Western Snowy Plover Numbers, Nesting Success, and Avian Predator Surveys in the San Francisco Bay, 2006.

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ABSTRACT

The San Francisco Bay Bird Observatory (SFBBO), the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge), the California Department of Fish and Game (CDFG), the Hayward Area Recreation Department (HARD) and the East Bay Regional Parks District (EBRPD) formed Recovery Unit 3 in the effort to monitor and manage the South San Francisco Bay's population of breeding Pacific Coast western snowy plover (*Charadrius alexandrinus nivosus*). We recorded plover numbers, nesting success, site use, and avian predator numbers during the 2006 snowy plover breeding season.

During the 2006 breeding season window survey of the Pacific Coast in May (May 24 – June 4), we counted 99 adult plovers in the Bay, 5.28% of the total number of plovers (1874) counted along the Pacific Coast. This is compared to 4.99% (72/1444) in 2003, 5.93% (113/1904) in 2004 and 7.38% (124/1680) in 2005. During our weekly surveys, the total number of adult plovers recorded was between 72 and 188, using totals from the two most comprehensive surveys, week 21 and week 25, respectively.

This year greater numbers of plovers were found nesting at Eden Landing and in Alviso than in 2005, likely due to high water levels in 2005 at Eden Landing that limited amount of available nesting habitat. Plovers were also found in one pond at Warm Springs, at one pond in Ravenswood, and one pond in the Dumbarton Ponds. Foraging plovers were also observed in the Hayward property and New Chicago Marsh in Alviso and chicks were seen near the Alviso Marina. Overall the 2006 season was more comparable to 2004 in numbers and distribution of nests.

We located a total of 81 nests within the study area. We found 11 nests on pond A8 within Refuge property. Out of these, 10 (91%) nests hatched and one (9%) was predated. Seventy nests were located at Eden Landing of which 37 (53%) hatched, 22 (31%) were predated, 4 (6%) were abandoned, 5 (7%) were flooded and 2 (3%) had unknown nest fates.

At Eden Landing, the mammalian and avian predator monitoring and management program was continued. Targeted mammalian predator species were non-native red fox (*Vulpes vulpes),* feral cats (*Felis felis*), striped skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*). Avian predator management activities focused on reducing predation from northern harriers (*Circus cyaneus*), common ravens (*Corvus corvax*) and American crows *(Corvus brachyrhynchos*). No direct predation of plovers or plover nests was observed, however northern harriers and ravens were frequently observed hunting and foraging in plover nesting ponds, several of which exhibited high nest predation rates. Predator monitoring and management should continue to be refined in 2007 to better protect plovers and plover nests, and additional methods of capture for avian predators should be tested.

The South Bay Salt Pond Restoration Project should continue to consider the habitat requirements of snowy plovers in the restoration planning process, including the need for large expanses of dry salt pond nesting substrate adjacent to high salinity foraging areas.

INTRODUCTION AND BACKGROUND

The Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*) was listed as a federally threatened species on March 5, 1993 (USFWS 1993). The Pacific coast population is genetically distinct from the interior-breeding population (Funk *et al*. 2006) and is defined as those plovers that nest along or near tidal waters. This includes plovers that nest in the South San Francisco Bay's salt ponds (Page and Stenzel 1985). Declines in the western snowy plover population are attributed to poor reproductive success caused by habitat loss and degradation, and human disturbance (Page *et al*. 1991). In 1991, there were 20 plover breeding areas in California's coastal areas, with 8 of the areas, including the San Francisco Bay, supporting almost 80% of the population (Page *et al.* 1991).

In 2001, the United States Fish and Wildlife Service drafted a recovery plan for the Pacific coast population of western snowy plover, creating six recovery units. Recovery Unit 3 encompasses the San Francisco Bay, including Napa, Alameda, Santa Clara and San Mateo Counties. The Don Edwards San Francisco Bay Wildlife Refuge (Refuge) started a snowy plover monitoring and management program on Refuge lands in 1992. The Refuge listed five goals for their program: 1) identify areas using by plovers for foraging, nesting and roosting, 2) to estimate plover numbers, including breeding pairs, 3) evaluate nesting success, 4) assess predation pressures on snowy plovers and 5) protect snowy plover breeding areas from disturbance and predation. Due to the importance of the California Department of Fish and Game's Eden Landing Ecological Reserve (CDFG, Eden Landing) to nesting plovers, the Refuge expanded the monitoring program to include this site in 2000. In addition, monitoring at the Hayward Shoreline property owned and operated by Hayward Area Recreational District and East Bay Regional Parks District (HARD, EBRPD) was initiated. The Refuge and the San Francisco Bay Bird Observatory (SFBBO) began cooperatively monitoring suitable plover habitat in the South Bay in 2003, in conjunction with the other agencies.

