snowy Plover breeding success.
    b. Relationship between number of predators observed and breeding success
5. Potential impacts to nesting Snowy Plovers of human disturbance from recreational trail use.
6. Identify benefits and challenges of Snowy Plovers and Least Terns nesting in close proximity within RU3 and how that relates to similar co-nesting within other RUs.
7. Long-term use of E14 large-scale oyster shell enhancement by breeding and wintering Snowy Plovers.

MONITORING RECOMMENDATIONS

1. The RU3 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. Identify funding sources for NASA owned areas of Crittenden Marsh and ACFCD's Patterson Pond.
3. Monthly surveys should include scouting areas that do not have a recent history of supporting breeding Snowy Plovers, including Crown Beach in Alameda and Bayfront habitat in Foster City, Redwood City, San Mateo, and San Leandro. As the amount of managed pond habitat decreases, Snowy Plovers may use historical or new areas for nesting.
4. Surveys in the North Bay should be conducted more frequently to better document Snowy Plover breeding effort.

ACKNOWLEDGEMENTS

In 2023, Western Snowy Plover monitoring was supported by the CDFW, USFWS, California Coastal Commission, Ducks Unlimited, California Wildlife Foundation, California Coastal Conservancy, Alameda County Fish and Game Commission, Santa Clara County Fish and Game Commission, Cargill Inc., and SFBBO donors. California Least Tern monitoring was supported by the California Coastal Conservancy and SFBBO donors. We are especially grateful to Rachel Tertes of the Don Edwards San Francisco Bay National Wildlife Refuge; Carly White, John Krause, and Karen Taylor of CDFW; Dave Riensche and Doug Bell of EBRPD; Karine Tokatlian of MROSD; and Jim Williams of Cargill for logistical support at the Refuge, ELER Hayward Shoreline, Crittenden Marsh, and PP1 respectively.

We thank SFBBO Biologists Josh Scullen, Parker Kaye, Jeremy Reinhard, Jesse Wentworth, Cole Jower, Dan Wenny, and Sirena Lao for their hard work throughout the season. We also thank our many dedicated volunteers for conducting Snowy Plover surveys, Least Tern Surveys, and data entry, especially Angela Voelker. We also thank Meg Marriott of USFWS; Karen Taylor of CDFW; David Riensche of EBRPD; Misaki Yonashiro of Vollmar Consulting; Carleton Eyster of Avocet Research Associates; and Ben Pearl of HT Harvey and Associates for contributing information about Snowy Plover nesting activity in Cullinan Ranch East, Napa-Sonoma Marshes Wildlife Area, Least Tern Island, Montezuma Wetlands Restoration Area, Hamilton Wetland Restoration Area, and the Shoreline Project Area, respectively.

Special thanks to Ben Pearl, the former Snowy Plover and Least Tern Director at SFBBO, who was always a phone call or text away throughout this season.

REFERENCES

Brussee, B. E., and P. S. Coates. 2018. Reproductive success of common ravens influences nest predation rates of their prey: implications for egg-oiling techniques. Avian Conservation and Ecology 13(1):17.

Mark A. Colwell, Katelyn M. Raby & Elizabeth J. Feucht. 2018. Breeding efficiency: a metric for assessing habitat quality and individual performance? Wader Study 125(3) 2018.

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

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

Harju, S., Olson, C. V., Hess, J., & Webb, S. L. (2021). Isotopic analysis reveals landscape patterns in the diet of a subsidized predator, the common raven. *Ecological Solutions and Evidence*, 2, e12100. https://doi.org/10.1002/2688-8319.12100

HT Harvey and Associates Ecological Consultants. 2012. "Least Tern Literature Review and Study Plan: Final Report." Prepared for: U.S. Army Corps of Engineers. File 3081.

Laake, J. and E. Rexstad. 2008. RMark – an alternative approach to building linear models in MARK. Program MARK: 'A Gentle Introduction', 7th ed. (eds E. Cooch & G.C. White), pp. C-1–C115.

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

Mayfield, H. R. 1975. Suggestions for calculating nest success. Wilson Bulletin 87: 456-466.

Page, G.W. and L.E. Stenzel. 1981. The breeding status of the Snowy Plover in California. Western Birds. Vol. 12, No. 1.

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

Pearl., B., K. Tokatlian, and J. Scullen. 2015. Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2015. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Pearl., B., K. Tokatlian, and J. Scullen. 2016. Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2016. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Pearl., B. and A. Chen. 2018. Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2017. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Robinson-Nilsen, C. and J. Demers. 2009. Western Snowy Plover Numbers, Nesting Success, Fledging Success, and Avian Predator Surveys in the San Francisco Bay, 2009. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

Robinson-Nilsen., C., K. Tokatlian, J. Scullen, and C. Burns. 2013. Western Snowy Plover Monitoring in the San Francisco Bay Annual Report 2013. Unpublished report. San Francisco Bay Bird Observatory, Milpitas, CA.

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

Trulio, L.; Clark, D.; Ritchie, S.; Hutzel, A. 2007. "Appendix D: Adaptive Management Plan for the South Bay Salt Pond Restoration Project." South Bay Salt Pond Restoration Project Final Environmental Impact Statement/Report.

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

U.S. Fish and Wildlife Service. 2007. Recovery plan for the Pacific Coast population of the

Western Snowy Plover (*Charadrius alexandrinus nivosus*). In 2 volumes. Sacramento, CA. xiv + 751 pp. Western Snowy Plover (*Charadrius alexandrinus nivosus*) Pacific Coast population draft recovery plan. Portland, OR. xix + 630 pp.

U.S. Fish and Wildlife Service. 1980. Revised California Least Tern Recovery Plan. Portland, Oregon. 108 pages.

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

U. S. Fish and Wildlife Service. 2019. 5-Year Review: Western Snowy Plover [Pacific Coast population Distinct Population Segment] (*Charadrius nivosus nivosus*) 2019. Arcata, CA. 11 pp.

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

XCLA Acetal Leg Bands I/D 3.1 mm. (n.d.). Retrieved December 30, 2015, from https://www.avinet.com/en/bands/xcla-acetal-leg-bands-id-31mm

XCLA Darvic Leg Bands I/D 3.1 mm. (n.d.). Retrieved December 30, 2015, from https://www.avinet.com/en/bands/xcla-darvic-leg-bands-id-31mm

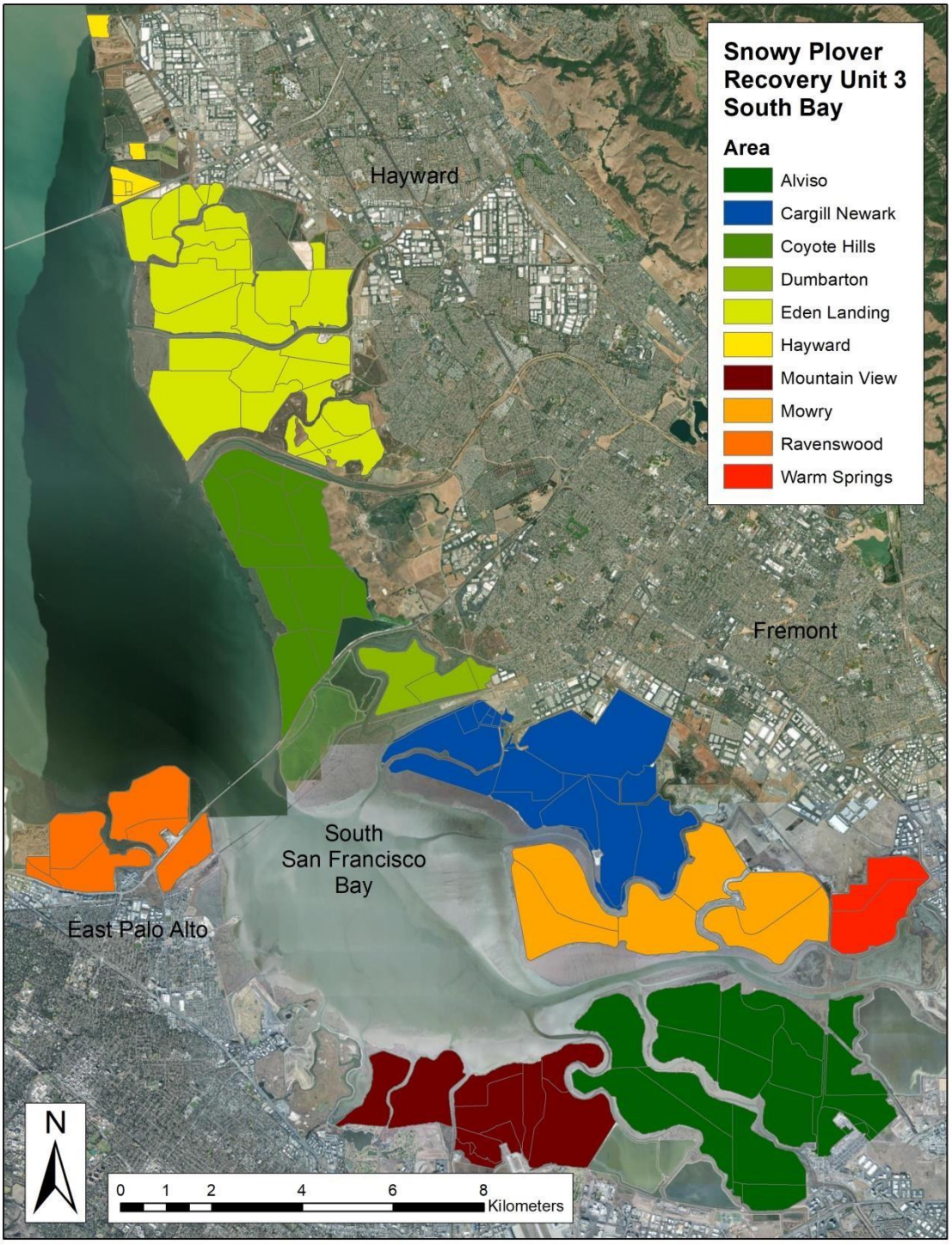

Figure 1: The Don Edwards San Francisco Bay National Wildlife Refuge, CDFW's ELER, EBRPD, HARD, and MROSD Lands in the South San Francisco Bay, California.

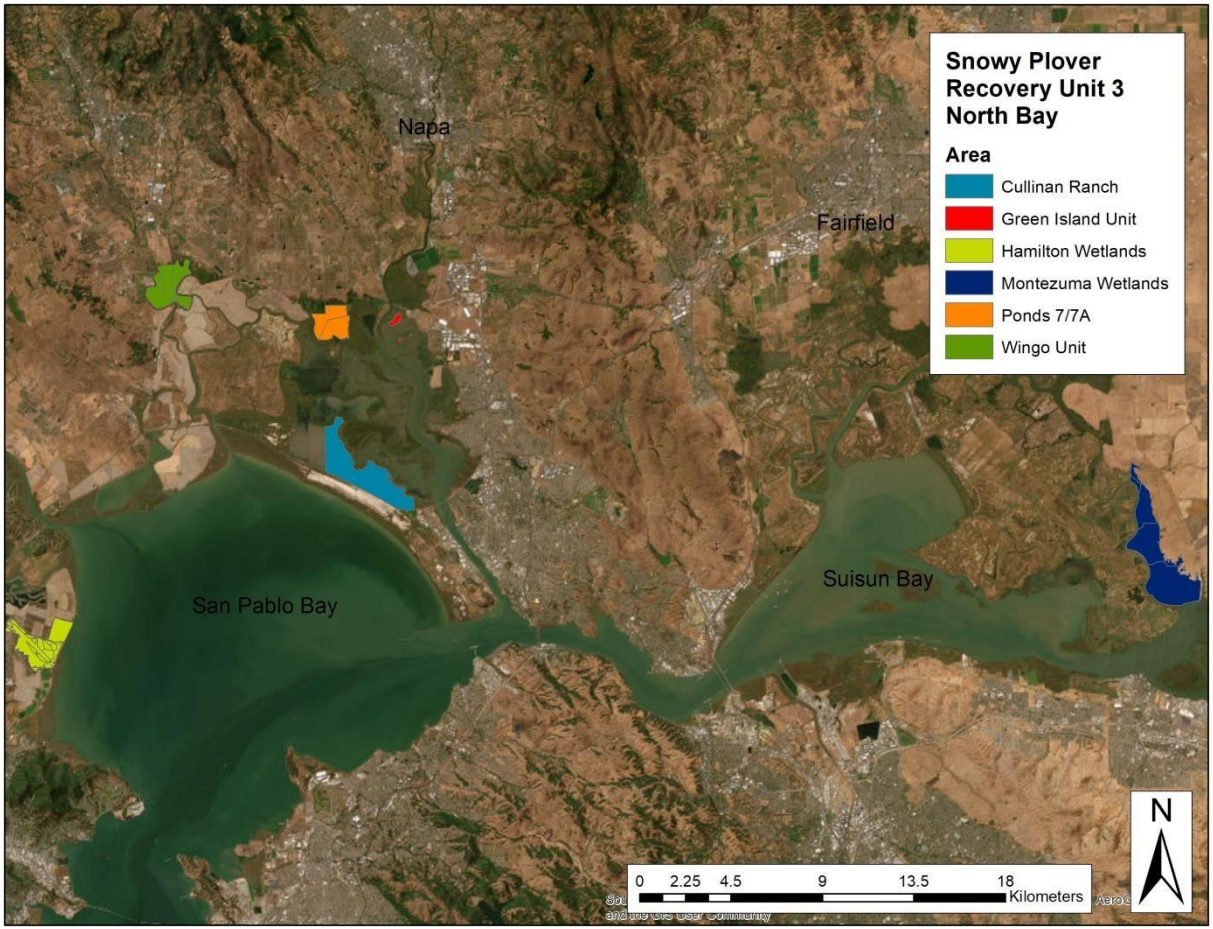

Figure 2: Snowy Plover breeding areas in San Pablo Bay at USFWS's San Pablo Bay National Wildlife Refuge: Cullinan Ranch; CDFW's Napa-Sonoma Marshes Wildlife Area: the Wingo Unit, Ponds 7/7a, and the nesting islands at the Green Island Unit (formerly called the Napa Plant Site); Coastal Conservancy's Hamilton Wetlands; and Montezuma Wetlands in Suisun Bay.

