SAN FRANCISCO BAY
BIRD OBSERVATORY

Snowy Plover Recovery and Education at Eden Landing Ecological Reserve, Alameda County, California

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SUMMARY

During the 2020 breeding season, the San Francisco Bay Bird Observatory (SFBBO) monitored Western Snowy Plover (*Charadrius nivosus nivosus*; Snowy Plover) population size, nesting and fledging success, and identified potential predators at Eden Landing Ecological Reserve (Figure 1.)

As part of the Pacific Coast breeding season window survey (May 12-22), we counted 115 adult Snowy Plovers at Eden Landing (Table 1). One injured male Snowy Plover was rescued from pond E6 in May, brought to International Bird Rescue for treatment. After surgery, the bird was deemed unreleasable and was transferred to the Monterey Bay Aquarium to serve as a species ambassador.

Over the course of the breeding season (March-September), SFBBO staff determined the fate of 71 nests at ponds E12-E14, finding that 41% hatched, 45% were depredated, 11% were abandoned, and 3% were flooded (Table 3). The presence of two broods on E14 from undetected nests indicates that some breeding activity was missed in these ponds (Table 3). Elsewhere in Eden Landing, SFBBO staff determined the fate of an additional 76 nests, finding that 49% hatched, 38% were depredated, 9% were flooded, and 4% were abandoned (Table 3). In E14, hatch rate was similar between Western (42%), Eastern (40%) shell plots and unshelled areas (40%), however a high rate of abandonment was observed in both Eastern and unshelled areas (Figure 2, Table 5).

In 2020, SFBBO banded 28 Snowy Plover chicks at E14 (n=27) and E13 (n=1) that successfully hatched from 12 nests (Table 6). From band re-sighting surveys, we determined that at least 21% of these chicks survived to fledge (28 days post-hatching) as of November 16, 2020 (Table 5). Elsewhere in Eden Landing, SFBBO staff banded 35 chicks from 15 successfully hatched nests, finding that at least 23% survived to fledge (Table 6). Overall apparent fledge rate at Eden Landing for banded chicks was 22%. Guests joined for banding on three occasions.

Docents performed three surveys at ponds E12-14 in 2020 (Table 5). Due to the COVID-19 Pandemic, docents did not attempt to speak with pedestrians and cyclists on trails during the two surveys performed in June and July, but instead searched for Least Terns and Snowy Plovers and recorded any observations of trespass into sensitive breeding habitat.

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 at E12-14, followed by Snowy Egrets (*Egretta thula*) and Great Egrets (*Ardea alba*) (Tables 6-9). Northern Harriers (*Circus cyaneus*) and Peregrine Falcons (*Falco peregrines*) were the most frequently observed raptors at the most important Snowy Plover breeding ponds. Common Ravens (*Corvus corax*) and White-tailed Kites (*Elanus leucurus*) were among other commonly sighted predatory species. Trail cameras placed at pond access points in E14 and E16B (Table 10), as well as tracks observed early in the season, indicated that Coyotes frequently hunted in important Snowy Plover breeding ponds.

INTRODUCTION AND BACKGROUND

The Pacific Coast population of the Western Snowy Plover (*Charadrius nivosus nivosus*; Snowy Plover) breeds along or near tidal waters and is behaviorally distinct from the interior population (Funk 2006). Coastal-breeding Snowy Plovers have declined as a result of poor reproductive success, likely due to habitat loss, habitat alteration, human disturbance, and increasing predation pressure (Page et al. 1991, USFWS 2007). In response to this decline, the U.S. Fish and Wildlife Service (USFWS) listed the Pacific Coast Western Snowy Plover population as federally threatened in 1993 (USFWS 1993). They are listed as a species of special concern in California (CDFW 1998). The most recent 5-year review (USFWS 2019), which reviewed all available data in all six recovery units, determined that the population remains threatened due to the same threats described above.

Western Snowy Plover Recovery Unit 3 consists of the San Francisco Bay Estuary and includes Alameda, Napa, Santa Clara, and Solano counties, and the bay portion of Marin, San Mateo, and Sonoma Counties (USFWS 2007). Snowy Plovers in this Recovery Unit nest almost exclusively in dry salt panne habitat provided by former salt evaporation ponds, as well as on pond berms, levees, and in dry, degraded marsh habitat. In 1992, the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) began surveying for Snowy Plovers on Refuge lands.

From 2003-2020, SFBBO conducted annual Snowy Plover monitoring and research within the South San Francisco Bay in support of the goals set forth by the RU3. Specifically, we: 1) identified areas used by Snowy Plovers through regular surveys of all potential nesting habitat from March through September, 2) participated in U.S. Fish and Wildlife Service-coordinated Range-wide breeding and winter window counts to estimate Recovery Unit 3 numbers, 3) recorded nest fates, nest densities, and chick fledging rates through nest-monitoring and chick-banding, 4) surveyed for potential avian predators , and 5) identified areas of potential disturbances from predators, trespass, construction activities and other human activities.

METHODS

Study Area

From March 2 to September 15, 2020, SFBBO staff and volunteers conducted Snowy Plover and avian predator surveys at Eden Landing Ecological Reserve. CDFW owns and manages Eden Landing (formerly known as Baumberg), which includes approximately 6,400 acres of former salt ponds, marsh, and tidal habitat (Figure 1).

Habitat Enhancement

At the beginning and end of the breeding season, when there were no Snowy Plover or California Least Tern active nests or chicks on the ponds, we led volunteer habitat

enhancement events to improve breeding habitat by removing predator perches, spreading shells, and increasing pond texture.

Surveys

Snowy Plover Breeding Surveys

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

From March 2 to September 15, 2020, SFBBO biologists, interns, and volunteers surveyed all potential breeding ponds weekly by driving slowly on the levees or walking levees without vehicle access. We stopped approximately every 0.3 miles to scan for Snowy Plovers with spotting scopes. During each survey, we recorded the number and behavior of all Snowy Plovers present, identified the sex and age class of each individual using plumage characteristics (Page et al. 1991), and marked the approximate location of sightings on a geo-referenced paper map. We also recorded the color-band status, and combination if applicable, of any banded Snowy Plover sighted. Any observed instances of interspecies aggression between Snowy Plovers and other nesting shorebirds and/or seabirds were recorded.

SFBBO Snowy Plover volunteers surveyed lower priority ponds monthly to check for possible nesting activity during the season.

From May 12-22, we participated in the Pacific Coast Snowy Plover breeding window survey. This survey was coordinated by the USFWS as part of an annual, regional effort to census all coastal-breeding Snowy Plovers during the same week. SFBBO surveyed all of Eden Landing for this survey.

Snowy Plover Docent Surveys

SFBBO Snowy Plover docent volunteers were stationed on public trails at Eden Landing ponds E12-E14 in January, June, and July during a 3-day window on the last weekend of the month. During each survey, docents looked for Snowy Plovers using a combination of spotting scopes and binoculars. In January, docents were equipped with a handout that provided general information about Snowy Plovers, including pictures, physical description, range, conservation status, reasons for decline, and ways to get involved with Snowy Plover conservation. During encounters with the public, docents recorded the type (pedestrian, bicyclist, other) and size of group, the nature of the contact (positive, negative, neutral), what information was shared (ecology, salt making history, conservation, etc.), and any other relevant information (Table 7)

In June and July, docents did not attempt to interact with pedestrians and cyclists due to the COVID-19 pandemic. Instead, docents surveyed the ponds for Least Terns and Snowy Plovers, and opportunistically recorded any observations of trespass into sensitive areas.

Nest Monitoring

Snowy Plover nests were located by first scanning for incubating adults or other signs of breeding behavior during weekly surveys. We then searched for nests on foot and recorded nest locations with a hand-held tablet (Apple® iPhone or iPad).

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

We defined a nest as successful if it hatched at least one egg. We calculated apparent nest success as the percentage of nests that successfully hatched at least one egg out of the total nests monitored.