Refuge biologists, working with the U.S. Department of Agriculture - Wildlife Services (Wildlife Services), began a mammalian predator management program in 1991, which is still active. This program was created to control predators of the snowy plover, California clapper rail (*Rallus longirostris obsoletus*) and other ground nesting birds as well as salt marsh harvest mouse (*Reithrodontomys raviventris*) by the non-native red fox (Harding *et al*. 1998). Other mammals targeted by this program are feral cats (*Felis felis*), striped skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*).

Avian predators are having an increased impact on snowy plovers in the San Francisco Bay. Common ravens (*Corvus corax*) have increased their numbers in the Bay Area and throughout California in recent years partly in response to increased food availability in urbanized areas (Boarman and Heinrich 1999). Ravens are a known snowy plover predator and have caused high levels of predation on nests and chicks: in 1988 and 1989, ravens destroyed approximately 67-69 percent of plover nests at Point Reyes National Seashore (Page 1988, 1990). Ravens are also regarded as a main snowy plover predator in Humboldt County (Colwell *et al.* 2002).

Another avian predator of concern is the northern harrier (*Circus cyaneus*), which nests in marshes and uplands adjacent to plover nesting ponds. For example, from 1999 through 2001 harriers were believed to be the main predators of plovers in the Salinas River National Wildlife Refuge (USFWS 2002). In addition, expanding populations of California gulls (*Larus californicus*) may disturb nesting plovers and have the potential to displace snowy plovers and other ground-nesting birds from their nesting habitat in salt ponds and on levees. Other avian predators of concern include the red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), peregrine falcon (*Falco peregrinus*), white-tailed kite *(Elanus leucurus*), American crow (*Corvus brachyrhnchos*), and loggerhead shrike (*Lanius ludovicianus*). To reduce impacts to plovers from some of these avian predators, the Refuge, CDFG, and Wildlife Services began an avian predator management program in 2004. This program first focused on reducing predation from crows and ravens; in 2006 we began managing northern harriers.

In 2006, the Refuge, SFBBO, CDFG, HARD and EBRPD continued monitoring plovers and avian predators in order to better understand plover populations and pond use in the area, as well as predation pressures on nesting plovers. This report is a presentation and analysis of the 2006 snowy plover breeding season data, including results from plover population level surveys, nest monitoring, avian predator surveys and avian and mammalian predator management programs.

STUDY AREA

Surveys were focused in the southern portion of San Francisco Bay, from just north of the San Mateo Bridge to the extreme south end of the Bay, where the majority of potential snowy plover nesting habitat occurs in the salt ponds. Due to limitations in survey personnel and presence of only a small amount of plover nesting habitat, no surveys were conducted in Napa County in the CDFG salt ponds this year, although this area is also a part of snowy plover Recovery Unit 3. Previous breeding season window surveys have recorded very small numbers of nesting snowy plovers in that area, on ponds 7 and 7A as recently as 2002 (USFWS unpubl. data).

Eden Landing, previously known as Baumberg, is managed by the CDFG and located immediately adjacent to the north Refuge boundary on the east side of the bay. This area encompasses all salt ponds between the Alameda Flood Control Channel and Highway 92 (San Mateo Bridge) and is bisected by Old Alameda Creek, which divides the area into north and south sections (Figure 1). In 2006 all ponds in the north section of Eden Landing were monitored (Figure 2), as well as a few ponds in the south section just north of the Alameda Flood Control Channel (Figure 3). Early this season we focused most survey effort on ponds B6A, B6B, B8 and B8A, since these ponds were partially dry and provided potential plover nesting habitat. Later in the summer, we focused more survey effort in ponds B12 and B14, as they dried (Figure 2). More infrequent surveys were conducted in ponds 3C and 4C, in the southern section of Eden Landing (Figure 3).

The Don Edwards San Francisco Bay National Wildlife Refuge is an urban refuge encompassing approximately 30,000 acres of salt ponds, tidal salt marsh, mudflats and upland habitats in south San Francisco Bay. For the purpose of this study, we divided the Refuge property into six geographic areas: Alviso, Coyote Hills, Dumbarton, Mowry, Ravenswood and Warm Springs (Figure 1). These areas were monitored monthly with the exception of the Coyote Hills ponds and the Mowry ponds. This year, surveys on the Refuge focused on potential nesting habitat on Alviso pond A8 (Figure 4) and Warm Springs pond A22 (Figure 5), but more infrequent surveys were conducted on New Chicago Marsh, the impoundment east of the Alviso Marina (Figure 4), and Ravenswood ponds R1, R4, and RSF2 (Figure 6).