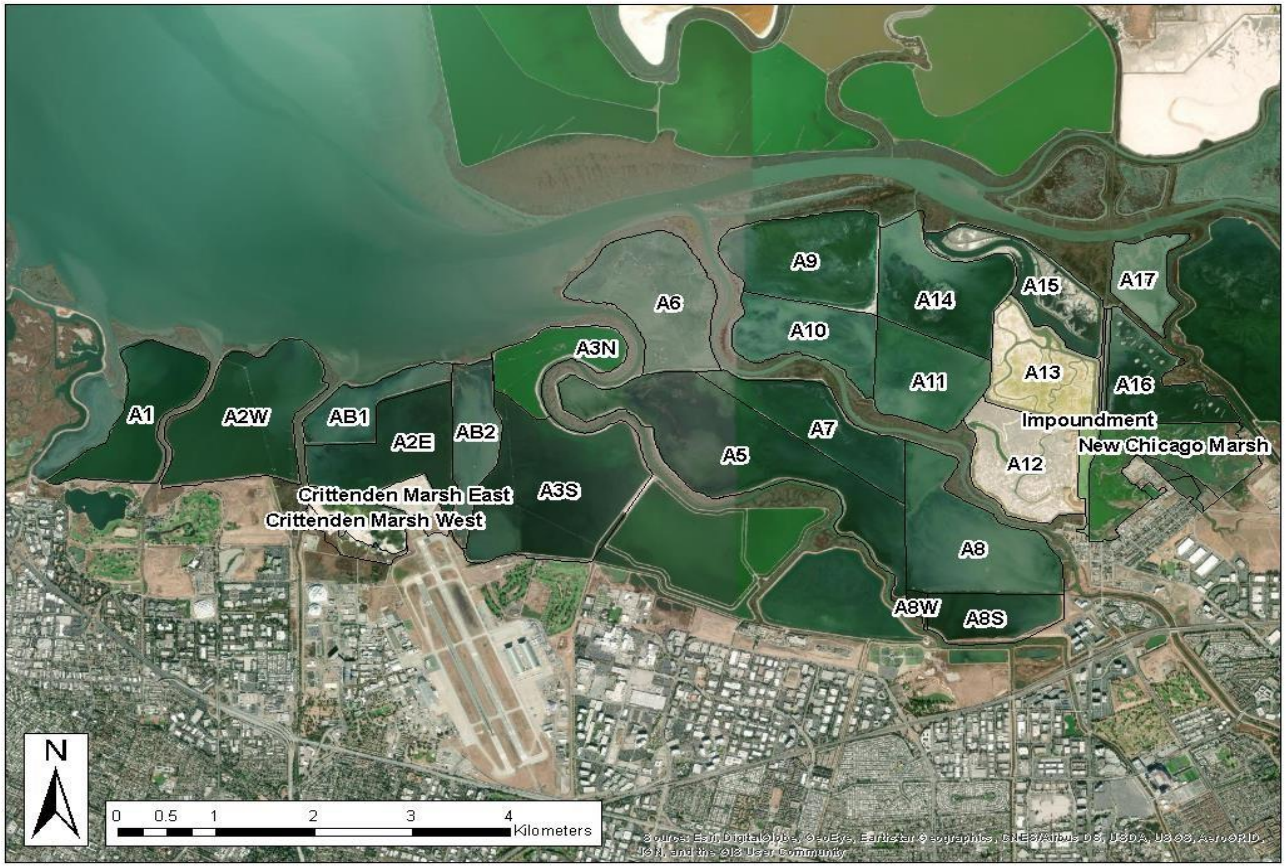

Figure 3: Ponds in the Refuge's Alviso Complex, including Mountain View (A1-A3N) and NASA/MROSD property (Crittenden Marsh), at the southern end of the South San Francisco Bay, California. See Figure 1 for location of Alviso within South San Francisco Bay.

Figure 4: 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 the South San Francisco Bay.

Figure 5: Ponds in the CDFW's ELER and ACPWA's Patterson Pond in the Coyote Hills complex. See Figure 1 for the location of ELER and Coyote Hills within South San Francisco Bay.

Figure 6: Ponds located in the Refuge's Warm Springs area, Fremont, California. See Figure 1 for location of Warm Springs within South San Francisco Bay.

Figure 7: 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 RES Environmental Services Inc. property Newark Slough Mitigation Bank (termed Hickory in this report). See Figure 1 for location of Dumbarton within South San Francisco Bay.

Figure 8: Ponds in Hayward Shoreline north of the San Mateo Bridge in Hayward, CA. See Figure 1 for location of OBN, Least Tern Island, and FDW within South San Francisco Bay.

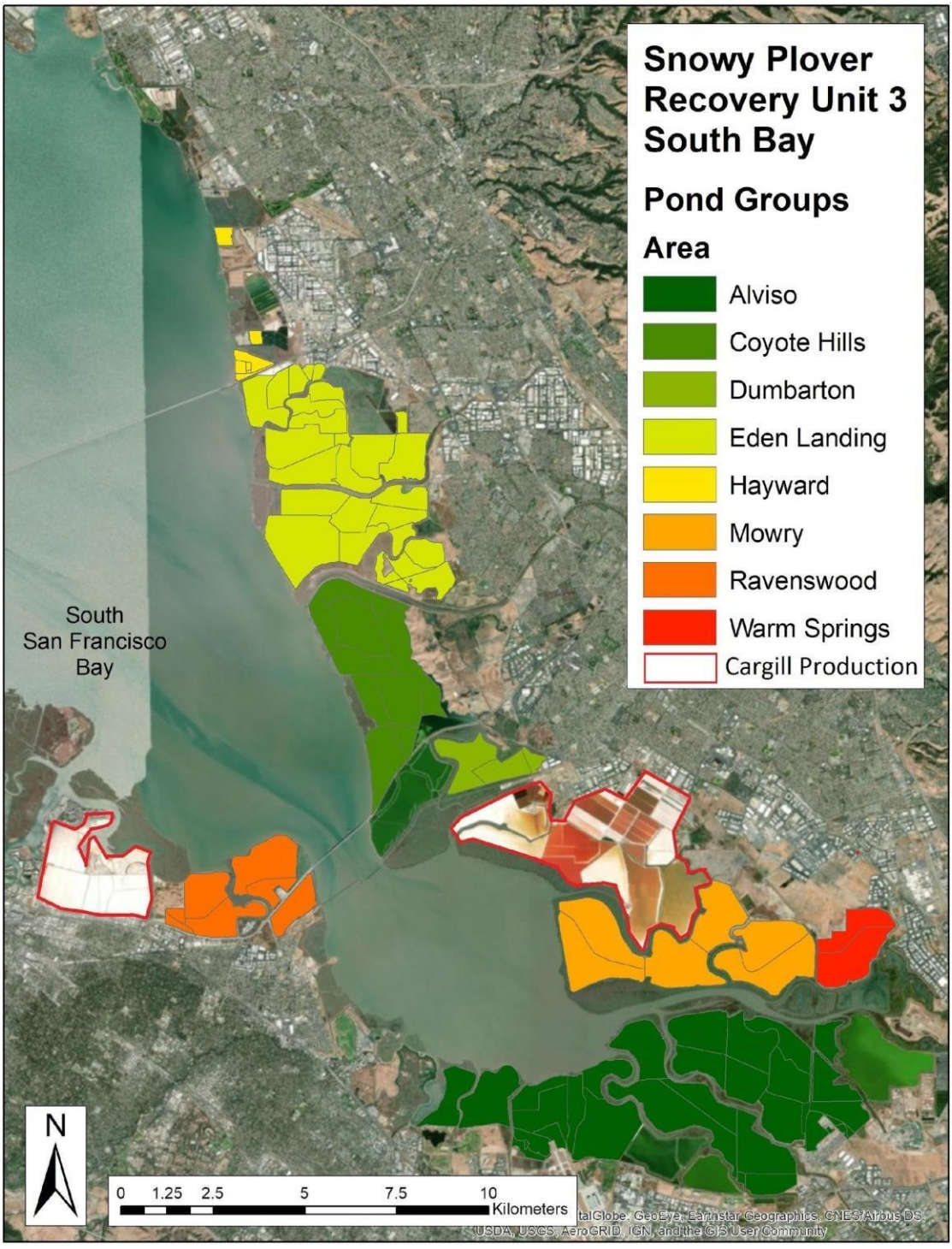

Figure 9: Cargill salt production ponds in relation to other pond groups, South San Francisco Bay, CA. The Redwood City plant is located west of the Ravenswood ponds, while the Newark plant is located between the Dumbarton and Mowry ponds.


BMK Wetlands
North Seasonal Wetlands
Eagle Ponds
Tidal Wetlands
South Seasonal Wetlands
N
0 0.2 0.4 0.8 1.2 1.6
Kilometers
USGS, AeroGRID, IGN, and the GIS User Community

Figure 10: Ponds and tidal areas within the Hamilton Wetlands and Bel Marin Keys Restoration Site, Novato, CA.

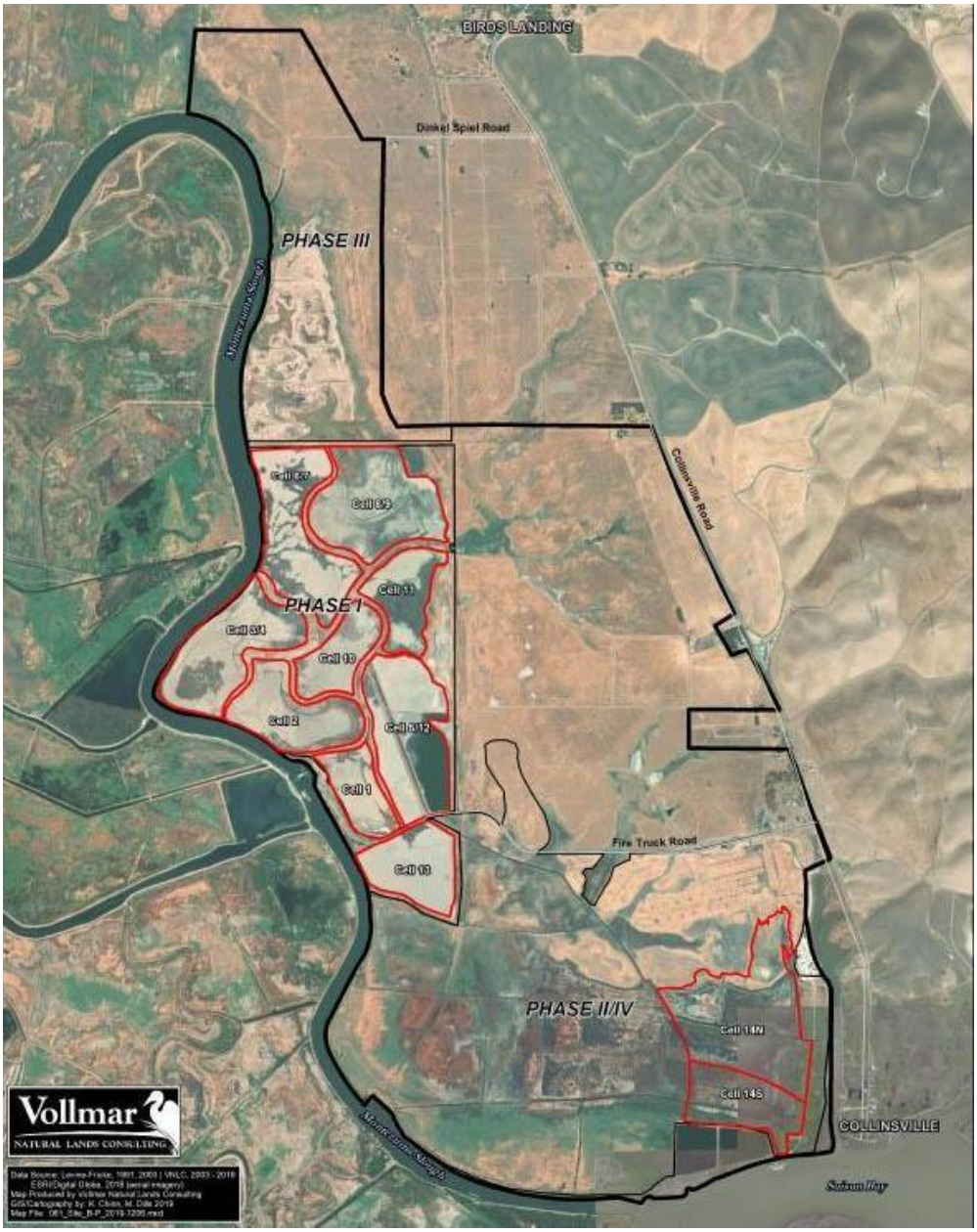

Figure 11: Phases and ponds within the Montezuma Wetlands Project Site, Solano County, CA. Image used courtesy of Vollmar Natural Lands Consulting.