Snowy Plover Nest Monitoring

During the first visit, we floated the eggs (Hays and LeCroy 1971) to estimate egg age if incubation had been observed (typically 3 egg clutch throughout most of season, sometimes 1-2 eggs later in season). Snowy Plover nests are active for an average of 33 days, from initiation (the date the first egg was laid) to hatching (Warriner et al. 1986), and using the known egg age, we calculated the nest initiation date and predicted hatch date for all nests monitored. When there were no longer eggs in the nest, we assigned each nest a fate based on evidence seen at the nest (Mabee 1997). Nest fates included: hatched, depredated, flooded, abandoned, failed to hatch, unknown, or other. In addition, we recorded whether the nest was located in an oyster shell enhancement (see *Oyster Shell Habitat Enhancements* methods below.)

Snowy Plover Color Banding

Chick Banding

Since 2008, SFBBO has banded Snowy Plover chicks to study their movements and to estimate fledging success rates in the South Bay, when resources allowed. To band chicks, biologists checked nests daily, starting four days before the estimated hatch date. Due to the precocial nature of chicks, arrival at nests was timed to allow complete hatching of chicks prior to their movement away from the nest; this is typically a several hour window. We banded each chick with a unique four-color combination by placing two bands on each leg below the tibiotarsal joint. Each combination consisted of three darvic (XCLA Darvic Leg Bands I/D 3.1mm n.d.) or acetal (XCLA Acetal Leg Bands I/D 3.1mm n.d.) color bands and one silver U.S. Geological Survey band. All bands were then wrapped in colored auto pin-striping tape. Both darvic and acetal color bands were used depending on availability.

We defined a fledged chick as one that survived to 28 days of age, at which point it is considered to be capable of flight (Warriner et al. 1986). We calculated apparent fledging success as the percentage of fledged, banded chicks out of the total chicks banded. Since re-sighting banded chicks on large salt ponds can be very difficult, this method of estimating fledging success has significant limitations and is a conservative estimate.

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

Adult Banding

In an effort to increase the number of color banded adults at Eden Landing, on several occasions we attempted to trap adults using noose mats placed around the nest. After placing the noose mats, biologists hid nearby and waited for the adult to attempt to return to the nest. If adults were trapped within five minutes, biologists would quickly band and process the adult, then release and confirm they came back to the nest. If they were not trapped within five minutes, biologists would remove the noose mats and cease attempts to trap the adult.

Oyster Shell Habitat

E14 Large Scale Enhancement

Our oyster shell pilot study (2008-2013) provided evidence that Snowy Plovers preferentially selected shelled areas for nest locations (Robinson-Nilsen et al. 2013). Based upon these findings, we began a large scale habitat enhancement project in September 2014 at E14 by treating 20.23 hectares with oyster shells at the previously tested density.

Two distinct plots were created within the pond – a western plot totaling 6.47 hectares (referred to as Western, totals 9.47 hectares when contiguous three pilot shelled one hectare plots included) and an eastern plot totaling 13.76 hectares (referred to as Eastern); the remaining untreated areas are termed non-shelled in this report. We designed a spatial configuration in which the shell blocks alternated with the non-shelled blocks in order to avoid clustering treatments in one region of the pond, as well as to address pre-existing variation in habitat quality for breeding Snowy Plovers. These shell plots likely attracted Least Terns to breed at E14 beginning in 2017.

Avian Predator Surveys

To identify avian predators in the area that might affect Snowy Plovers, SFBBO biologists and interns conducted predator surveys concurrently when surveying ponds for Snowy Plovers. Volunteers conducted avian predator surveys at ponds surveyed monthly for Snowy Plovers. Observers chose survey points that provided a comprehensive scan of all required ponds for predators. At each survey point, the location, start time, and stop time were recorded. Observers recorded the number, species, behavior, and habitat type at the time of sighting of any predators present. The approximate locations of the predators were marked on a map. In

addition, observers documented any predator nests in the area and their fates when possible. We calculated the average number of predators observed per survey at each pond during the season. While most predators likely have a larger territory than a single pond (Strong et al. 2004), we felt it meaningful to present indices of predator abundance at the pond scale since both predator, Least Tern, and Snowy Plover surveys were conducted at this level.

We defined avian predators as any species that could potentially prey on a Snowy Plover nest, chick, or adult. This includes most raptors, gulls, corvids, herons, and egrets (Table 11) found at Eden Landing. While there are a number of potential mammalian predators (Table 12), and their signs (e.g., tracks) were recorded opportunistically, these surveys were not designed to detect mammals, particularly since many are nocturnal. Among all predators, we considered Northern Harriers, Peregrine Falcons, Common Ravens, California Gulls, and mammals (especially coyotes, red fox and striped skunk) to be the most critical potential predators to Least Tern and Snowy Plover adults, eggs, and chicks due to previous predation captured on camera and consistent with previous documentation of predation.

Due to past concerns over predators identifying nest cameras, especially mammals, SFBBO was cautious in deploying Snowy Plover nest cameras in 2020. Due to presence of coyote at Eden Landing throughout the season, only one Snowy Plover nest at E14 had a camera on it. The camera on this nest was placed directly on the ground between 2-3 meters from the nest; this method was used after testing other further but unsuccessful placements in the past. Cameras were housed in a camouflage case and made even less conspicuous by using oyster shells, wood and other debris from the surrounding area. Three rapid-fire still images were taken whenever motion was detected, in color by day and monochrome infrared by night. Cameras were checked each time the nest was checked, typically once per week, at which time the memory card and batteries were replaced as needed.

In order to provide an index of mammalian predator activity at ponds E12-14, cameras were placed on the narrow E12/13 levee, at pond E14 access points, and at random locations throughout the pond to opportunistically capture evidence of mammals in these areas.

Habitat Availability

Habitats within the South San Francisco Bay ponds change based on precipitation, management, and other factors. In order to better measure the available potential nesting habitat over the course of the season, habitat availability surveys were continued during the 2020 breeding season.

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

on the same day as each breeding survey in order to maintain comparability with nesting behavior. Though the habitat availability maps are an estimate with some measure of error, they provide a much more accurate measure of potentially available nesting habitat over time compared to previous methods used from 2003-2014.

RESULTS

Habitat Enhancement

Volunteer Events

On March 7, 2020, SFBBO led a volunteer event to improve Least Tern and Snowy Plover habitat in the Western shell plot in pond E14 (Figure 3). Volunteers used hand tools to remove overgrown vegetation and dismantle remnant hunting and salt production infrastructure, and stomped on unshelled areas of the pond to increase pond texture. Staff set out 70 wooden numbered A-frame chick shelters in a gridded system, set out 50 terra cotta chick shelters, and spread 50 Least Tern decoys throughout the enhanced area. Decoys were set out in a mix of pairs to show that the area was good for breeding, and single decoys to advertise that there were available mates.

Due to the COVID-19 Pandemic, the Snowy Plover Mudstomp Event planned for March 28, 2020 was canceled. However, on both September 26 and October 3, SFBBO staff led groups of 35 Boy Scouts and parents in efforts to improve Snowy Plover habitat at Pond E8. During these events, volunteers removed over 100 large wooden posts that formerly supported a salt production pipeline and provided perches for raptors. In this same area, volunteers spread oyster shell to increase texture and further enhance the habitat for breeding Snowy Plovers.

Snowy Plover Surveys

We observed a mean of 144 birds observed per week from March 2 through September 15 at all ponds surveyed in Eden Landing (Figure 4). Pond E14 supported the largest numbers of Snowy Plovers at Eden Landing, with a mean of 44 birds observed per week (Figure 3). Ponds E12 (1 bird/week) and E13 (8 birds/week) supported smaller numbers of Snowy Plovers during the season.

Early and Late Season Trends

In March, we observed a large Snowy Plover flock at E14 during the first three surveys, with 118, 113, and 141 adults observed on March 2, 9, and 16, respectively (Figure 3). Due to Covid-19, SFBBO did not survey on March 23, however by March 30, the number of Snowy Plovers at E14 had declined to 96. Many of the birds observed during the first three surveys may have been staging (for migration) and arriving for the breeding season.