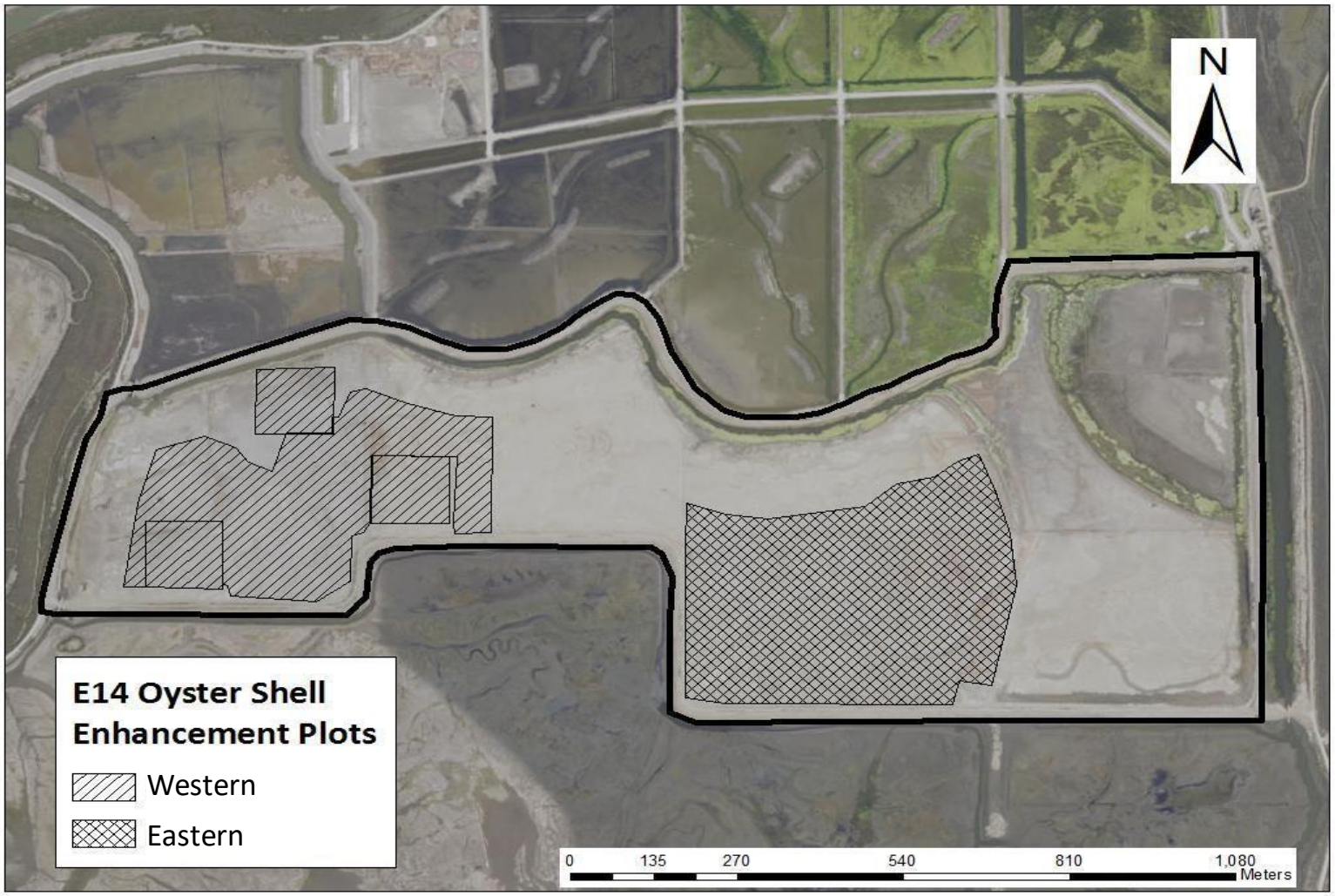

Figure 12: Oyster shell enhancement plots at Pond E14, ELER, Hayward, CA. Note that since deployment in fall of 2014, additional oyster shell has been spread by volunteers in both nesting and foraging areas.

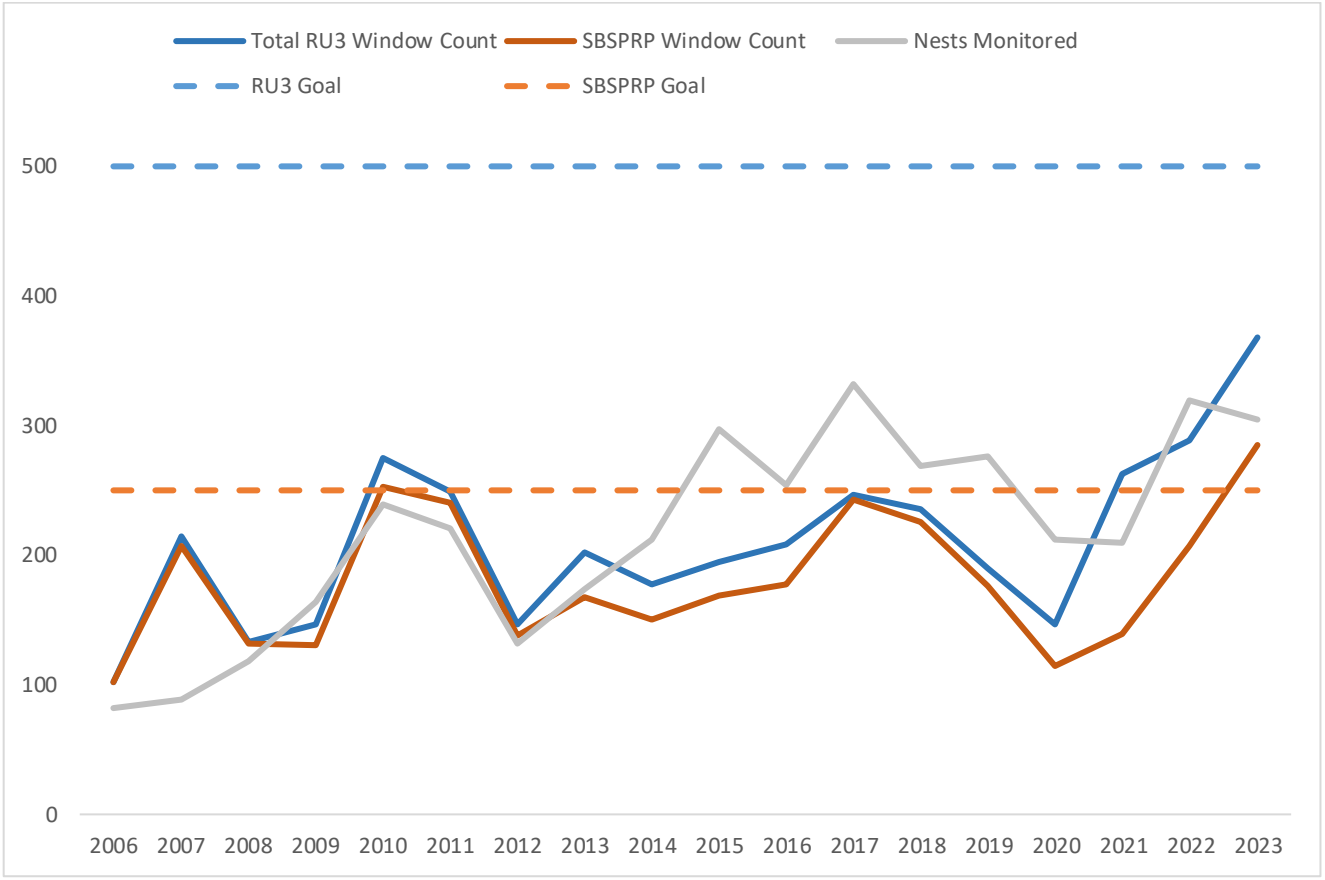

Figure 13: The total number of Snowy Plover adults counted during the breeding window survey across RU3 and within the SBSPRP footprint, and the total number of Snowy Plover nests counted during the season in all regularly monitored RU3 areas, San Francisco Bay, from 2006-2023. The dashed lines represent the goals for the number of breeding adults within RU3 as a whole (500 birds) and within the SBSPRP footprint (250 birds), which were set by the USFWS Recovery Plan and the SBSPRP's Adaptive Management Plan documents respectively. Note that in 2020, due to the Covid-19 pandemic Refuge lands were not surveyed.

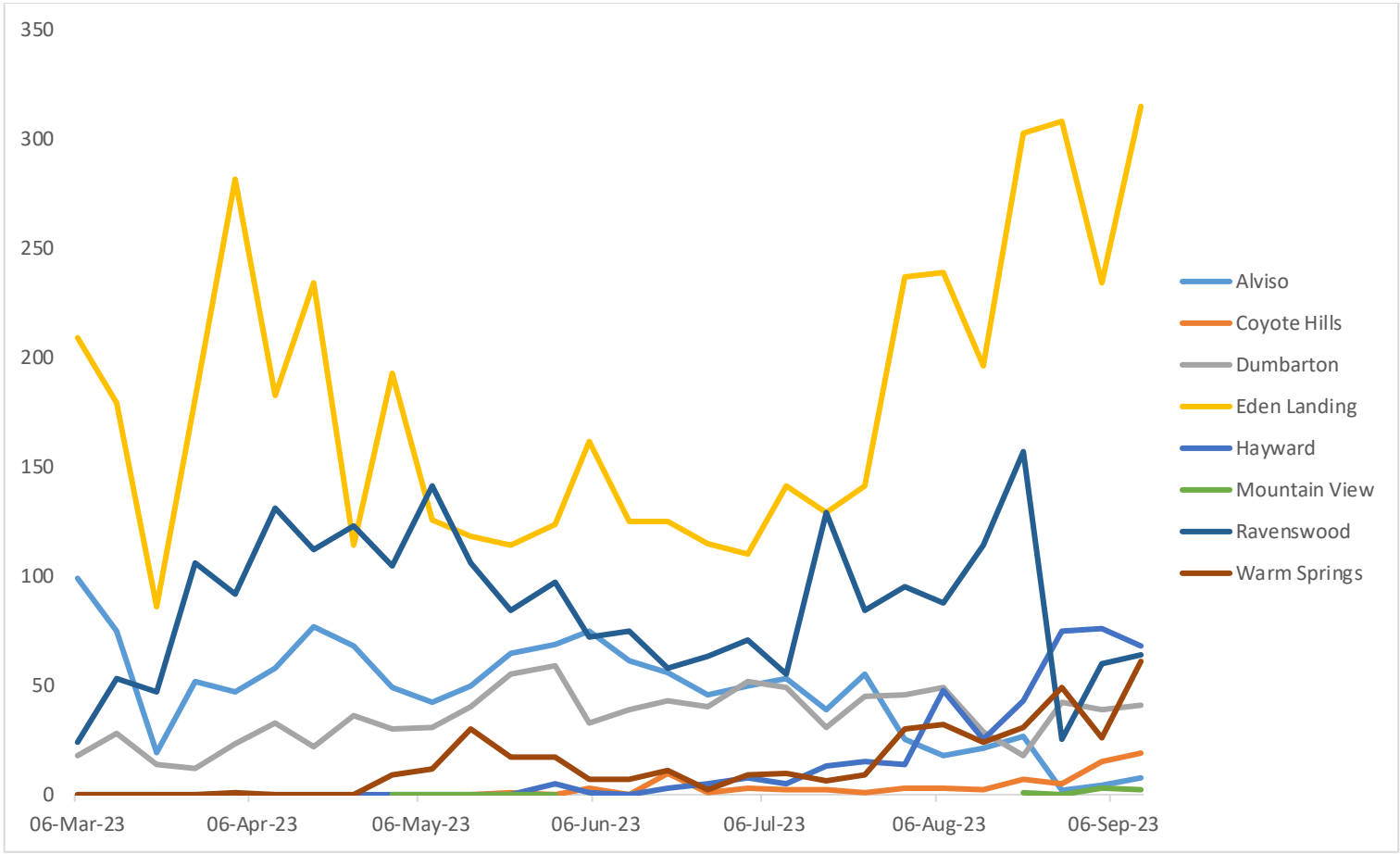

Figure 14: Weekly counts of adult Snowy Plovers by week and area, South San Francisco Bay, California, 2023. Data presented here for all locations monitored where Snowy Plovers were observed. Note the high number of Snowy Plovers observed in March, April, August, and September are presumed to be migrating and not breeding in the San Francisco Bay.

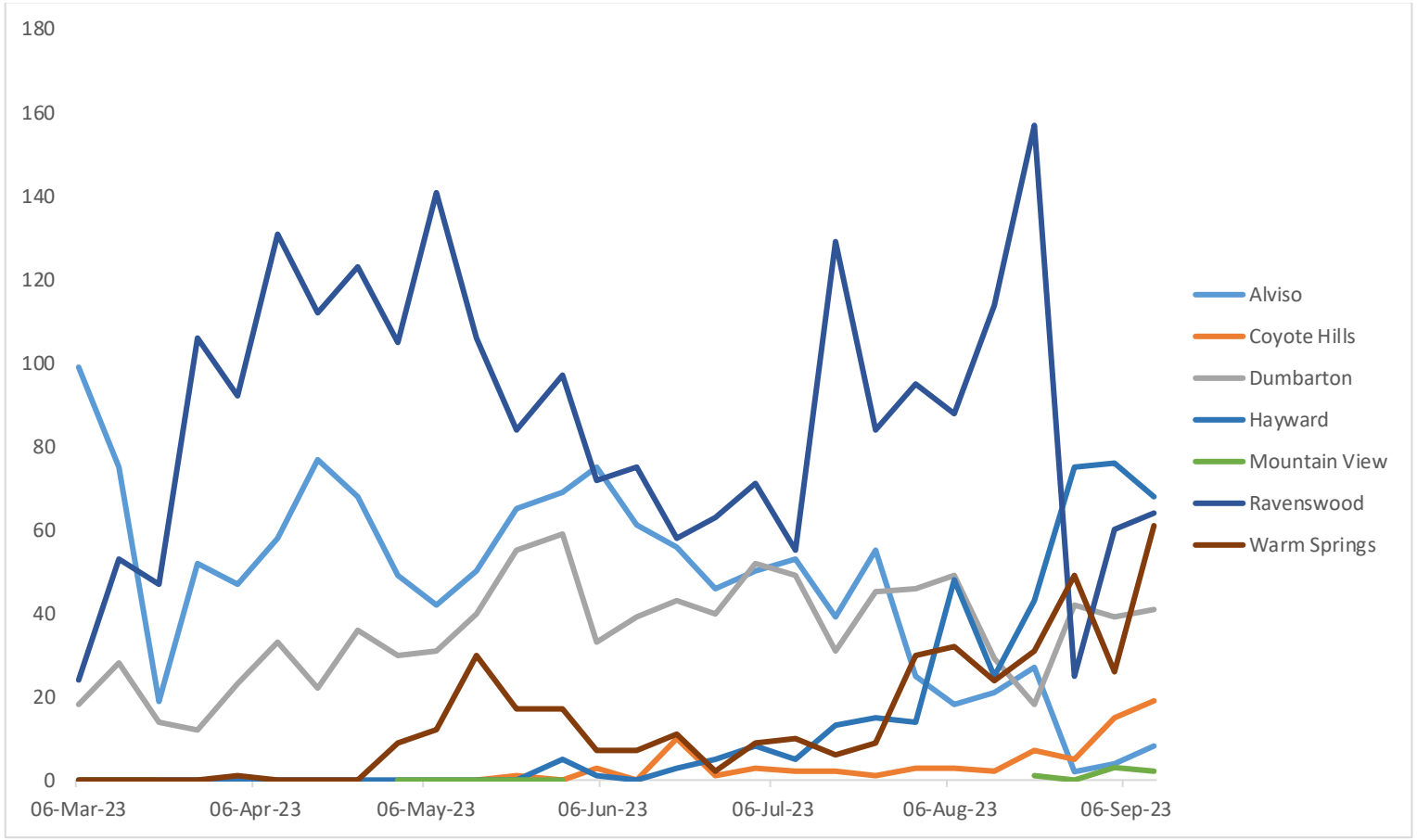

Figure 15: Weekly counts of adult Snowy Plovers by week and area, South San Francisco Bay, California, 2023. Data are presented for all locations except ELER to facilitate interpretation of the data. Note the high number of Snowy Plovers observed in March, April, May, August, and September are presumed to be migrating and not breeding in the San Francisco Bay.