Contrary to past years, a large flock was not observed at E14 during August and September (Figure 3). Instead, large flocks were found at ponds E6A and E6C (Figure 4).

Snowy Plover Docent Surveys

In 2020, SFBBO volunteers conducted one normal docent survey and two modified docent surveys at ponds E12-14 (Table 5). Zero contacts were made during the normal survey, and no incidences of trespass were noted during the two modified surveys.

Snowy Plover Nesting

Nesting Abundance and success

Over the course of the breeding season, we monitored a total of 147 Snowy Plover nests at Eden Landing, finding that 45% hatched, 41% were depredated, 6% were abandoned, and 7% were flooded (Table 4).

Snowy Plover Color Banding

Chick Fledging Success

As part of our efforts to document breeding success, we banded 27 chicks from 11 nests at E14, and 1 chick from 1 nest at E13 (Table 5). As of November 15, 2020, five chicks from E14 were determined to have fledged, resulting in 0.45 chicks fledged/male in the pond, while the one chick banded in E13 was determined to have fledged (Table 5). Elsewhere in Eden Landing, we banded an additional 35 chicks from 15 nests, determining that 8 fledged and resulting in 0.53 chicks fledged/male (Table 5). Considerable effort was put into finding fledglings during band resighting surveys, yet due to the difficulties in finding and reading banded Snowy Plovers in San Francisco Bay, it is possible that additional chicks fledged as well.

Adult banding

On May 2, biologists successfully trapped and banded an adult male (ak:bw, Table 13) at a nest in northwest E14, not far from the public trail between E13 and E14. On May 19, biologists unsuccessfully attempted to trap a male in E14. It would not cross the noose mats surrounding it's nest. This male had been previously banded but was missing a band on the right leg. On June 11, biologists successfully trapped and banded an adult male (wn:yy) and female (ak:rr) attending to a nest on E6B that had just hatched. The three chicks were banded immediately afterwards. On July 7, a female that had been previously banded as a chick in 2016 was recaptured and tape reapplied to the USGS band.

Color banding guests

Due to the COVID-19 pandemic, guests were not invited to join for Snowy Plover banding for much of the season. However, once regional restrictions loosened and appropriate guidelines were put in place, guests joined SFBBO biologists to band on three different occasions, including at E6A on July 23, E14 on July 30, and E4C on August 3. Social distancing guidelines were followed at all times.

Oyster Shell Habitat Enhancements

During the sixth season following large scale enhancement at pond E14, we documented a total of 71 nests in pond E14; 19 nests in Western (which includes the three 1-ha pilot plots), 27 nests in Eastern, and 25 nests in the non-shelled areas of the pond (Control) (Table 6).

Examining the treatments individually, apparent nest success in Western was 42%, an increase from 2019 (37%), while apparent nest success in Eastern was 41%, a decrease from 2019 (48%)(Table 3). Apparent nest success in Control was 40%, an increase from 2019 (33%). Depredation was the most significant cause of nest failure in all areas of E14 (Western=58%, Eastern=41%, and Control=40%). Nest abandonment in Eastern (15%) and Control (16%) were notably high.

Avian Predators

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 all ponds (Tables 6-9). Gull species were usually found foraging in shallow water or roosting in large flocks along levees and berms. Snowy Egrets (*Egretta thula*) and Great Egrets (*Ardea alba*) were frequently observed hunting throughout Eden Landing. Northern Harriers (*Circus cyaneus*) were frequently observed hunting from levees and flying low over E14, with 1.1 observed per survey (Table 6). Peregrine Falcons (*Falco peregrines*) (0.9 per survey) were also frequently observed hunting in E14, often perching on remnant salt production and hunting infrastructure to scan the pond. Both species were frequently observed hunting throughout Eden Landing (Tables 7-9). Common Ravens (*Corvus corax*), White-tailed Kites (*Elanus leucurus*), and Red-tailed Hawks (*Buteo jamaicensis)* were among other commonly sighted predatory species (Tables 6-9).

Mammalian Predators

After observing high rates of depredation in March and April, SFBBO biologists placed wildlife trail cameras (Reconyx PC900 HyperFire) at random locations on the pond to determine if predators would look for eggs at the cameras. These cameras were not visited by mammalian or avian predators. However, due to continued evidence of coyotes at the reserve recorded by trail cameras at E14 and nearby pond E16B, a camera was placed on only one Snowy Plover nest.

SFBBO does not conduct targeted surveys for mammalian predators. However, to provide an index of mammal presence on the ponds, trail cameras were placed at E14 and E16B access points and along the narrow E12/13 levee from April-July.

Human Disturbance

At E12-14, cameras traps captured pictures of coyotes at E14 on two occasions, and at nearby pond E16B, coyotes on seven different occasions (Table 9). Humans and off-leash dogs were captures by trail cameras trespassing on five occasions at E12-14, and at nearby E8, one image of a motorcyclist riding on the pond was captured. New tracks from the motorcyclist were observed on E8 throughout July and August. On May 5, a motorcyclist (likely the same

individual), was observed by Wildlife Services riding on the levee between ponds E13 and E14. Throughout the season, biologists frequently observed people trespassing into restricted areas of E12-14, and less commonly, in other areas of Eden Landing.

DISCUSSION

Population Size

The number of adult Snowy Plovers observed at E12-14, and Eden Landing as a whole, was nearly identical between 2019 (Pearl et al. 2019) and 2020 (Table 5-6). Eden Landing remains the most critical site for Snowy Plovers in the San Francisco Bay throughout the year, hosting 78% of all adults observed during the breeding window survey (Table 2). As such, meeting RU3 population goals will largely depend upon growth of the Eden Landing sub-population. As recently as 2011, the reserve hosted 185 breeding adults, confirming that the area is capable of supporting a larger population given that habitat conditions and management allow for it.

Injured adult rescued

On May 4, SFBBO biologist Jessica Gonzalez observed a male Snowy Plover in pond E6 with a broken wing. Jessica was able to capture the bird and take it to International Bird Rescue (IBR) in Fairfield. IBR successfully conducted surgery on the bird to repair it's broken wing, however after post-surgery rehab, it was determined that it would never be able to regain full flight capability. As a result, the bird was transferred to the Monterey Bay Aquarium, where it now serves as an ambassador for Snowy Plovers.

Nest Abundance and Success

We observed a significant decline in Snowy Plover breeding activity at E14, with 43% less nests found in 2020 compared to 2019 (Pearl et al. 2019). Nest initiation during the first half of the season followed a similar trend observed since oyster shell enhancement in late 2014, with a large amount of nests initiated March 9-May15 (n=41, Figure 5). However, only 21 more nests were initiated May 16-June 29 (Figure 5), and the number of adults observed on the pond steadily declined from 66 on May 19 to 5 adults on July 6 (Figure 3). Elsewhere at Eden Landing, an additional 21 nests were initiated from June 30-July 27 (Figure 6), indicating that E14 was abandoned by plovers as a nesting area after June 29. The consistent presence of Northern Harriers and Peregrine Falcons hunting in the pond (Table 7), which have been previously identified by SFBBO as significant predators of Snowy Plover adults, eggs, and chicks at E14, likely played a significant role in this observed trend. Coyotes may have also depressed breeding activity in E14.

The observed hatch rate of Snowy Plover nests in E14 in 2020 (40%) was nearly identical to that observed in 2019 (41%), however we observed the largest rate of nest abandonment (13%, Table 4) of any site monitored by SFBBO since 2003. This was likely due to increased human disturbance. Although Eden Landing has seen relatively light foot traffic since opening, and COVID-19 restrictions initially kept the number of people using the trails low, by mid-April Eden

Landing received larger numbers of pedestrians and cyclists than usual (pers. obs.), including numerous trespassers onto levees in sensitive areas closed to the public (Table 9). All eight abandoned nests were located 220±131ft from the levee, well within the 540ft mean distance at which Snowy Plovers have been observed flushing from nets when approached by pedestrians (Trulio et al. 2012). It's likely that at least some of these nests were abandoned due to human disturbance from trespassers.

Depredation was the major limiting factor for Snowy Plover recovery at Eden Landing during the 2020 breeding season (USFWS 2007, USFWS and CDFW 2007). Despite continued efforts to improve habitat for both species, there remain a large amount of perches within breeding and foraging habitat that allow raptors to hunt from closer range than would generally occur in natural salt panne habitats. In addition, the arrival of coyotes to the reserve in 2019 poses a new challenge to predator management efforts. Tidal marsh restoration has improved habitat for Northern Harriers, resulting in increased sightings of these raptors at the reserve. These issues must be addressed in order to support recovery of Snowy Plovers at Eden Landing.

Snowy Plover Banding

Chick Fledging Success

We were able to band 44% of all monitored Snowy Plover nests that hatched at E14 (Table 4), finding that only 19% of chicks banded survived to fledged (n=27, Table 4). Anecdotally, unbanded Snowy Plover broods hatched on E14 also had poor survival, with few broods seen past 1-2 weeks of age throughout the season. Poor chick survival at E14 was likely due to the frequent presence of Northern Harriers, Peregrine Falcons, and coyotes on the pond. Elsewhere in Eden Landing, chick survival was marginally better, with a fledge rate of 25% observed (n=36) (Table 4), indicating that these predators likely impacted chick survival throughout the reserve.

Adult Snowy Plover

For the first time since 2016, we attempted to trap and band adult Snowy Plovers at Eden Landing. We were successful in trapping on three out of four attempts, including two males and two females (Table 10). In the case of the male trapped at E14, he had not returned to the nest after six hours, and as a precaution, biologists collected the eggs and delivered the eggs to Monterey County SPCA to be hatched and raised. These chicks were released at Eden Landing on June 11, 2020. It is unknown why the male had not returned to the nest, however biologists will carefully consider all known information prior to deciding to trap an adult to prevent incidences like this in the future.

On another occasion, a male that had been previously banded but missing a band would not cross the mats, therefore we were unable to determine his complete combination. Use of other trap types requested but not yet approved by USFWS, including spring traps, may allow for trapping individuals such as these more easily.

Avian Predators

Northern Harriers were the most frequently observed raptor at E14 in 2020 (1.1/ survey, Table 6), and were often flushed by biologists driving during the course of their survey. They were frequently perched on levee sides with mustard and other vegetation that provided cover for them, often near the enhanced colony area. Recent research into the importance of different predators of shorebird chicks, including the closely related Marsh Harrier (*Circus aeruginosus*), found that their rate of predation on chicks was directly linked to the activity of predators onsite (Mason et al. 2018). Early in the season, one male and up to two female Northern Harriers were frequently observed hunting on the pond. Later in the season, only the male was observed, and since Northern Harriers are polygynous (Simmons et al. 1986), it is possible that there were multiple Northern Harrier nests near E14 in 2020. On May 18, the male was observed successfully hunting for a Dunlin that was roosting in the middle of the enhanced colony area. Although Northern Harriers were not observed depredating Least Tern or Snowy Plover adults, eggs, or chicks during the 2020 breeding season, our past observations at E8A (Robinson-Nilson and Demers 2009) and E14(Pearl et al. 2019) and their consistent presence on the pond lead us to believe that they were again the most significant predators of Snowy Plovers at E14. They likely also played a major role in the depression of Least Tern nesting at E14. Due to their documented history of impacts to both species at E14 and across the Pacific Coast, trapping and relocation of Northern Harriers should be considered a priority at this highly critical site for both Least Terns and Snowy Plovers.

Peregrine Falcons were the second most frequently observed raptor on E14 (0.9/survey, Table 6), and sightings of juveniles in June and July indicate that they likely nested somewhere in or around Eden Landing. They were often observed perched on abandoned salt production and hunting structures within the shell plots. These perches allowed Peregrine Falcons to hunt prey undetected at a much closer distance than would normally occur at salt panne or beach habitat, likely resulting in high hunt success rates. Although SFBBO removed numerous perches from the enhanced colony area during the March habitat enhancement event, and has conducted similar work at volunteer events in the past, there remain a large amount of predator perches throughout E14. Removal of these perches will be a primary focus of future volunteer habitat enhancement events at E14.

Gull spp. were the most frequently observed predator at ponds E12-14, however it is unlikely that they had a significant impact upon Least Tern or Snowy Plover breeding success at E12-14. Gulls were typically observed foraging in water or roosting on levees, and were never observed foraging on dry pond bottom in E14. They may have impacted the fate of the two nests in E12, which were both located on islands that gulls roost on, and could have opportunistically depredated chicks foraging on levees, islands, and along wet areas of E14.

Although Common Ravens were sighted with moderate frequency at E14 (0.5/survey, Table 6), it is unknown how much of an impact they had on Least Tern and Snowy Plover breeding. Wildlife Services spent a large amount of time targeting Common Ravens for removal, which

may have prevented individuals from heavily exploiting eggs and chicks in E14. They were observed on trail cameras at both the west and east end of E14, and likely were responsible for some Snowy Plover egg and chick loss.

Mammalian Predators

Although we did not conduct targeted mammalian surveys, trail cameras placed at strategic locations on ponds and levees indicated that coyotes were frequently present at E12-14 and E16B. From March through May, when the ponds were wet enough to leave prints, coyote tracks were observed throughout these ponds, further confirming their presence in these ponds. Coyotes have been identified as a significant predator of Snowy Plovers across the Pacific Coast (Page et al. 2009) and interior population (Ellis et al. 2020). Although we can't confidently determine the number of Snowy Plover eggs and chicks depredated by coyotes, they likely had a significant impact upon their breeding success at Eden Landing in 2020. Although no other mammals were observed by biologists or recorded on camera, the numerous mammals removed by Wildlife Services during trapping efforts (E. Covington, pers. comm.) indicate that they were present in large numbers and likely also affected Snowy Plover recovery.

In order to promote successful breeding for Snowy Plovers, it is vital that predator control efforts continue. These include trapping efforts to remove small to medium sized mammals, as well as targeted efforts to remove coyotes and red fox.

Human Disturbance

We observed a significant increase in use of trails at E12-14 by pedestrians and cyclists in 2020 (pers. obs.). This increase was also observed at nearby Hayward Regional Shoreline (M. Taylor, pers. comm.), and was likely due to the COVID-19 pandemic significantly altering people's schedules, allowing people more time to explore local open spaces. Along with the increased traffic, we observed numerous occurrences of trespass onto levees seasonally closed to protect breeding Least Terns and Snowy Plovers. The rate of abandonment observed at E14 (13%) was the highest observed at any site in RU3 since SFBBO began monitoring in 2003. The nests that were abandoned were located 66.9±39.9 m from the levee, well within the average distance at which Snowy Plovers in the San Francisco Bay were observed flushing from nests when approached directly (164m) or tangentially (145.6m) (Trulio et al. 2012).

Although the impact of motorcycle riding near breeding Snowy Plovers at Eden Landing is unknown, this type of activity would likely cause significant disturbance, negatively affecting both species recovery. All things considered, it seems apparent that human disturbance played a larger role in Snowy Plover breeding than is usual for the San Francisco Bay. This increase in traffic, and potentially trespassing, is likely to continue for as long as the COVID-19 pandemic affects societal routines. Increasing the amount of signage in sensitive areas, and potentially

providing more detail to justify closure of these areas, could result in increased compliance and reduce the impact of human disturbance on breeding Least Terns and Snowy Plovers.

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Figure 1. Ponds in the CDFW's Eden Landing Ecological Reserve, Hayward, California.