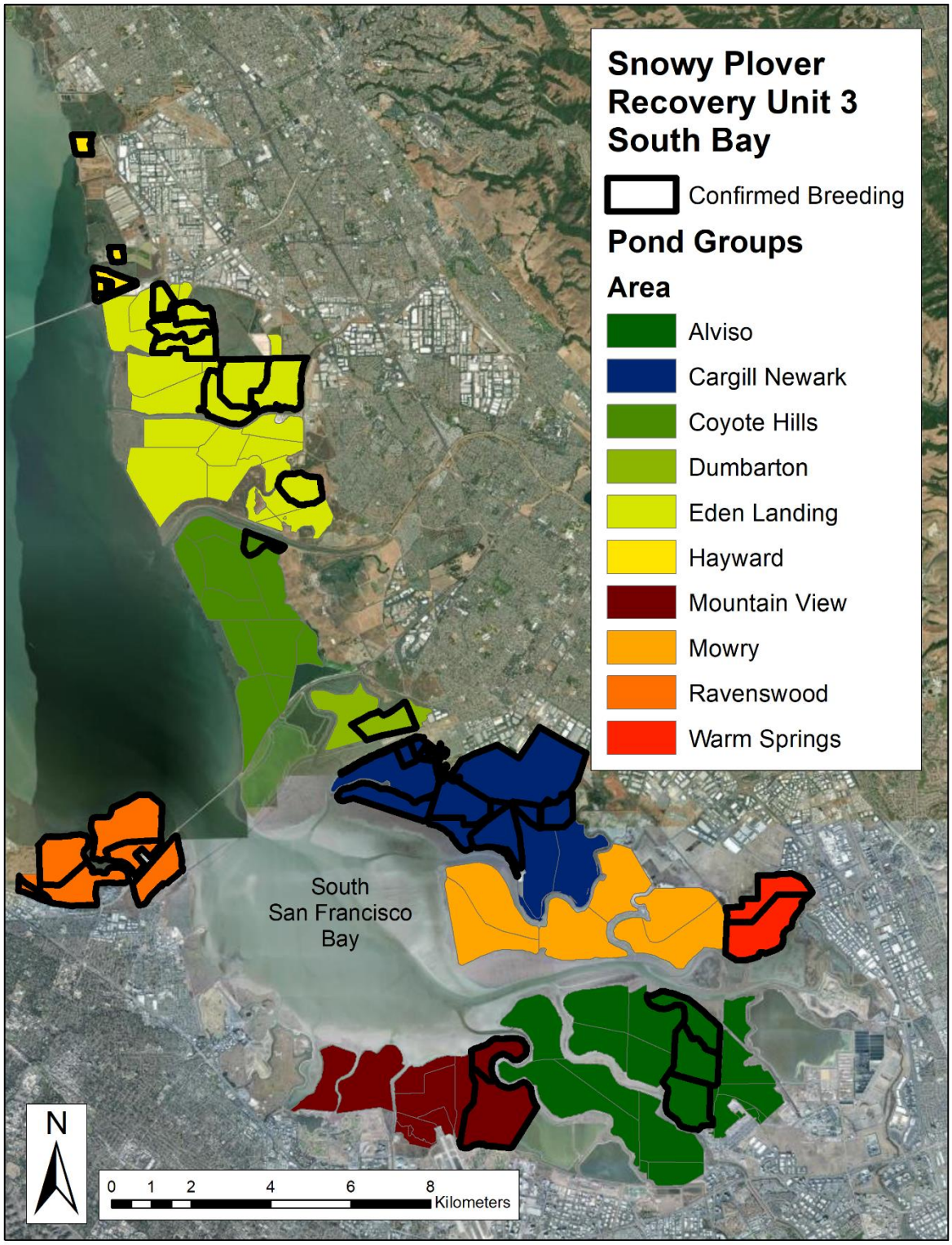

Figure 16: Areas (black outline) with documented Snowy Plover nesting activity during the 2023 breeding season, South San Francisco Bay, California.

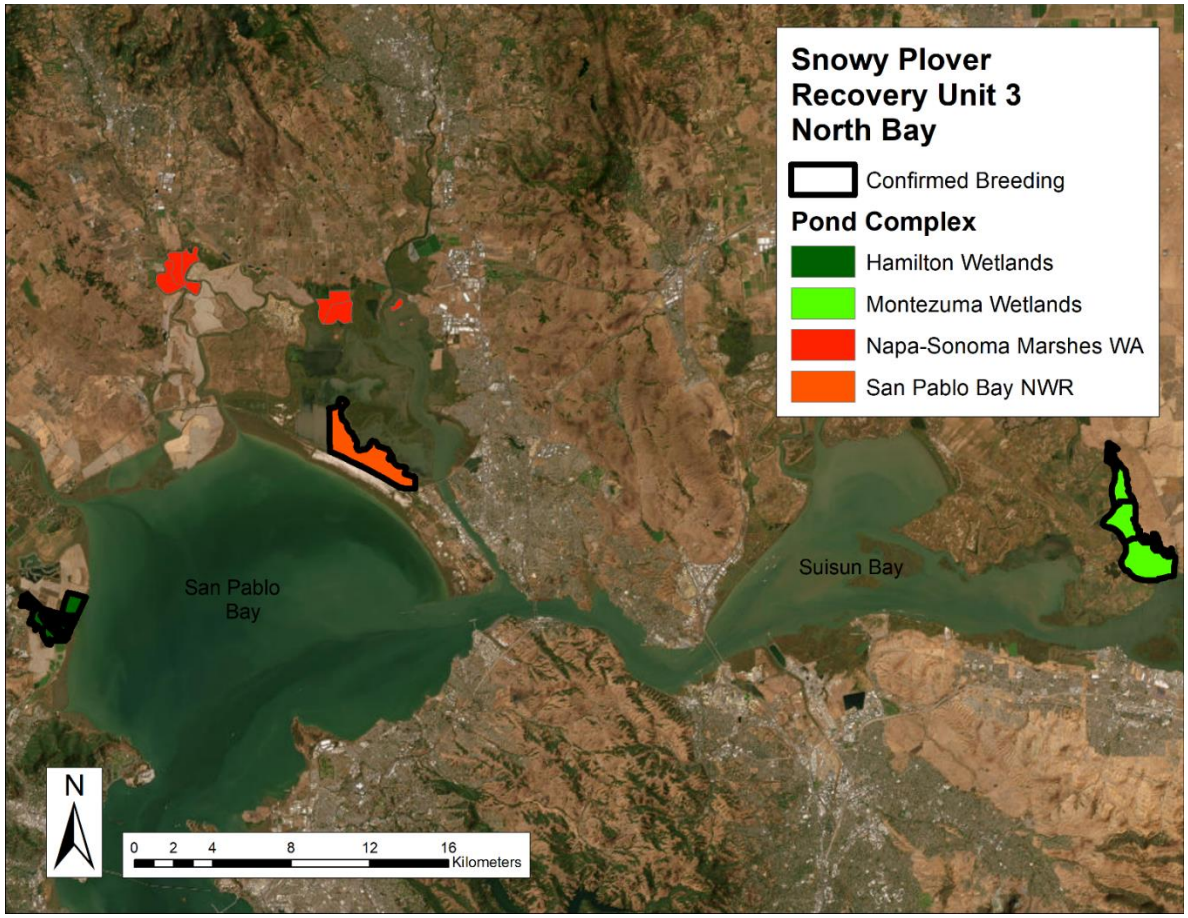

Figure 17: Areas (black outline) with documented Snowy Plover nesting activity during the 2023 breeding season, San Pablo Bay and Suisun Bay, California.

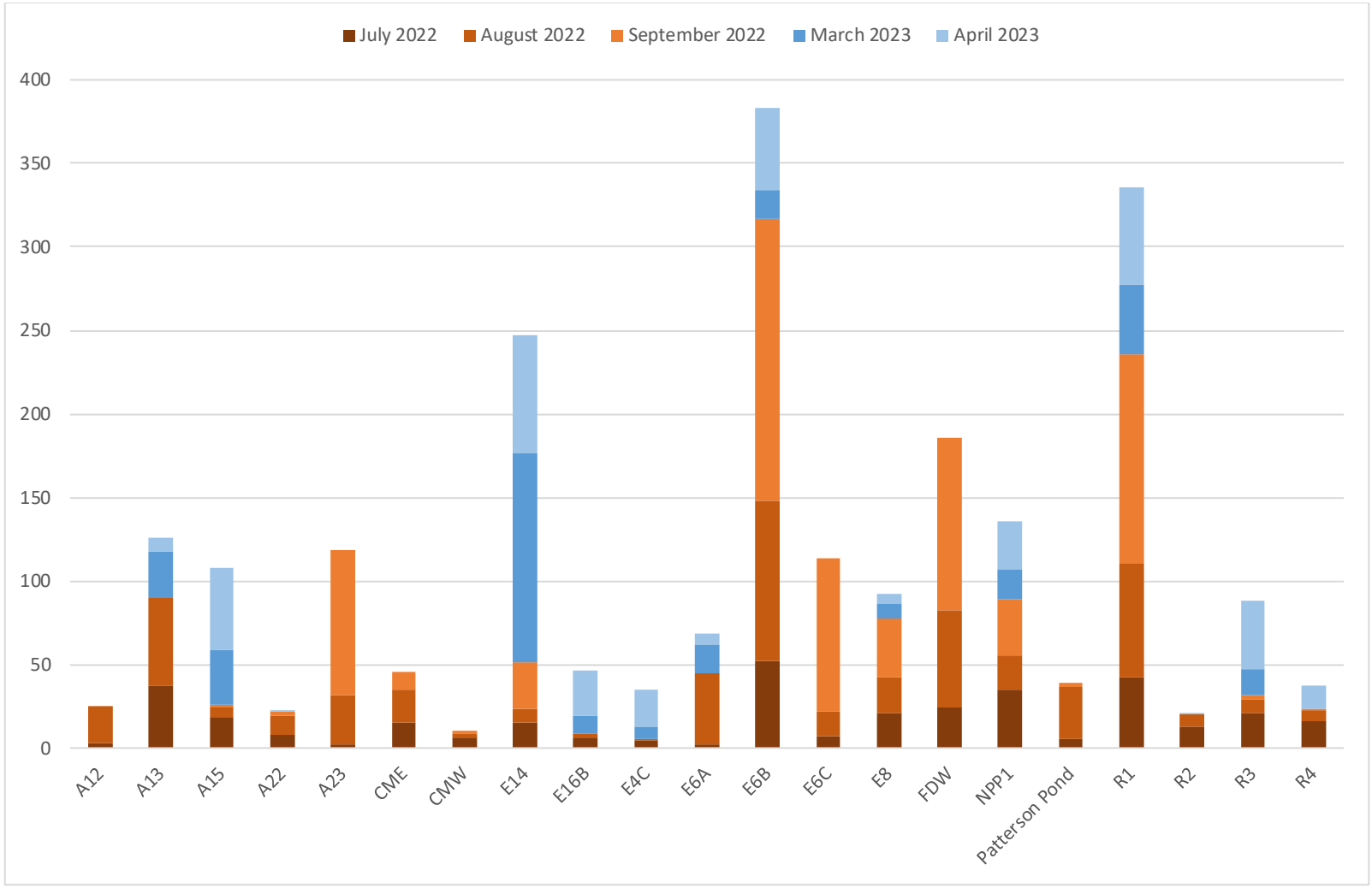

Figure 18: Average number of plovers, excluding chicks, observed per survey at select ponds during July to September 2022 and March to April 2023. This figure shows that ponds are used by Snowy Plovers in varying intensity during the beginning and end of the breeding season depending upon habitat availability.

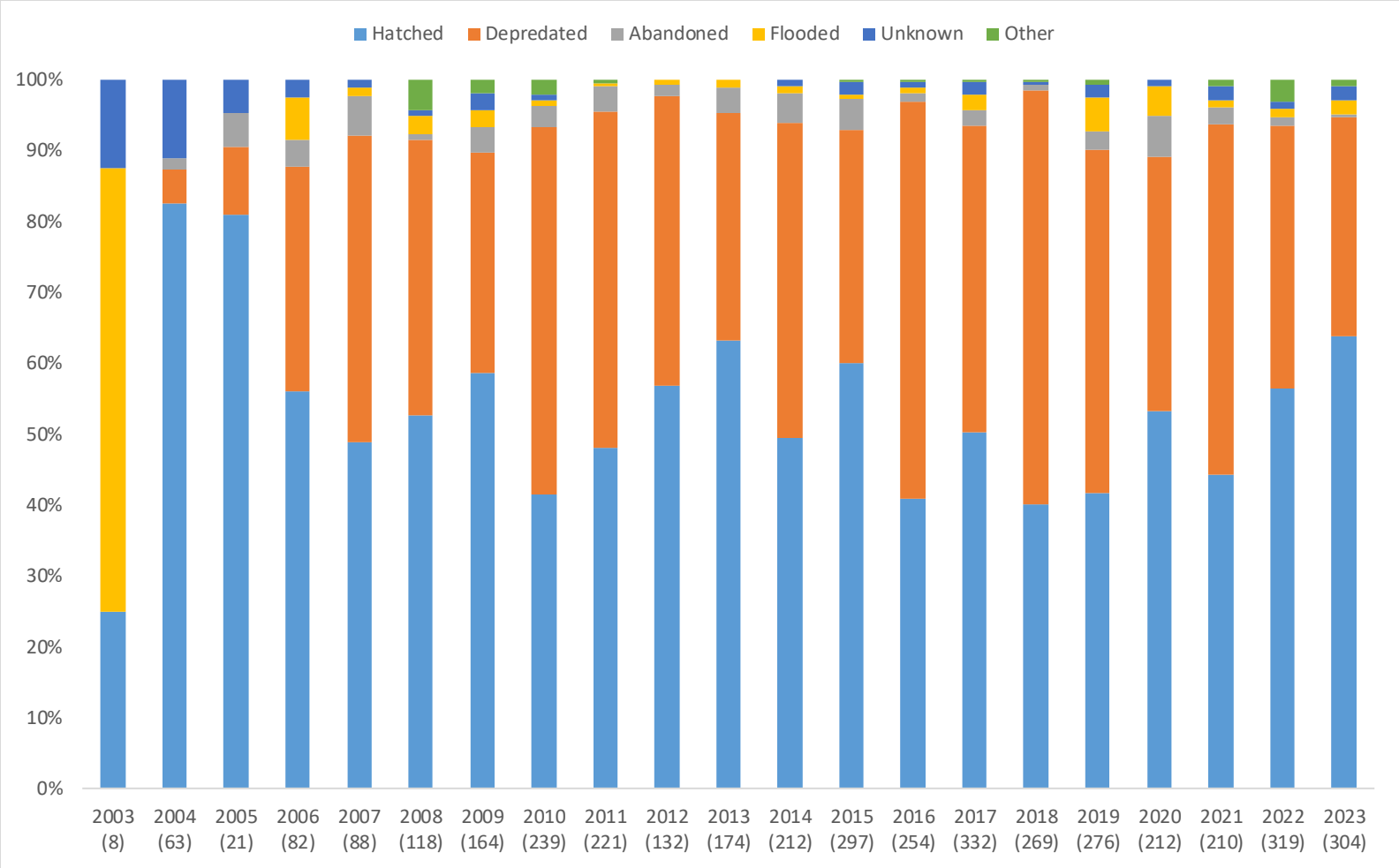

Figure 19: Annual apparent Snowy Plover nest fates in the South San Francisco Bay, California, 2008-2023. The number of nests monitored is indicated in parentheses beneath the year.

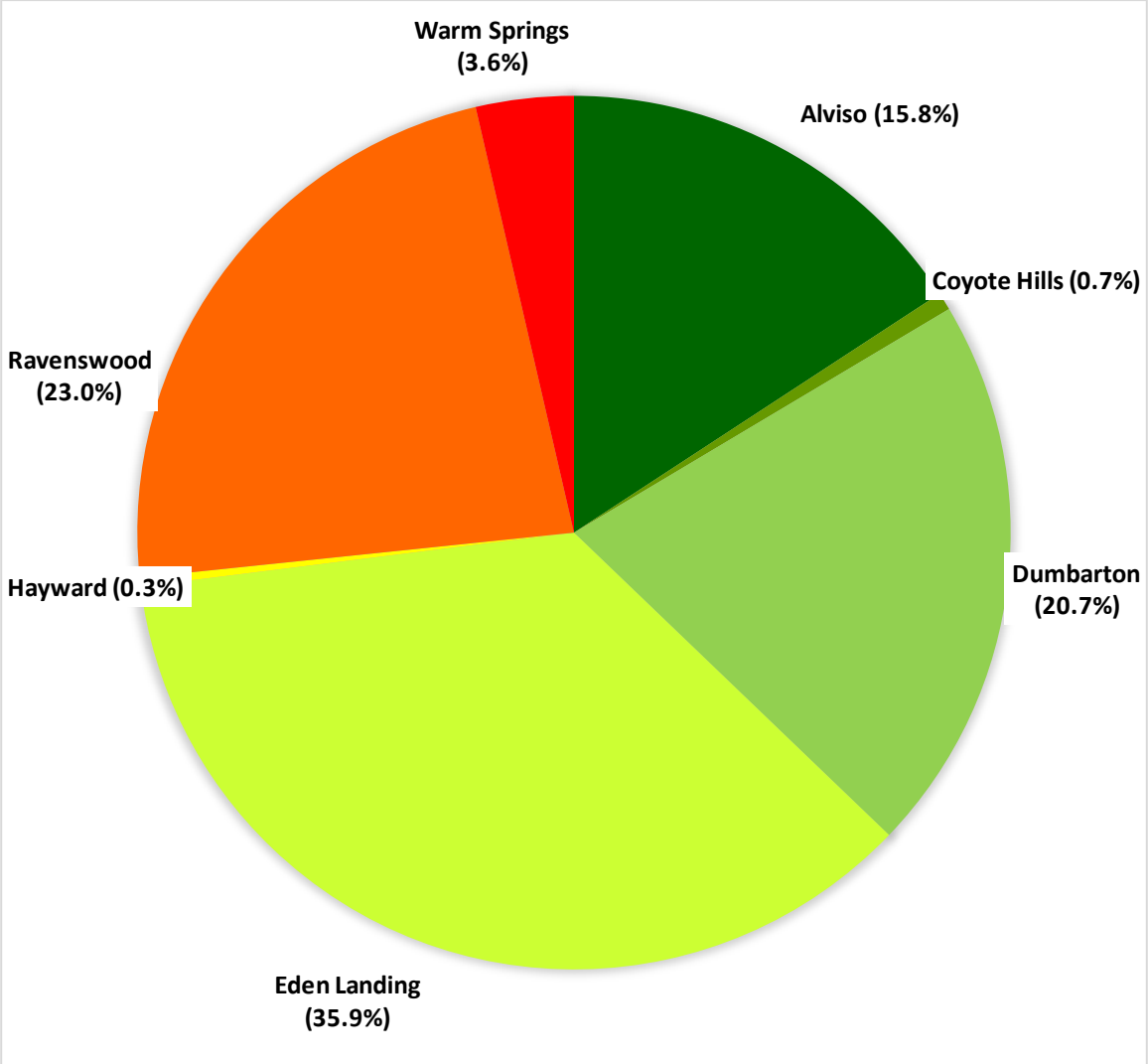

Figure 20: The proportion of Snowy Plover nests found in each pond complex in the South San Francisco Bay, California, 2023.

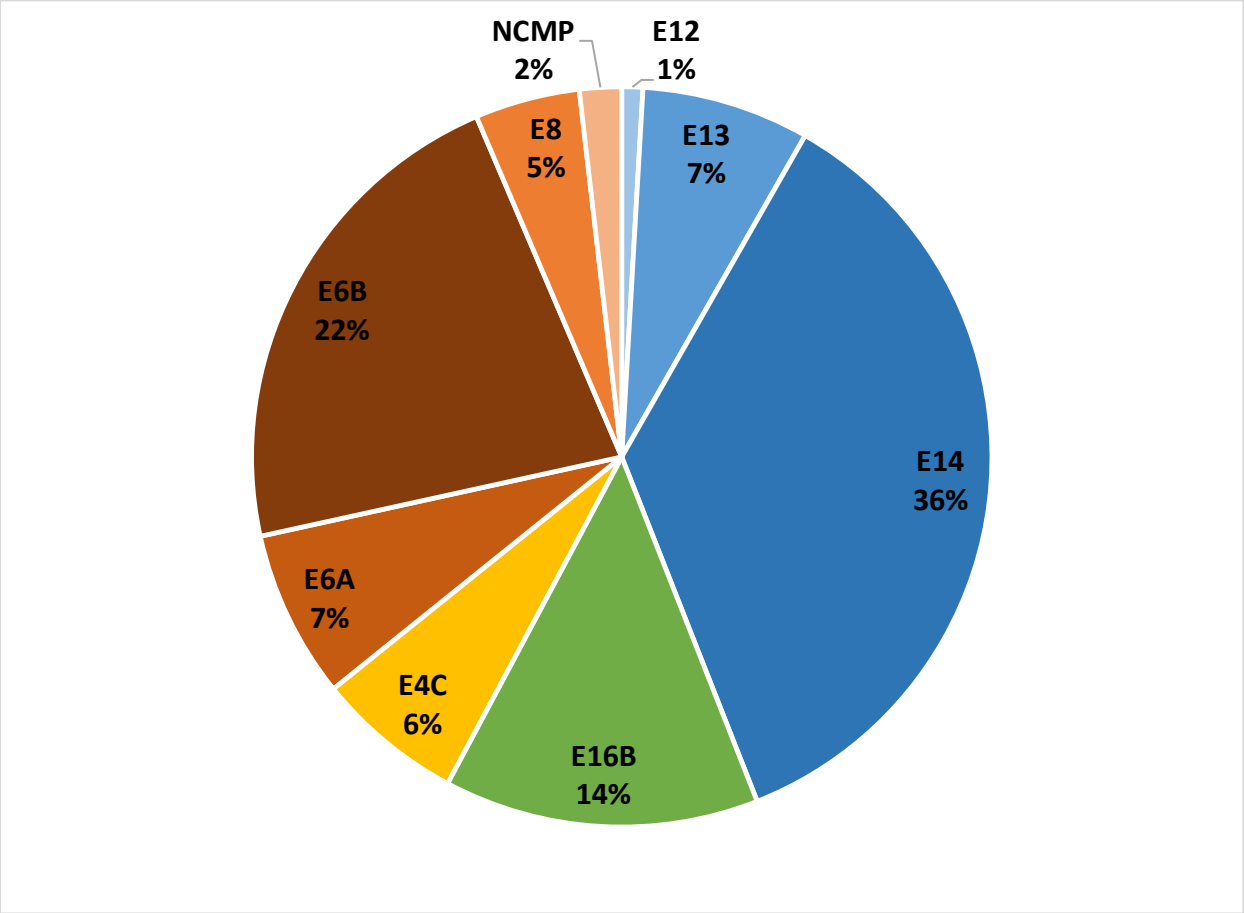

Figure 21: The proportion of Snowy Plover nests found in each pond within the ELER, Hayward, California, 2023. Note that 36% of ELER nests were found in pond E14.

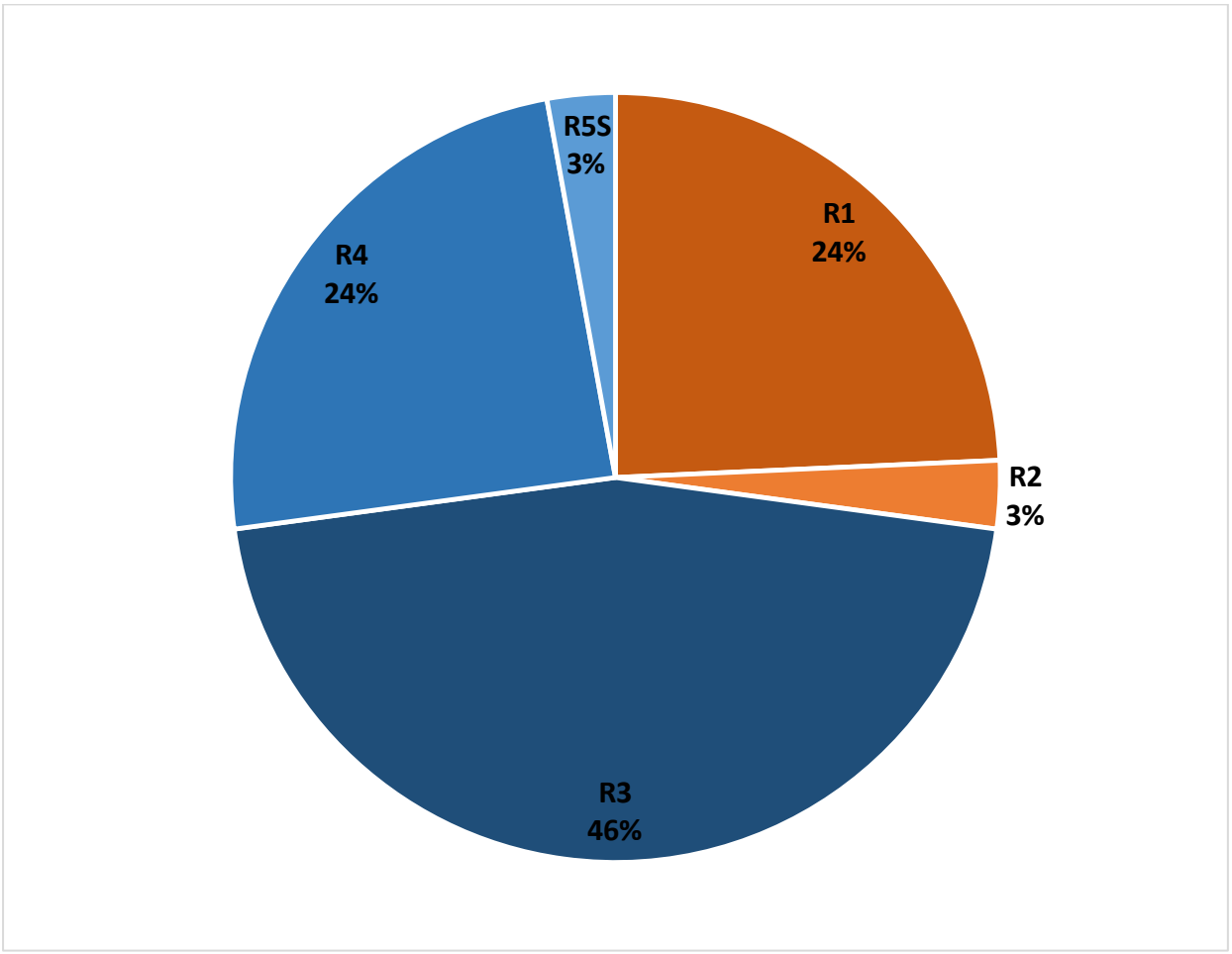

Figure 22: The proportion of Snowy Plover nests found in each pond within the Ravenswood Complex, Don Edwards San Francisco Bay National Wildlife Refuge, Menlo Park, California, 2023.