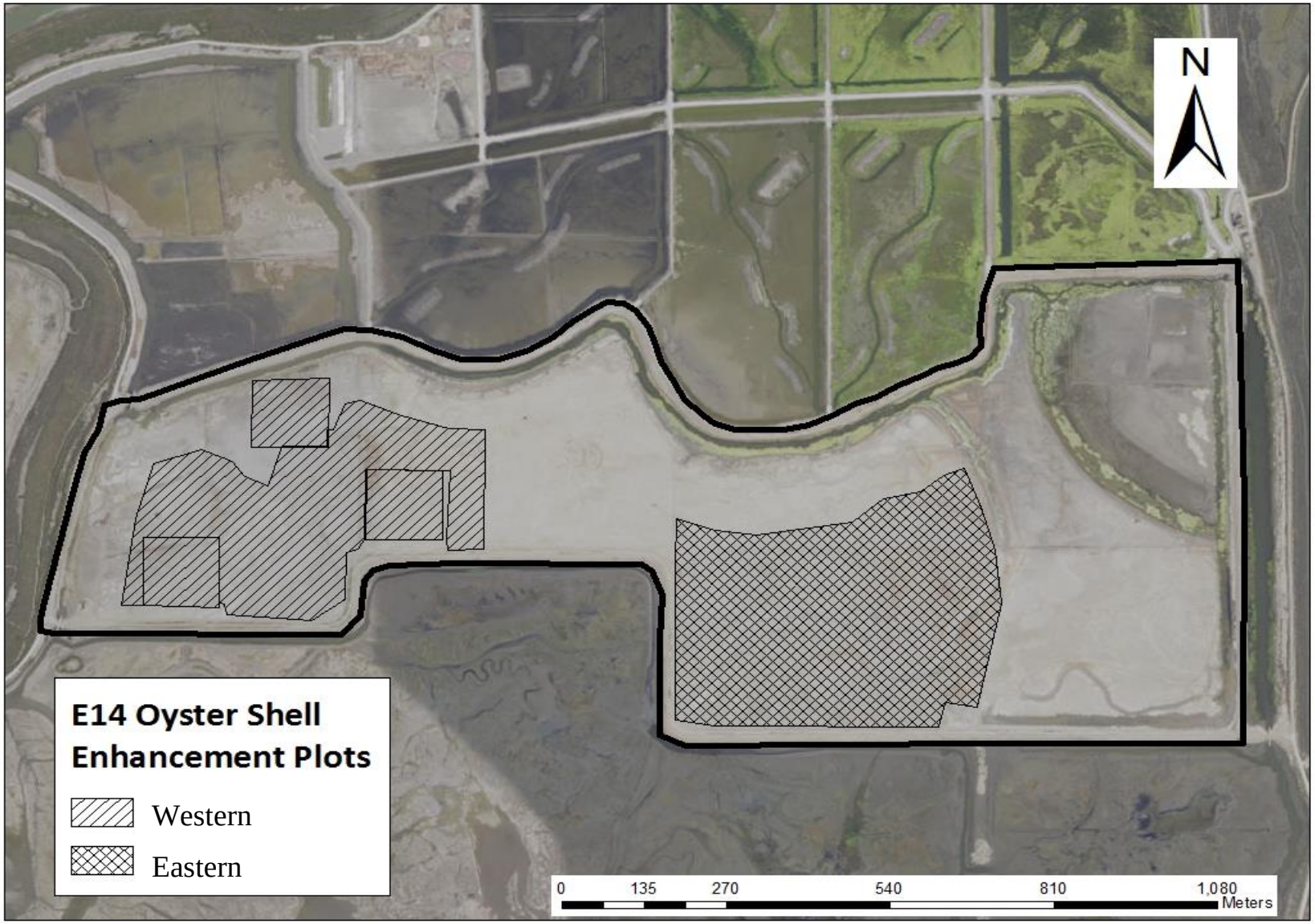

Figure 2. Oyster shell enhancement plots at Pond E14, Eden Landing Ecological Reserve, Hayward, CA.

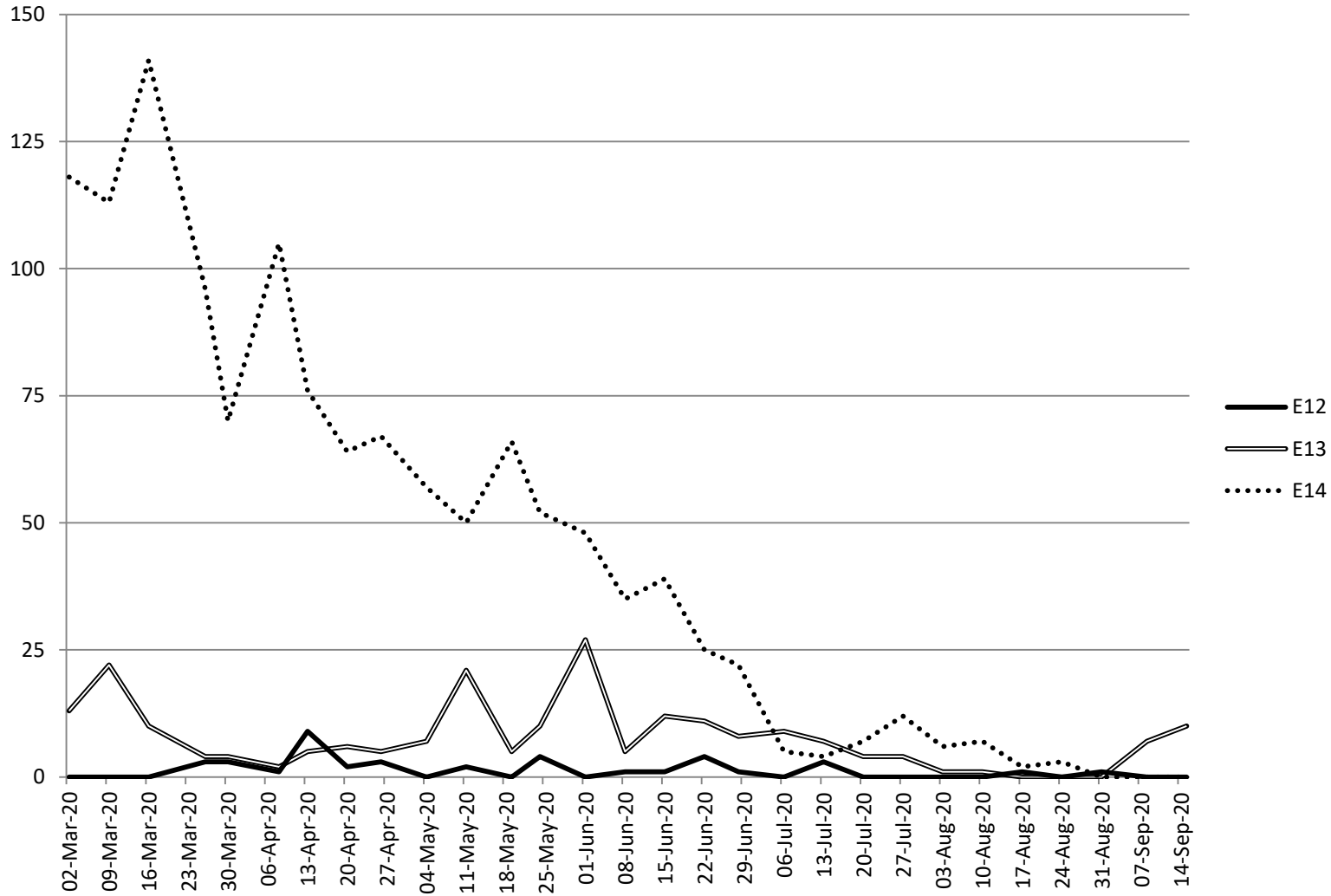

Figure 3 . Weekly counts of Snowy Plover adults observed from March 2-September 15, 2020, at Ponds E12-14, Eden Landing.

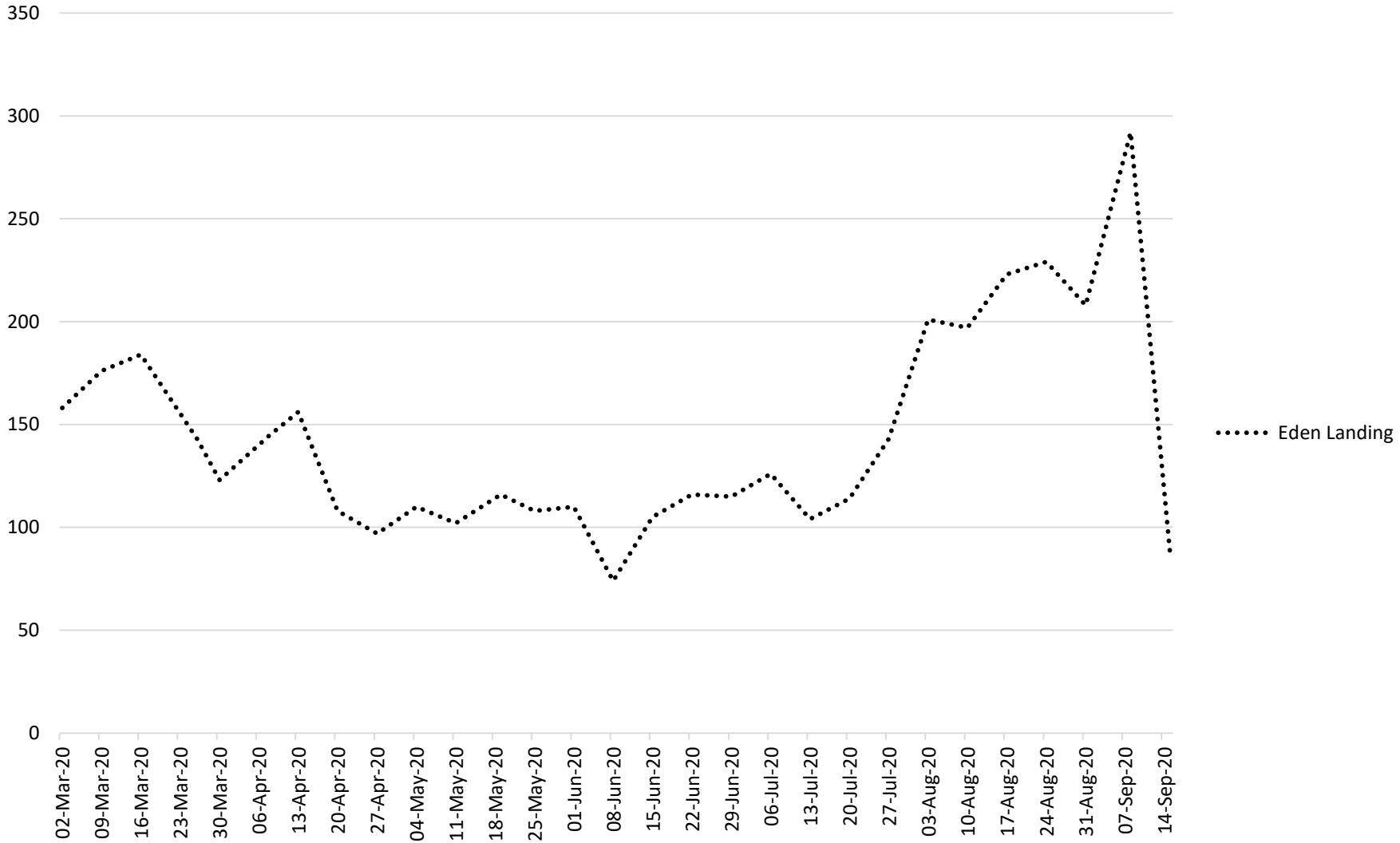

Figure 4. Weekly counts of adult Snowy Plovers at Eden Landing Ecological Reserve, Hayward, California, 2020.

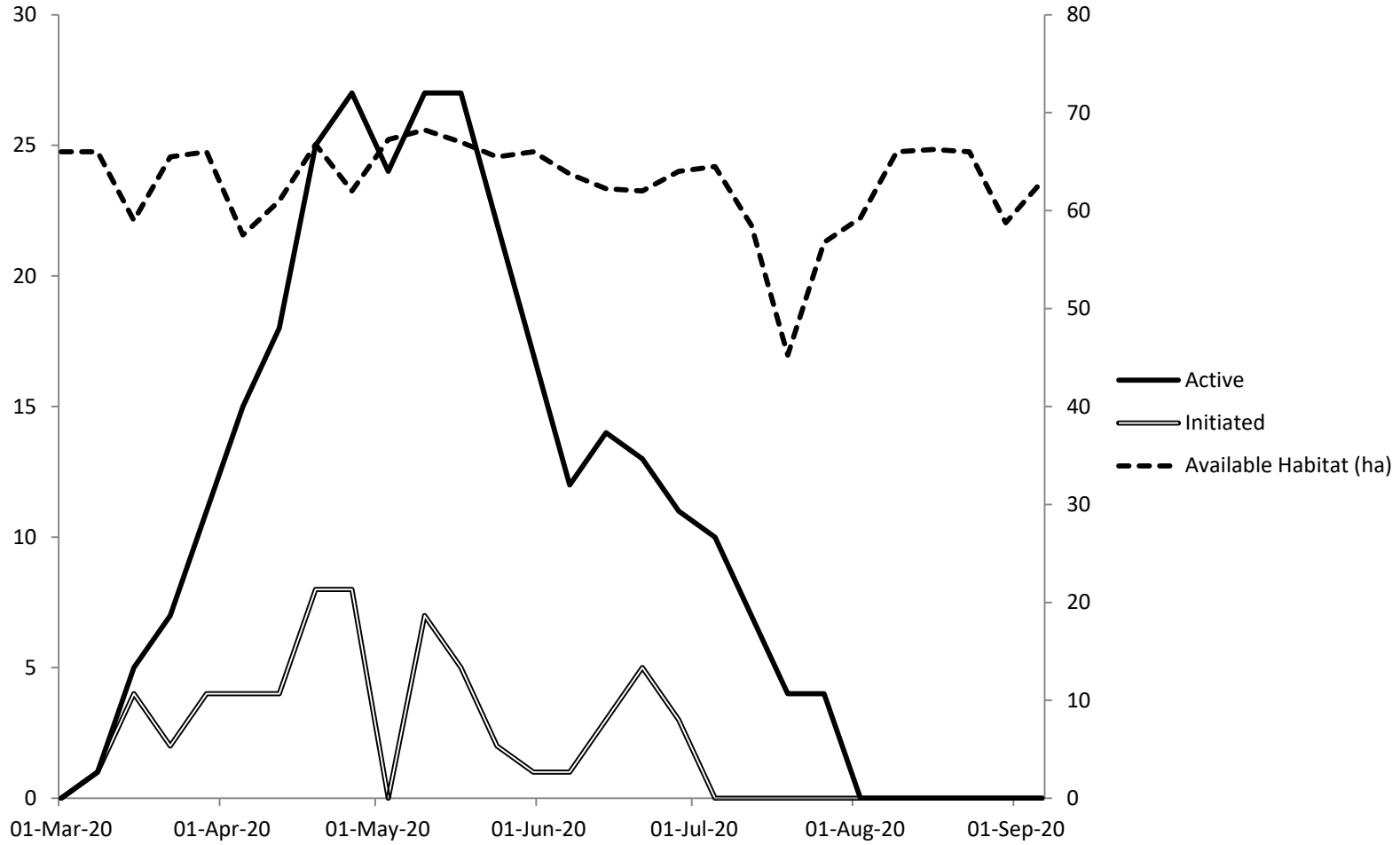

Figure 5. Active and initiated Snowy Plover nests at pond E14, Eden Landing Ecological Reserve during the 2020 breeding season.