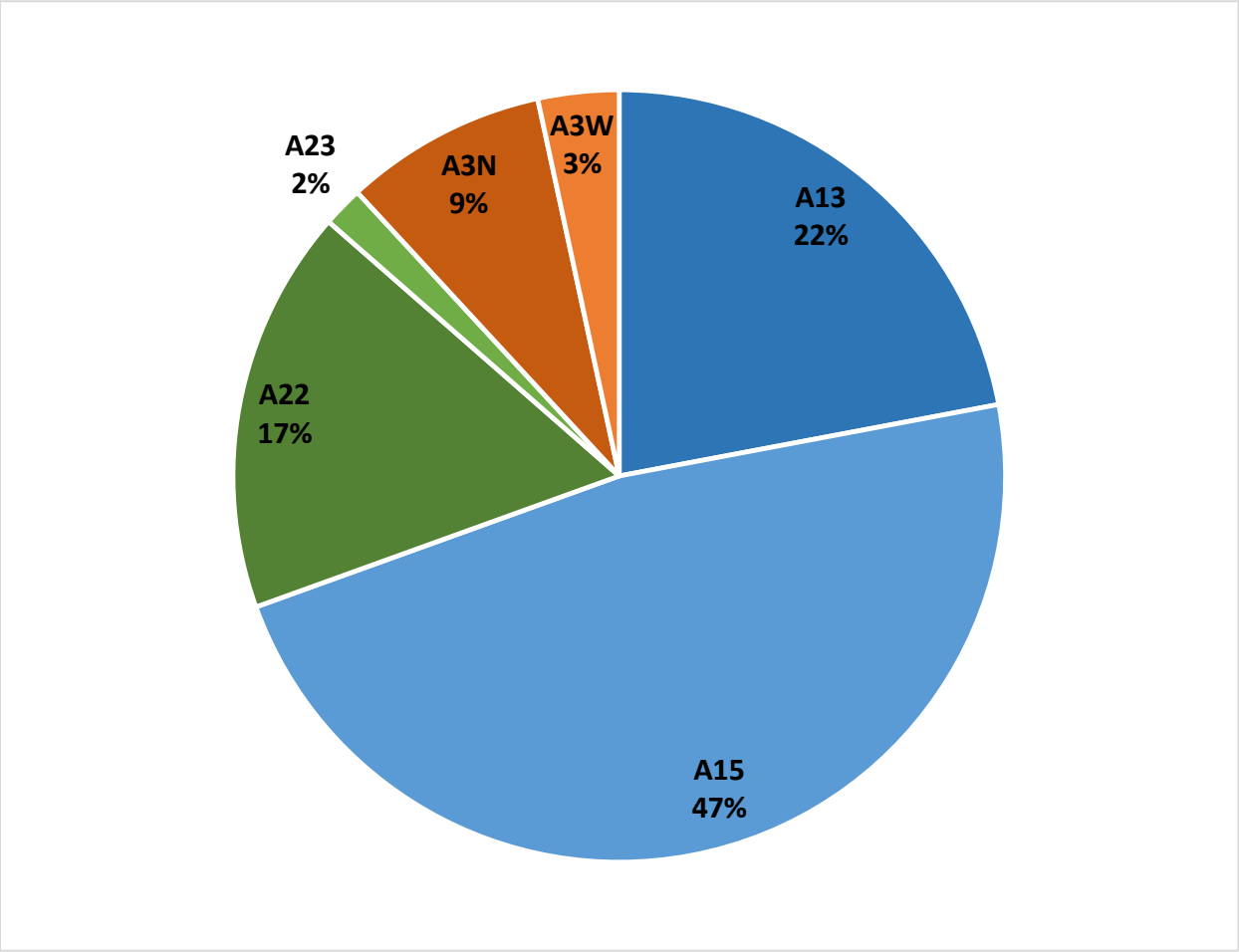

Figure 23: The proportion of Snowy Plover nests found in each pond within the Alviso, Mountain View, and Warm Springs Pond Complexes, Don Edwards San Francisco Bay National Wildlife Refuge and MROSD and NASA co-owned Crittenden Marsh, Santa Clara County and Alameda County, California, 2023.

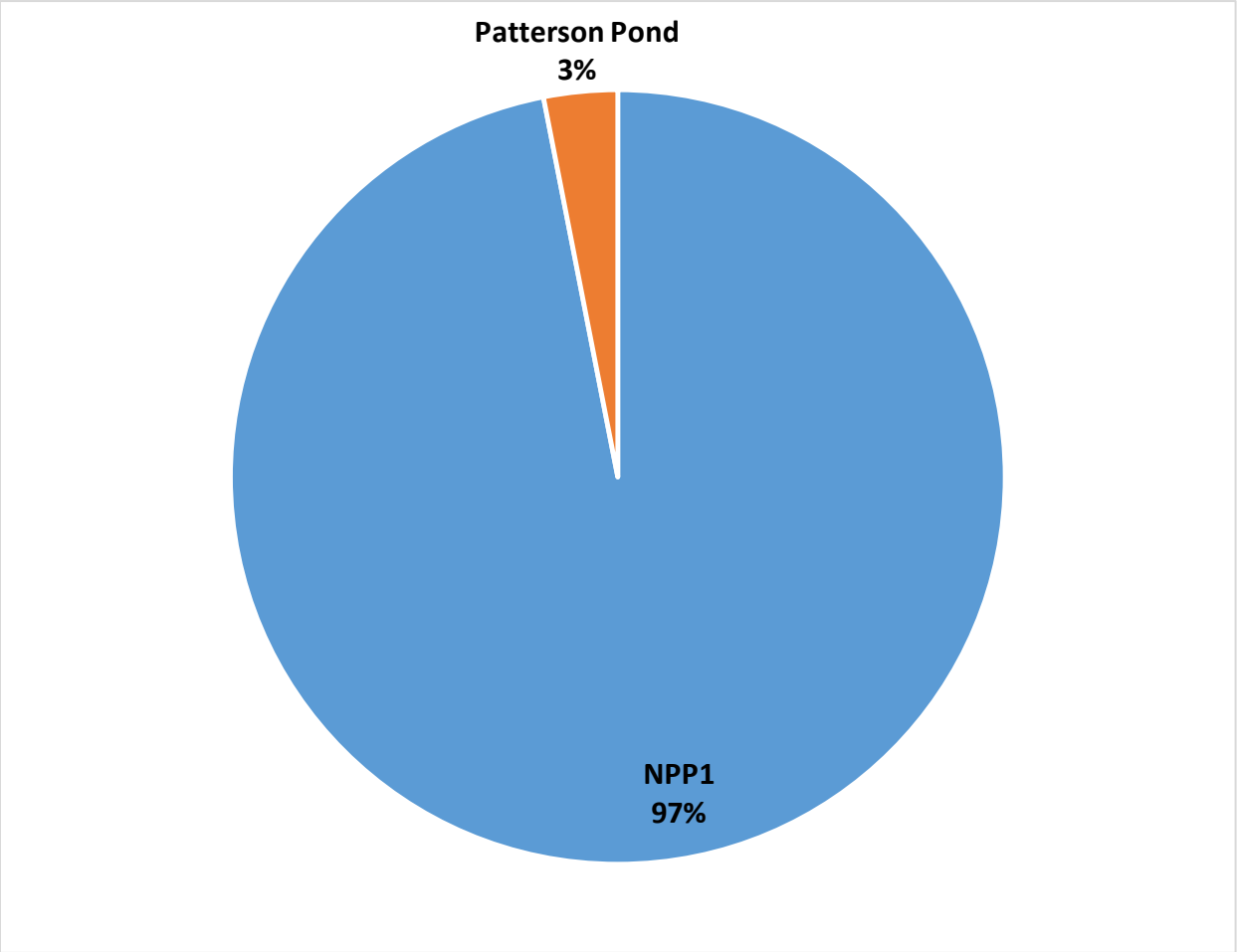

Figure 24: The proportion of Snowy Plover nests found in each pond collectively within the Dumbarton Complex, Don Edwards San Francisco Bay National Wildlife Refuge and ACFCD Patterson Pond in the Coyote Hills Area, Alameda County, California, 2023

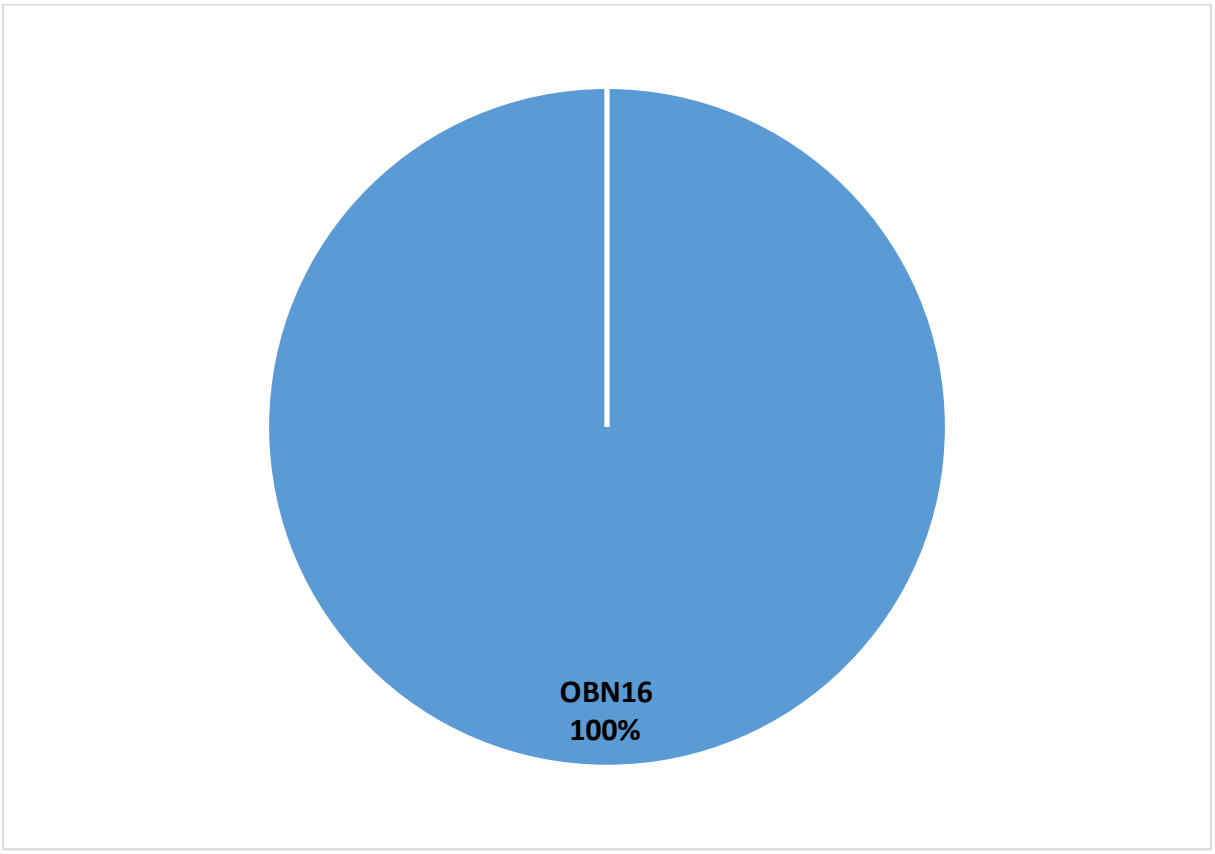

Figure 25: The proportion of Snowy Plover nests found in each pond monitored by SFBBO within Hayward Area Recreation District owned property at Hayward Regional Shoreline, Alameda County, California, 2023.

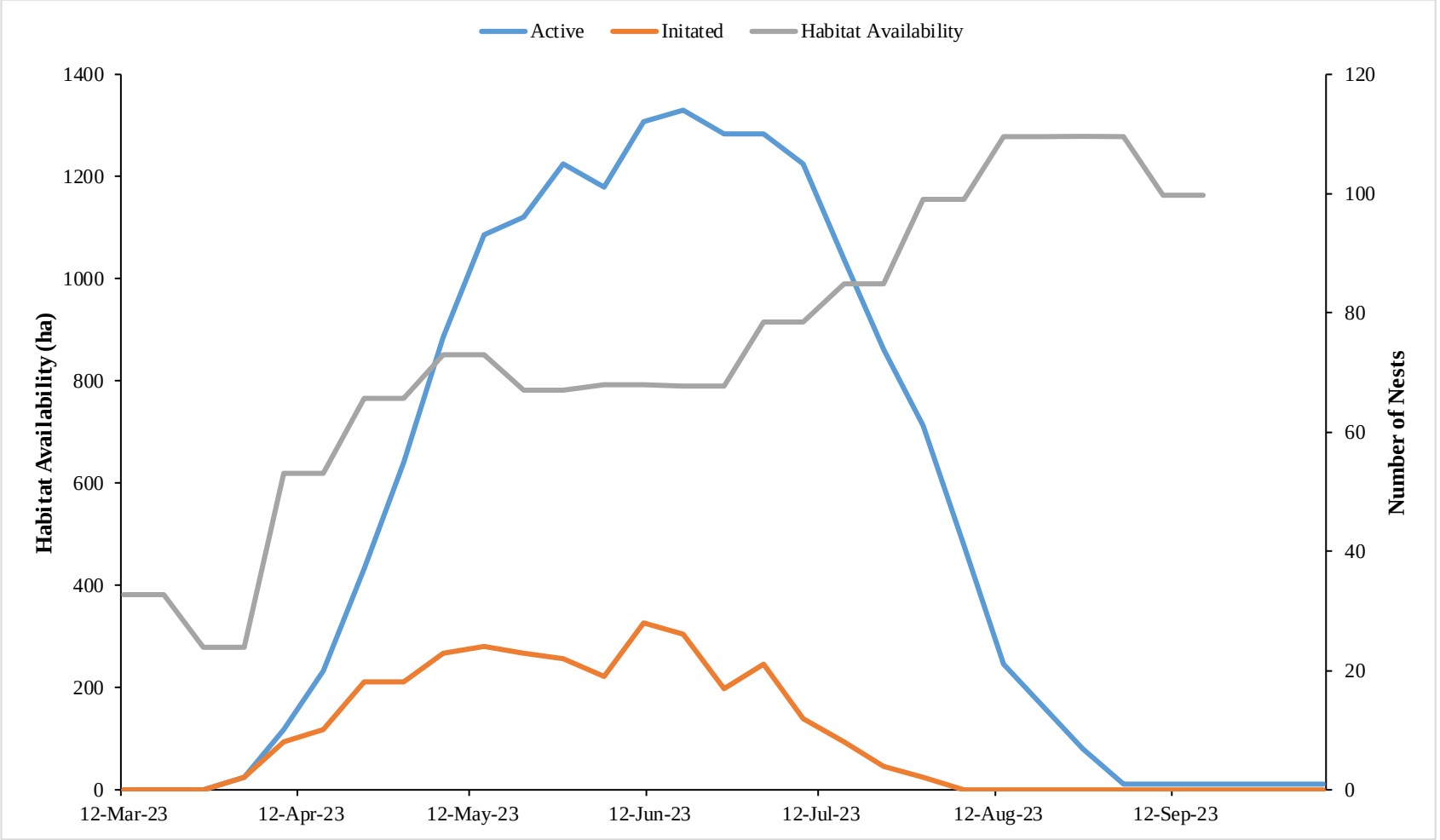

Figure 26: The weekly number of initiated and active Snowy Plover nests and estimated habitat availability in the South San Francisco Bay, California, 2022.