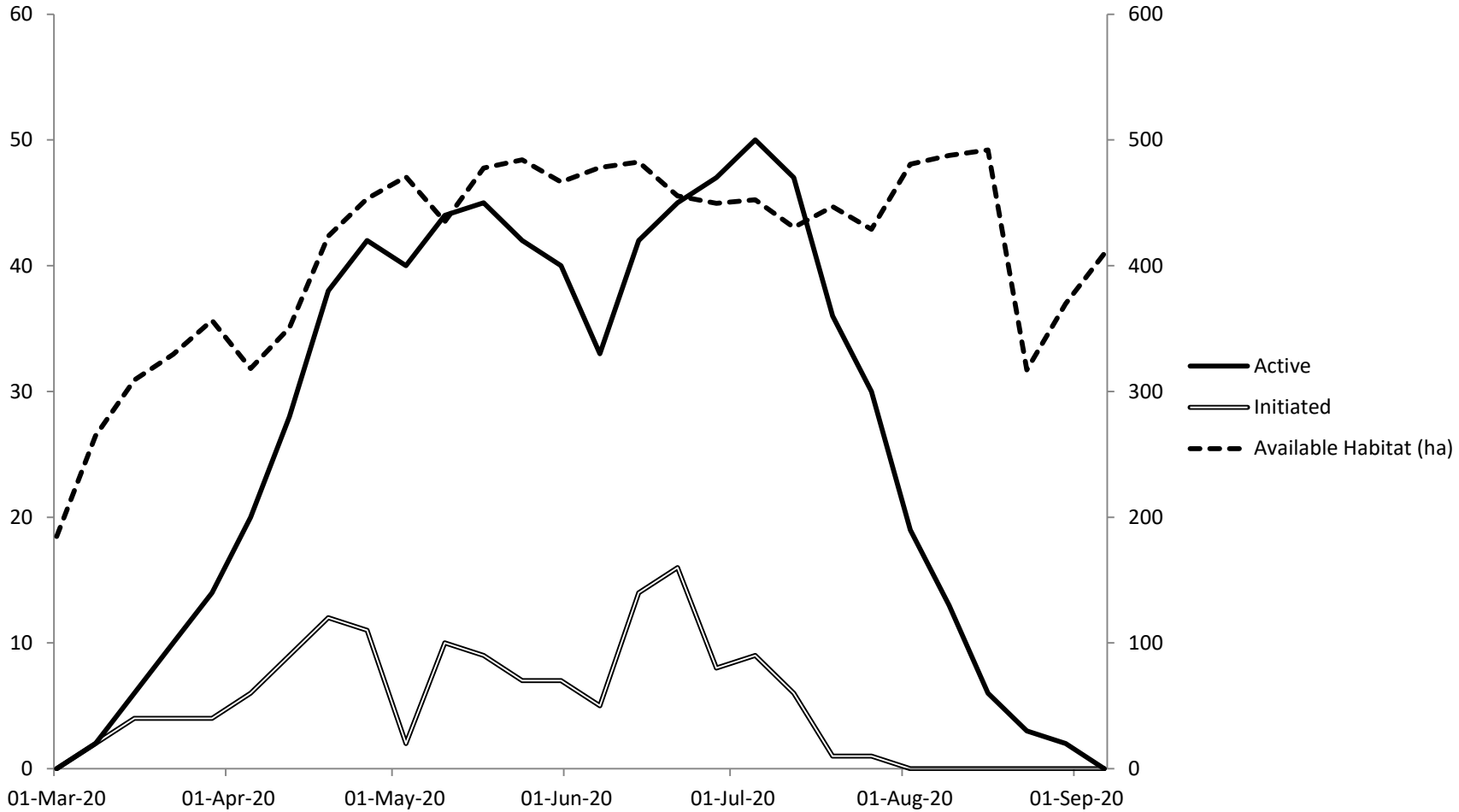

Figure 6. Weekly active and initiated Snowy Plover nests and available breeding habitat at Eden Landing Ecological Reserve in 2020.

Table 1. Number of Western Snowy Plovers observed at Recovery Unit 3 sites during annual breeding window surveys in May, 2005-2020. A dash in place of a number indicates that the site was not surveyed.

REGION	SITE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Alameda	Eden Landing	91	84	162	94	88	184	185	82	97	94	76	120	144	142	117	115
	Coyote Hills	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
	Crown Beach	-	-	-	-	-	-	-	-	-	0	0	0	-	-	-	-
	Dumbarton	0	0	2	0	0	0	0	0	0	0	0	0	2	7	2	-
	Hayward	0	0	0	1	4	12	8	9	32	7	2	4	0	7	12	19
	Warm Springs	23	7	0	3	14	27	17	3	1	11	24	14	2	20	7	-
Marin	Hamilton Wetlands	-	-	-	-	-	-	-	-	-	-	-	0	-	0	0	2
Napa	Napa	0			0	12	10	1	0	3	10	10	0	-	2	2	-
San Mateo	Ravens-wood	3	3	23	24	21	42	27	33	59	45	68	42	76	51	48	-
Santa Clara	Alviso	7	8	20	11	8	0	11	20	10	0	1	21	19	4	1	-
	Mountain View	-	-	-	-	-	-	-	-	-	11	0	0	0	2	0	8
North Bay Delta	Montezuma Wetlands	-	-	-	-	-	-	-	-	-	-	14	6	3	0	0	3
Total Unit 3		**124**	**102**	**207**	**133**	**147**	**275**	**249**	**147**	**202**	**178**	**195**	**208**	**246**	**235**	**190**	**147**

Table 2. Snowy Plover nest fates in 2020 at Eden Landing Ecological Reserve, Hayward, CA.

Pond	Hatched	Depredated	Abandoned	Flooded	**Nests Monitored**	Detected as brood	**Total**
E6A	3	2	0	0	**5**	1	**6**
E6B	7	10	0	0	**17**	1	**18**
E8	10	6	0	0	**16**	2	**18**
E12	0	2	0	0	**2**	0	**2**
E13	4	3	0	0	**7**	0	**7**
E14	25	27	8	2	**62**	2	**64**
E15B	0	1	0	0	**1**	2	**3**
E16B	8	8	0	2	**18**	1	**19**
E1C	1	0	0	0	**1**	0	**1**
E4C	3	1	1	1	**6**	0	**6**
E5C	2	0	0	0	**2**	0	**2**
E6C	2	1	0	6	**9**	0	**9**
E6	1	0	0	0	**1**	0	**1**
Total	**66**	**61**	**9**	**11**	**147**	**9**	**156**

Table 3. Snowy Plover nests fates in E14 by habitat treatment. Western and Eastern plots were enhanced with oyster shell in 2014, all other areas are termed Unshelled.

Plot	**Hatched**	**Depredated**	**Abandoned**	**Flooded**	**Total**
Western	8	11	0	0	**19**
Eastern	11	11	4	1	**27**
Unshelled	6	5	4	1	**16**
Total	**25**	**27**	**8**	**2**	**62**

Table 4. Apparent fledging success of Snowy Plover chicks by pond and chicks fledged per male in the South San Francisco Bay, California, 2020. Chicks were considered fledged if they survived to 28 days. *N* is the number of individuals banded.

Pond	**N**	**Fledged**	**Fledging Success**	**Males**	**Chicks fledged/Male**
E14	27	5	19%	11	0.45
E13	1	1	100%	1	1
E16B	6	1	17%	2	0.5
E8	6	1	17%	4	0.25
E6A	3	1	33%	1	1
E6B	11	2	18%	4	0.5
E4C	7	3	43%	3	1
E5C	2	0	0%	1	0
Total	**63**	**14**	**22%**	**27**	**0.52**

Table 5. Docent survey results at Eden Landing.

Date	Location	Public Contacts	Group Size	Type	Info. Shared	Nature of Contact
1/23/20	E12-14	0	N/A	N/A	N/A	N/A
6/28/20	E12-14	0	N/A	N/A	N/A	N/A
7/27/20	E12-14	0	N/A	N/A	N/A	N/A

Table 6. The average number of predators observed per survey at the Whales Tail loop, Eden Landing Ecological Reserve, Hayward, California, March-September 2020.