Table 1: Number of Western Snowy Plovers observed in RU3 sites during annual breeding window surveys in May, 2010-2023. Note that in 2020, due to the Covid-19 pandemic Refuge lands were not surveyed.

COUNTY	SITE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Alameda	Eden Landing	184	185	82	97	94	76	120	144	142	117	115	44	89	116
	Coyote Hills	0	0	0	0	0	0	1	0	0	1	0	8	4	1
	Crown Beach	-	-	-	-	0	0	0	-	-	-	-	0	0	0
	Dumbarton	0	0	0	0	0	0	0	2	7	2	-	16	12	55
	Hayward	12	8	9	32	7	2	4	0	7	12	19	56	36	5
	Warm Springs	27	17	3	1	11	24	14	2	20	7	-	5	5	18
Marin	Hamilton Wetlands	-	-	-	-	-	-	0	-	0	0	2	0	5	9
Napa	Napa	10	1	0	3	10	10	0	-	2	2	-	0	4	0
San Mateo	Ravenswood	42	27	33	59	45	68	42	76	51	48	-	67	74	84
Santa Clara	Alviso	0	11	20	10	0	1	21	19	4	1	-	23	39	70
	Mountain View	-	-	-	-	11	0	0	0	2	0	8	35	8	1
Solano	Montezuma Wetlands	-	-	-	-	-	14	6	3	0	0	3	9	5	4
	Cullinan Ranch East	-	-	-	-	-	-	-	-	-	-	-	-	0	5
Total RU3		**275**	**249**	**147**	**202**	**178**	**195**	**208**	**246**	**235**	**190**	**147**	**263**	**281**	**368**

Table 2: Number of Western Snowy Plovers observed in RU3 sites during annual winter window surveys, 2010-2023.

COUNTY	SITE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Alameda	Eden Landing	0	156	151	209	192	204	125	179	236	177	262	-	287	121
	Coyote Hills	0	0	0	0	0	0	0	0	0	22	7	-	0	0
	Crown Beach	-	-	-	-	6	15	26	-	34	48	22	-	-	25
	Dumbarton	13	0	2	0	0	0	0	17	0	0	0	-	20	-
	Hayward	23	1	0	-	0	0	4	0	0	21	0	-	0	0
	Warm Springs	74	53	29	0	0	123	0	34	28	36	0	-	24	-
Marin	Hamilton Wetlands	-	-	-	-	-	-	18	0	29	0	0	-	20	20
Napa	Napa	0	4	0	5	0	26	0	-	-	0	-	-	0	12
San Mateo	Ravenswood	18	13	11	23	0	23	21	22	18	0	23	-	22	74
Santa Clara	Alviso	0	15	37	0	0	0	143	90	0	72	0	-	35	6
	Mountain View	-	-	-	-	0	0	0	0	0	0	0	-	0	0
Solano	Montezuma Wetlands	-	-	-	-	-	0	0	-	11	4	0	-	0	-
	Cullinan Ranch East	-	-	-	-	-	-	-	-	-	-	-	-	8	5
Total RU3		**128**	**242**	**230**	**237**	**198**	**391**	**333**	**342**	**356**	**380**	**314**	**-**	**416**	**262**

Table 3: Ponds surveyed weekly from for the entire breeding season (March 1-September 15) in the South San Francisco Bay, 2023.

Location	Ponds
Alviso	A12, A13, A15, NCM
Coyote Hills	Patterson Pond
Dumbarton	PP1, Hickory
Eden Landing	E1C-6C, E6, E6A, E6B, E8, E8XN, E12-14, E14B-E16B, E20B, NCMP
Hayward	LETE Island[4]
Ravenswood	R1-5S, RSF2 Cell U3
Warm Springs	A22-23

Table 4: Ponds surveyed with changing frequency throughout the breeding season in the South San Francisco Bay, 2023.

Location	Ponds	Survey Timing
Coyote Hills	Patterson Pond	Every other week from March 6 to May 8, weekly from May 15 to September 15.
Mountain View	A3N, A3W, AB1, AB2	Weekly beginning April 17. AB1 and AB2 surveyed until July 3, A3W surveyed until August 14, A3N surveyed until August 28.
Mountain View	CME, CMW	Every other week from March 6 to August 14. Weekly from August 21 to September 15.
Hayward	FDW, FDE, OBN1-17	Every other week from March 6 to May 8, weekly from May 15 to September 15.

Table 5: North Bay sites in RU3, 2023.

Location	Land Owner	Ponds
Montezuma Wetlands[5]	Montezuma Wetlands, LLC	Phase III, Phase I, Phase II/IV
Napa-Sonoma Marshes Wildlife Area[6]	CDFW	7/7A, Green Island Unit, Wingo Unit
Hamilton Wetlands and Bel Marin Keys Restoration Site[7]	SCC	North Seasonal Wetlands, Eagle Ponds, BMK Seasonal Ponds

[4] Surveyed weekly by EBRPD
[5] Surveyed by Vollmar Natural Lands Consulting in varying intensities
[6] Surveyed by CDFW staff and volunteers in varying intensities
[7] Surveyed weekly by Avocet Research Associates

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*
Sharp-shinned Hawk	*Accipter striatus*
Red-Tailed Hawk	*Buteo jamaicensis*
Red-shouldered Hawk	*Buteo lineatus*
White-tailed Kite	*Elanus leucurus*
Northern Harrier	*Circus hudsonius*
Osprey	*Pandion haliaetus*
Burrowing Owl	*Athene cunicularia*
Short-eared Owl	*Asio flammeus*
Great Horned Owl	*Bubo virginianus*
California Gull	*Larus californicus*
Western Gull	*Larus occidentalis*
Herring Gull	*Larus argentatus smithsonianus*
Iceland Gull	*Larus glaucoides*
Glaucous-winged Gull	*Larus glaucescens*
Glaucous Gull	*Larus hyperboreus*
Mew Gull	*Larus canus*
Ring-Billed Gull	*Larus delawarensis*
Bonaparte’s Gull	*Chroicocephalus philadelphia*
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**
Coyote	*Canis latrans*
Domestic Dog	*Canis familiaris*
Domestic Cat	*Felis catus*
Grey Fox	*Urocyon cinereoargenteus*
Common Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Striped Skunk	*Mephitis mephitis*
Virginia Possum	*Didelphis virginiana*
Human	*Homo sapiens*

Table 8: Snowy Plover nest fates by pond in RU3, California, 2023.

Location	Abandoned	Depredated	Flooded	Hatched	Other	Unknown	Monitored	Detected as Brood	Total
Alviso									
A12[8]	0	2	0	0	2	0	4	0	4
A13	0	9	0	4	0	0	13	3	16
A15	0	17	0	11	0	0	28	1	29
Cargill Production[9]									
M8	0	0	0	0	0	0	0	1	1
Coyote Hills									
Patterson Pond	0	0	0	2	0	0	2	0	2
Dumbarton									
PP1	0	13	1	46	1	2	63	4	67
Eden Landing									
E12	0	0	0	1	0	0	1	0	1
E13	0	1	0	5	0	2	8	0	8
E14	0	12	0	26	0	1	39	3	42
E16B	0	5	2	8	0	0	15	2	17
E4C	0	2	1	4	0	0	7	0	7
E6A	1	0	0	7	0	0	8	0	8
E6B	0	7	0	17	0	0	24	3	27
E8	0	1	1	2	1	0	4	0	4
NCMP	0	0	0	2	0	0	2	0	2
Hayward									
FDW	0	0	0	0	0	0	0	1	1
LETE Island[10]									5

[8] All A12 nests were monitored by HT Harvey and Associates.
[9] SFBBO does not survey any Cargill-owned salt production ponds. Any nests recorded at those locations are from third parties.
[10] All LETE Island nests were monitored by EBRPD.

Location	Abandoned	Depredated	Flooded	Hatched	Other	Unknown	Monitored	Detected as Brood	Total
OBN16	0	0	0	1	0	0	1	0	1
Mountain View									
A3N	0	0	0	5	0	0	5	0	5
A3W	0	1	1	0	0	0	2	3	5
Ravenswood									
R1	0	1	0	15	1	0	16	7	23
R2	0	0	0	2	0	0	2	1	3
R3	0	15	0	16	0	1	32	3	35
R4	0	3	0	14	0	0	17	5	22
R5	0	0	0	2	0	0	2	0	2
SF2	0	0	0	0	0	0	0	1	1
Warm Springs									
A22	0	7	0	3	0	0	10	2	12
A23	0	0	0	1	0	0	1	0	1
South Bay Total	1	96	6	194	5	6	304	40	348
Hamilton Wetlands									
Eagle Ponds	0	1	0	3	0	0	4	0	4
North Seasonal Wetlands	0	3	0	1	1	0	5	3	8
Bel Marin Keys	0	1	0	0	0	0	1	1	2
Montezuma Wetlands									
Montezuma Wetlands	0	1	0	1	0	1	3	4	7
San Pablo Bay NWR									
Cullinan Ranch	0	0	0	0	0	1	1	0	1
Total North Bay	0	6	0	5	1	2	14	8	22
RU3 Total	1	102	6	199	5	8	318	48	370

Table 9: Least Tern nest fates by pond in ELER, California, 2023.

Pond	Failed	Probable Hatched	Hatched	Unknown	Total
E13	13	3	3	6	25
E14	18	0	2	2	22
E6B	15	8	7	0	30
Total	46	11	12	8	77

Table 10: Apparent fledging success (all sites combined) of Snowy Plover chicks in the South San Francisco Bay, California, 2008-2022. Chicks were considered fledged if they survived to 31 days (2008-2016), and 28 days (2017-2023). *N* is the number of chicks banded.

Year	N	Fledging Success
2023	194	34%
2022	304	34%
2021	149	31%
2020	85	27%
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 11: Apparent fledging success of Snowy Plover chicks by pond and chicks fledged per male in the South San Francisco Bay, California, 2023. Chicks were considered fledged if they survived to 28 days. *N* is the number of individuals banded.

Pond	N	Fledged	Fledge Rate	Males	Chicks fledged per male
A15	3	1	33%	1	1.00
A22	3	0	0%	1	0.00
E13	4	3	75%	2	1.50
E14	30	12	40%	12	1.00
E16B	3	3	100%	1	3.00
E4C	2	2	100%	1	2.00
E6A	12	0	0%	4	0.00
E6B	9	6	67%	4	1.50
NCMP	4	1	25%	2	0.50
PP1	61	25	41%	26	0.96
R1	18	2	11%	7	0.29
R3	36	9	25%	14	0.64
R4	9	1	11%	4	0.25

Table 12: Snowy Plover color band combinations deployed in 2023.

ak:kb	gk:kp	kk:py	na:yk	nn:bg	nn:py	on:kp	rk:rk	vo:gy	vo:rp	wn:gy
ak:kg	gk:kr	kk:wk	ng:bk	nn:bk	nn:ra	on:kr	rk:yk	vo:ka	vo:rw	wn:ka
ak:kk	gk:kw	kk:yk	ng:gk	nn:br	nn:rk	on:kw	vo:aa	vo:kb	vo:ry	wn:kr
ak:kw	gk:ky	ko:ak	ng:ka	nn:bw	nn:ro	on:pk	vo:ab	vo:kg	vo:wa	wn:kw
ak:ky	gk:wk	ko:kg	ng:ko	nn:ga	nn:rr	on:pp	vo:ag	vo:oa	vo:wb	wn:ky
ak:ok	ka:bk	ko:ko	ng:kp	nn:gg	nn:ry	on:wk	vo:ap	vo:ok	vo:wo	wn:pk
ak:pa	ka:gk	ko:kr	ng:kr	nn:gk	nn:wa	on:yo	vo:aw	vo:op	vo:wp	wn:rk
ak:py	ka:kk	ko:kw	ng:ky	nn:gp	nn:wk	rk:ak	vo:ba	vo:or	vo:wr	wn:rr
ak:rk	ka:ko	ko:ky	ng:pk	nn:gr	nn:wy	rk:ka	vo:bb	vo:oy	vo:ww	wn:wg
ak:wk	ka:ky	ko:ok	ng:rk	nn:gy	nn:yk	rk:kg	vo:bg	vo:pa	vo:wy	yv:ak
ak:wy	ka:ok	ko:pk	ng:wk	nn:kb	nn:yp	rk:kk	vo:bo	vo:pb	vo:yb	yv:ka
ak:ya	ka:rp	ko:yk	ng:yk	nn:kw	nn:yy	rk:ko	vo:bp	vo:pg	vo:yo	yv:kb
gk:bk	kk:ak	na:bk	nn:aa	nn:ky	on:ak	rk:kp	vo:br	vo:po	vo:yr	yv:kg
gk:gk	kk:bk	na:gk	nn:ao	nn:oa	on:gk	rk:kr	vo:by	vo:pw	vo:yw	yv:kk
gk:kb	kk:gk	na:ka	nn:ap	nn:ok	on:ka	rk:kw	vo:ga	vo:ra	vo:yy	yv:ky
gk:kg	kk:kr	na:kb	nn:aw	nn:op	on:kb	rk:ky	vo:gg	vo:rg	wn:ar	yv:ok
gk:kk	kk:ky	na:kk	nn:ba	nn:pb	on:kg	rk:ok	vo:gp	vo:rk	wn:bw	yv:pk
gk:ko	kk:ok	na:pk	nn:bb	nn:po	on:kk	rk:pk	vo:gr	vo:ro	wn:by	yv:wk

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

Table 13: All 2023 Snowy Plover chicks confirmed as fledged.

ak:kb	kk:bk	ng:kp	nn:ro	rk:ak	vo:ka	vo:ro	wn:bw
ak:kg	kk:ok	ng:kr	nn:wy	rk:ka	vo:oa	vo:wo	wn:by
ak:kk	kk:yk	ng:pk	on:ak	rk:kk	vo:ok	vo:ww	wn:ky
ak:rk	ko:kg	nn:bg	on:ka	rk:kw	vo:op	vo:wy	yv:ak
gk:gk	ko:ky	nn:gk	on:kb	rk:yk	vo:or	vo:yb	yv:kb
gk:kk	na:pk	nn:kw	on:kr	vo:bo	vo:oy	vo:yo	yv:kk
ka:rp	ng:ka	nn:oa	on:pk	vo:br	vo:pb	vo:yr	yv:ok
kk:ak	ng:ko	nn:ra	on:pp	vo:gp	vo:pg	wn:ar	yv:pk

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

Table 14: Return rates of 2022 banded fledges and all other birds banded before 2023 in the South San Francisco Bay, California, 2023.

Status	Observed in 2022	Observed in 2023	Return Rate
2022 fledges	103	62	60%
All other banded adults	108	63	58%

Table 15: The average number of predators observed per survey at the Ravenswood Complex, South San Francisco Bay, California, March-September 2023. The number of surveys performed in the season is shown in parentheses next to the site name.

Species	R1 (29)	R2 (29)	R3 (30)	R4 (29)	R5 (28)	SF2 (28)
American Crow	0	0	9.86	4.18	5.82	0.11
American Kestrel	0.07	0	0.11	0	0	0
Black-crowned Night-Heron	0.07	0	0	0	0	0.04
Burrowing Owl	0	0	0.04	0	0.04	0
California Gull	8.21	13.04	6.04	2.07	0.53	77.43
Common Raven	0.82	0.21	1.43	0.25	0.39	0.75
Cooper's Hawk	0	0	0	0.04	0	0
Glacuous-winged Gull	0	0	0	0	0	0.04
Great Blue Heron	1.21	0.04	0.11	0.04	0.04	0.04
Great Egret	3.82	0.07	0.14	0.25	0.47	1.04
Herring Gull	0.04	0	0	0	0	0.04
Merlin	0	0	0.04	0	0	0
Northern Harrier	0.43	0.04	0.25	0.18	0.07	0.07
Osprey	0.04	0.18	0	0	0	0
Peregrine Falcon	0.25	0	0.07	0	0	0
Red-tailed Hawk	0.14	0.04	0.29	0.07	0	0.07
Ring-billed Gull	0.14	0	0	0	0	0.32
Skunk	0	0	0	0.07	0	0
Snowy Egret	12.11	0	0.21	0	0.54	3.68
Unidentified Gull	29.54	6.68	1.21	99.75	0.11	37.46
Unidentified Predator	0	0	0.04	0	0	0
Western Gull	0.14	0	0.04	0	0	0
White-tailed Kite	0.07	0	0.04	0	0	0

Table 16: The average number of predators observed per survey at the Alviso Complex, Don Edwards SF Bay Santa Clara County, California, March-September 2023.

Species	A12 (27)	A13 (28)	A15 (28)	NCM (27)
American Crow	0	0	0.89	0
American Kestrel	0	0	0.04	0
Bald Eagle	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Bonaparte's Gull	0	0.07	0	0
California Gull	27.68	20.33	37.36	0
Common Raven	0.64	1.33	7.93	0.22
Franklin's Gull	0	0	0	0
Great Blue Heron	0	0.04	0.25	0.04
Great Egret	0	0.04	1.11	0.17
Herring Gull	0.16	0	0.46	0
Merlin	0	0	0.04	0
Northern Harrier	0	0	0.43	0
Osprey	0	0	0.04	0
Peregrine Falcon	0	0.04	0.43	0
Ring-billed Gull	0.04	0	0	0
Snowy Egret	0	0	0.43	0
Unidentified Gull	149.24	200.19	95.54	2.61
Western Gull	0.04	0	0	0

Table 17: The average number of predators observed per survey at the Warm Springs Unit, Don Edwards SF Bay National Wildlife Refuge, Alameda County, California, March-September 2023.

Species	A22 (28)	A23 (28)
American Crow	2.14	0.52
Bald Eagle	0.25	0
California Gull	52.5	65.67
Common Raven	8.21	1.33
Feral Cat	0.04	0
Great Blue Heron	0.07	0.15
Great Egret	0.14	0
Herring Gull	0.39	0
Northern Harrier	0.43	0.07
Peregrine Falcon	0.07	0
Red-tailed Hawk	0.25	0.07
Skunk	0	0.04
Snowy Egret	0.64	0
Unidentified Gull	84.18	211.89

Table 18: The average number of predators observed per survey at the Dumbarton Complex, Don Edwards SF Bay NWR, and adjacent salt panne habitat, Alameda County, California, March-September 2023.

Species	Hickory (28)	PP1 (28)
American Crow	1.26	1.71
Bonaparte's Gull	0	0.21
California Gull	0	49.32
Common Raven	0	0.43
Coyote	0.04	0
Great Egret	0.07	0
Northern Harrier	0	0.07
Peregrine Falcon	0	0.04
Red-shouldered Hawk	0.04	0
Red-tailed Hawk	0.56	0.04
Unidentified Gull	0.15	28.21
Unidentified Predator	0	0.14

Table 19: The average number of predators observed per survey at Mountain View Ponds, South San Francisco Bay, California, March-September 2023.

Species	A3N (20)	A3W (18)	AB1 (12)	AB2 (10)
American Crow	0	0	0.17	0
American Kestrel	0	0	0	0
Bald Eagle	0	0.06	0	0
Black-crowned Night-Heron	0.40	0.5	0	0
Bonaparte's Gull	0	0	0	0
California Gull	2.75	118.50	183.25	1027.50
Common Raven	3	0.78	1.67	0.40
Franklin's Gull	0	0.06	0	0
Great Blue Heron	2.25	2.22	0.17	0
Great Egret	0.50	7.55	0.67	0.10
Herring Gull	0	0	0	0
Merlin	0	0	0	0
Northern Harrier	0.05	0	0	0
Osprey	1.30	0	0	0
Peregrine Falcon	0.10	0	0	0
Ring-billed Gull	0.65	0	0	0
Snowy Egret	1.10	10.72	6.42	2.00
Unidentified Gull	8.95	162.56	0	1
Western Gull	0	0.56	0	0

Table 20: The average number of predators observed per survey in South Eden Landing Ecological Reserve, Hayward, California, March-September 2023.

Species	E1C (27)	E2C (27)	E3C (27)	E4C (27)	E5C (27)	E6 (23)	E6C (22)
American Crow	0.04	0.04	0.07	0	0	0	0
Bald Eagle	0	0	0	0	0.04	0	0
Black-crowned Night-Heron	0	0.04	0	0	0	0	0
California Gull	0.52	1.15	29.85	38.37	3.69	2.39	26.77
Common Raven	0.30	0	0.04	0.19	0	0	0
Coyote	0	0	0	0.04	0	0.04	0
Feral Cat	0	0	0	0	0	0	0.05
Golden Eagle	0.04	0	0	0	0	0	0.05
Great Blue Heron	0.07	0.04	0	0	0	0	0
Great Egret	0.26	0.11	2.93	1	0.04	0.09	0.59
Human	0	0.04	0.04	0	0	0	0
Northern Harrier	0	0.04	0.04	0	0	0	0.05
Peregrine Falcon	0	0	0	0.07	0	0.04	0
Red-tailed Hawk	0	0	0	0	0.31	0	0
Ring-billed Gull	0	0	0.11	0	0	0	0
Snowy Egret	0.85	0.30	1.19	0.63	0.12	0.13	1.27
Unidentified Gull	0	0	2.41	7.56	0.04	0.57	0
Unidentified Hawk	0	0.04	0	0	0	0	0

Table 21: The average number of predators observed per survey at the Whale's Tail loop, Eden Landing Ecological Reserve, Hayward, California, March-September 2023.

Species	E12 (28)	E13 (28)	E14 (28)	E8XN (27)
American Crow	0.04	0	0.46	0
Bald Eagle	0	0	0.04	0
Black-crowned Night-Heron	0.04	0.35	0	0.04
California Gull	3.19	0.12	1.64	0
Common Raven	0.19	0.12	1.14	0
Coyote	0	0	0.04	0
Great Blue Heron	0.15	0.27	0.07	0.08
Great Egret	1.08	1.92	0.32	0.96
Herring Gull	0	0.08	0	0
Merlin	0	0	0.04	0
Northern Harrier	0	0.19	1.04	0
Osprey	0	0	0.07	0
Peregrine Falcon	0	0.04	0.29	0
Red Fox	0	0	0.18	0
Red-tailed Hawk	0.04	0	0.04	0
Ring-billed Gull	0.12	0	0	0
Snowy Egret	1.58	4.85	0.61	0.84
Unidentified Gull	56.42	73.12	3.14	0
Western Gull	0.04	0	0	0
White-tailed Kite	0	0	0.07	0

Table 22: The average number of predators observed per survey at the Old Alameda Creek Loop, Eden Landing Ecological Reserve, Hayward, California, March-September 2023.

Species	E6A (28)	E6B (30)	E8 (28)	E20B (28)	NCMP (14)
American Crow	0.18	0.00	0.14	0.00	0.00
American Kestrel	0.04	0.00	0.00	0.00	0.00
Bald Eagle	0.00	0.03	0.04	0.00	0.00
Black-crowned Night-Heron	0.11	0.17	0.00	0.04	0.00
California Gull	5.00	30.33	0.07	0.79	0.00
Common Raven	0.79	0.67	0.25	0.00	0.00
Coyote	0.11	0.00	0.07	0.00	0.00
Feral Cat	0.04	0.00	0.00	0.00	0.00
Great Blue Heron	0.79	0.57	0.14	0.32	0.00
Great Egret	4.93	4.83	1.29	0.93	0.00
Herring Gull	0.00	0.03	0.04	0.00	0.00
Merlin	0.00	0.03	0.00	0.00	0.00
Northern Harrier	0.14	0.30	0.11	0.00	0.00
Peregrine Falcon	0.29	0.10	0.00	0.04	0.00
Red-tailed Hawk	0.93	0.07	0.14	0.00	0.43
Skunk	0.04	0.00	0.00	0.00	0.00
Snowy Egret	15.29	5.20	2.04	2.04	0.00
Unidentified Gull	62.36	14.50	2.50	1.32	0.00
White-tailed Kite	0.00	0.03	0.11	0.00	0.00

Table 23: The average number of predators observed per survey at the Mount Eden Creek Loop, Eden Landing Ecological Reserve, Hayward, California, March-September 2023.

Species	E14B (29)	E15B (28)	E16B (28)
American Crow	0	0.111	0
Bald Eagle	0	0	0.036
California Gull	0.207	0	0.679
Common Raven	0.034	0.037	0.036
Gray Fox	0	0	0.036
Great Blue Heron	0	0	0.036
Great Egret	2.207	0	0.071
Herring Gull	0	0	0.036
Northern Harrier	0	0	0.179
Peregrine Falcon	0	0	0.143
Red Fox	0	0	0.036
Red-tailed Hawk	0	0.037	0
Snowy Egret	5.379	0.074	0.607
Unidentified Gull	5.517	0	0.286
White-tailed Kite	0.034	0.111	0.286

Table 24: The average number of predators observed per survey at FDW, FDE, and OBN Ponds, Hayward Regional Shoreline, Hayward, California, May-September 2023.

Species	FDE (22)	FDW (22)	OBN 1-17 (21)*
American Crow	0.55	0	0.14
Bonaparte's Gull	0	0	0.05
California Gull	0	0.32	1.90
Common Raven	0.05	0.05	0
Herring Gull	0	0	0.43
Northern Harrier	0	0.05	0
Red-tailed Hawk	0.32	0	0
Ring-billed Gull	0	0.82	0.81
Unidentified Gull	0	0.23	13.10
Western Gull	0	0.18	0.05
White-tailed Kite	0.05	0	0

*OBN ponds with zero observed predators: OBN 3, 12, 14, 16, and 17

Table 25: The average number of predators observed per survey at Patterson Pond, Alameda County, California, March-September 2023.

Species	Patterson Pond (23)
California Gull	11.48
Common Raven	0.22
Great Blue Heron	0.13
Great Egret	0.35
Northern Harrier	0.09
Red-tailed Hawk	0.04
Ring-billed Gull	0.04
Snowy Egret	0.09
Unidentified Gull	4.04

Table 26: Chi-square analyses for nest habitat type selection at pond E14.

Treatment	Observed	Expected	$\chi 2$	df	**p-value**
Western	10	9.8	10.2	2	***0.0058***
Eastern	14	6.7			
Control	15	22.5			

Table 27: Snowy Plover averaged apparent nest densities (nest/ha) by pond at all locations surveyed throughout the season in the South San Francisco Bay, 2023. We calculated nest densities (nest/ha) in each pond every week using data from habitat availability surveys; weekly densities were then averaged.

Complex	Pond	Average Density
Alviso	A13	0.077
Alviso	A15	0.116
Warm Springs	A22	0.066
Warm Springs	A23	0.014
Eden Landing	E12	1.067
Eden Landing	E13	0.574
Eden Landing	E14	0.131
Eden Landing	E16B	0.113
Eden Landing	E4C	0.084
Eden Landing	E6A	0.053
Eden Landing	E6B	0.086
Eden Landing	E8	0.041
Dumbarton	PP1	0.977
Hayward	OBN	0.079
Coyote Hills	Patterson Pond	1.350
Ravenswood	R1	0.043
Ravenswood	R2	0.030
Ravenswood	R3	0.099
Ravenswood	R4	0.359
Ravenswood	R5	0.050
Average Overall		***0.271***

Table 28: Results of the Cox proportional hazards analysis of nest survival, showing no significant effects of any of the tested variables.

Variable	coef	exp(coef)	se(coef)	z	P
Initiation date	-0.019491	0.980698	0.015228	-1.28	0.201
Shells (E14E) vs control	0.276439	1.318427	1.083937	0.255	0.799
Shells (E14W) vs control	1.582972	4.869405	0.933637	1.695	0.090
Distance to nearest levee	0.004119	1.004128	0.007916	0.52	0.603

Table 29: Results of the additional Cox proportional hazards analysis, with both shell-supplemented plots combined into one group, again showing no significant effects of the tested variables on nest survival.

Variable	coef	exp(coef)	se(coef)	z	P
Initiation date	-0.018426	0.981742	0.016295	-1.131	0.258
Shells vs control	1.039265	2.827138	0.903103	1.151	0.250
Distance to nearest levee	-0.002221	0.997782	0.00594	-0.374	0.709

ATTACHMENT A: Site Descriptions