Predator Name	E12 (29)	E13 (29)	E14 (29)	E8XN (25)
Unidentified Gull	13.138	45.586	3.207	0
California Gull	17.724	16.414	10.103	0.08
Snowy Egret	1.483	4.31	0.483	0.64
Great Egret	1.69	2.931	0.862	0.56
Ring-billed Gull	5.483	0.069	0.069	0
Northern Harrier	0.069	0.172	1.138	0.04
Peregrine Falcon	0	0	0.862	0.04
Great Blue Heron	0.276	0.276	0.103	0.24
Western Gull	0.207	0.379	0	0
Common Raven	0	0	0.517	0
White-tailed Kite	0	0.034	0.345	0.12
Black-crowned Night-Heron	0.034	0.172	0.069	0
Merlin	0	0.034	0.241	0
Red-tailed Hawk	0.034	0	0.138	0
Iceland Gull	0.103	0.034	0	0
American Crow	0.103	0	0	0
Short-eared Owl	0	0	0.069	0
Bald Eagle	0.034	0	0	0

Table 7. The average number of predators observed per survey at the Mount Eden Creek Loop, Eden Landing Ecological Reserve, Hayward, California, March-September 2020.

Predator Name	E10 (25)	E11 (26)	E14B (27)	E15B (27)	E16B (28)
California Gull	25.92	29.385	1.926	0.259	0.321
Unidentified Gull	29.16	7.577	2.815	0.037	0.214
Snowy Egret	6.88	13.154	1.963	0.037	0.214
Great Egret	1.48	3.769	0.074	0	0.25
White-tailed Kite	0.36	0.038	0	0	0.571
Great Blue Heron	0.4	0.269	0.037	0	0
Herring Gull	0.6	0	0	0	0
Ring-billed Gull	0.24	0.231	0.074	0	0
Black-crowned	0.24	0.077	0	0	0.036

Night-Heron					
Peregrine Falcon	0.16	0.038	0	0	0.143
Western Gull	0.24	0	0	0	0
Northern Harrier	0.08	0.077	0	0	0.071
American Crow	0	0.077	0.037	0.074	0
Common Raven	0	0	0.074	0.074	0
Cooper's Hawk	0	0	0	0.037	0
Iceland Gull	0	0	0.037	0	0
Red-tailed Hawk	0	0	0	0	0.036

Table 8. The average number of predators observed per survey in South Eden Landing Ecological Reserve, Hayward, California, March-September 2020.

Predator Name	E1C (28)	E2C (26)	E3C (28)	E4C (27)	E5C (25)	E6 (27)	E6C (16)
Unidentified Gull	0.071	3.846	59.464	5.296	41.68	12.37	0.438
California Gull	0.143	0.038	16.821	0.593	26.04	50.481	0.125
Snowy Egret	0.036	0.154	11.143	0	0	6.852	0.188
Great Egret	0.107	0.038	2.571	0	0	2.815	0.125
Ring-billed Gull	0.929	0.231	0	0	0	0	0
Mew Gull	0.214	0	0	0	0	0.889	0
Great Blue Heron	0	0.077	0.107	0	0	0.333	0.062
Common Raven	0.357	0.038	0	0	0	0	0.125
White-tailed Kite	0.036	0	0	0.074	0.04	0.037	0.312
Northern Harrier	0	0	0	0.037	0.04	0.037	0.25
Red-tailed Hawk	0.071	0	0.071	0.111	0	0.037	0.062
Black-crowned Night-Heron	0.036	0	0	0	0	0.296	0
Peregrine Falcon	0	0	0.036	0.037	0	0	0.125
Herring Gull	0	0	0	0	0	0.185	0
American Crow	0.071	0	0	0.074	0	0	0
Burrowing Owl	0.071	0	0	0	0	0	0
Barn Owl	0	0	0	0	0	0.037	0
Loggerhead Shrike	0	0	0	0	0	0.037	0
Western Gull	0	0	0	0	0	0.037	0

Table 9. The average number of predators observed per survey at the Old Alameda Creek Loops, Eden Landing Ecological Reserve, Hayward, California, March-September 2020.

Predator Name	E20B (19)	E6A (29)	E6B (29)	E8 (29)
California Gull	0	39.586	5	0.069
Snowy Egret	0	24.276	1.552	3.345
Unidentified Gull	0	23.517	0.172	0.517

Great Egret	0	8.517	2.31	1.552
Great Blue Heron	0	0.759	0.379	0.379
Peregrine Falcon	0.105	0.655	0.379	0.138
Red-tailed Hawk	0.211	0.655	0.138	0.103
Northern Harrier	0	0.241	0.207	0.345
Ring-billed Gull	0	0.103	0.621	0.034
White-tailed Kite	0.105	0.069	0.034	0.241
Herring Gull	0	0.138	0.034	0.069
Black-crowned Night-Heron	0.053	0.138	0.034	0
Common Raven	0.053	0	0	0.069
Bald Eagle	0.053	0.034	0	0.034
Western Gull	0	0.069	0	0
American Kestrel	0	0.034	0	0.034
Feral Cat	0	0.034	0	0

Table 10. Predators and trespassers recorded by trail cameras at Eden Landing Ecological Reserve, Hayward, CA, 2020.

Date	Time	Species	Pond	Location	Description
4/27/20	11:40 p.m.	Coyote	E16B	southeast corner	Looked at camera from afar, walked away
4/29/20	5:15 a.m.	Coyote	E16B	southeast corner	Ran by camera, around until 6:02AM, appeared to be hunting
5/2/20	12:34 a.m.	Coyote	E14	E14/E8XN levee	Ran by camera
5/7/20	7:58 p.m.	Pedestrian	E12	E12/13 levee	Walked by camera
5/7/20	5:46 p.m.	Common Raven	E14	southwest corner	Walked around area for approximately 30 mins
5/7/20	9:21 a.m.	Common Raven	E8	southeast corner	Flew by camera
5/14/20	4:13 a.m.	Coyote	E14	southwest corner	Approached camera, potentially interested in, around for approximately 4 minutes
5/14/20	6:02 p.m.	Dog	E12	E12/13 levee	Off leash, ran in front of camera
5/15/20	12:21 p.m.	Common Raven	E14	southwest corner	Walked around in front of camera, potentially interested in
5/16/20	5:25 a.m.	Coyote	E16B	southeast corner	Ran by camera
5/18/20	1:21 p.m.	Great Egret	E14	southwest corner	Walked in front of camera, appeared to be headed towards Western shell plot
5/24/20	7:26 p.m.	Human, Dog	E14	E14/E8XN levee	Three pedestrians and one dog walked by camera, picked up, put back down
5/27/20	12 p.m.	Common Raven	E14	E14 Eastern Levee	Two ravens walked around levee, eventually pushed camera over
6/16/20	5:15 p.m.	Coyote	E16B	southeast	In front of camera
6/27/20	8:41 p.m.	Human	E14	southwest	Two tresspassers running on pond
6/27/20	9:08 p.m.	Coyote	E16B	southeast	In front of camera
7/1/20	9:45 a.m.	Northern Harrier	E12	E12/13 levee	Male perched on levee
7/1/20	10:53 p.m.	Coyote	E16B	southeast	In front of camera
7/2/20	10:20 a.m.	Coyote	E16B	southeast	In front of camera
7/2/20	8:56 p.m.	Human	E12	E12/13 levee	Two trespassers walked on levee past camera
7/4/20	2:13 p.m.	Human	E8	southeast	Trespasser rode motorcycle on pond, back wheel caught on camera

Table 11. Potential avian predator species.

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

Table 12. Potential mammalian predator species.

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

Table 13. Adult Snowy Plover banding attempts at Eden Landing in 2020.

Date	Pond	Sex	Band Combo	Note
5/2/2020	E14	Male	ak:wb	Did not return to nest for several hours after banding, eggs taken to Monterey County SPCA where hatched and raised, released at Eden Landing on 6/11/20
5/19/20	E14	Male	kk:gx	Would not cross mats, unable to re-cap. Previously banded, missing 2nd band on right, believed to be kk:gy
6/11/20	E6B	Male Female	wn:yy ak:rr	Both adults trapped and banded first, three chicks banded afterwards
7/7/2020	E13	Female	yv:rw	Banded as chick at E14 in 2016, violet tape reported missing by 12/27/16

a = aqua, b = blue, g = green, k = black, n = brown, o =orange, p = pink, r = red, v = violet, w = white, x =no band