Hayward Area Recreational District (HARD) owns land north of Highway 92 in Hayward, including Franks Dump West and Oliver Brother's North ponds OBN1-OBN17, which contain potential snowy plover foraging and nesting habitat. This area is co-managed by East Bay Regional Parks District staff (Figure 1). Occasional surveys were conducted on this site throughout the breeding season. In addition, the San Leandro Marina Park, owned by the City of San Leandro, was surveyed for the first time this year because an adult plover was seen foraging at the park during the 2006 winter survey.

Figure 1: The Don Edwards San Francisco Bay National Wildlife Refuge was divided into six geographic areas: Dumbarton, Coyote Hills, Mowry, Warm Springs, Alviso and Ravenswood. CDFG's Eden Landing is just north of the Refuge boundary on the east side of the bay, Hayward Area Recreation District lands are just north of Eden Landing, and San Leandro Marina is directly north of the Hayward site.

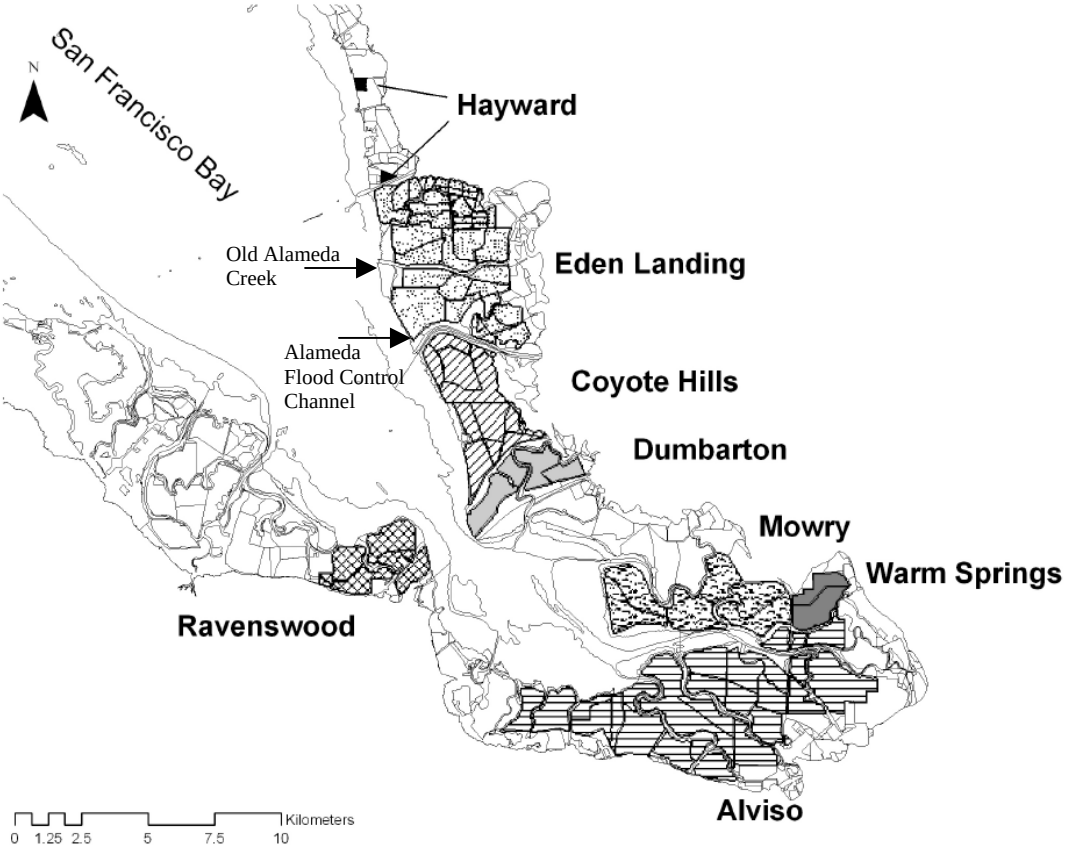


Figure 2: Salt ponds located in the northern part of Eden Landing, south of Highway 92 and north of Old Alameda Creek.

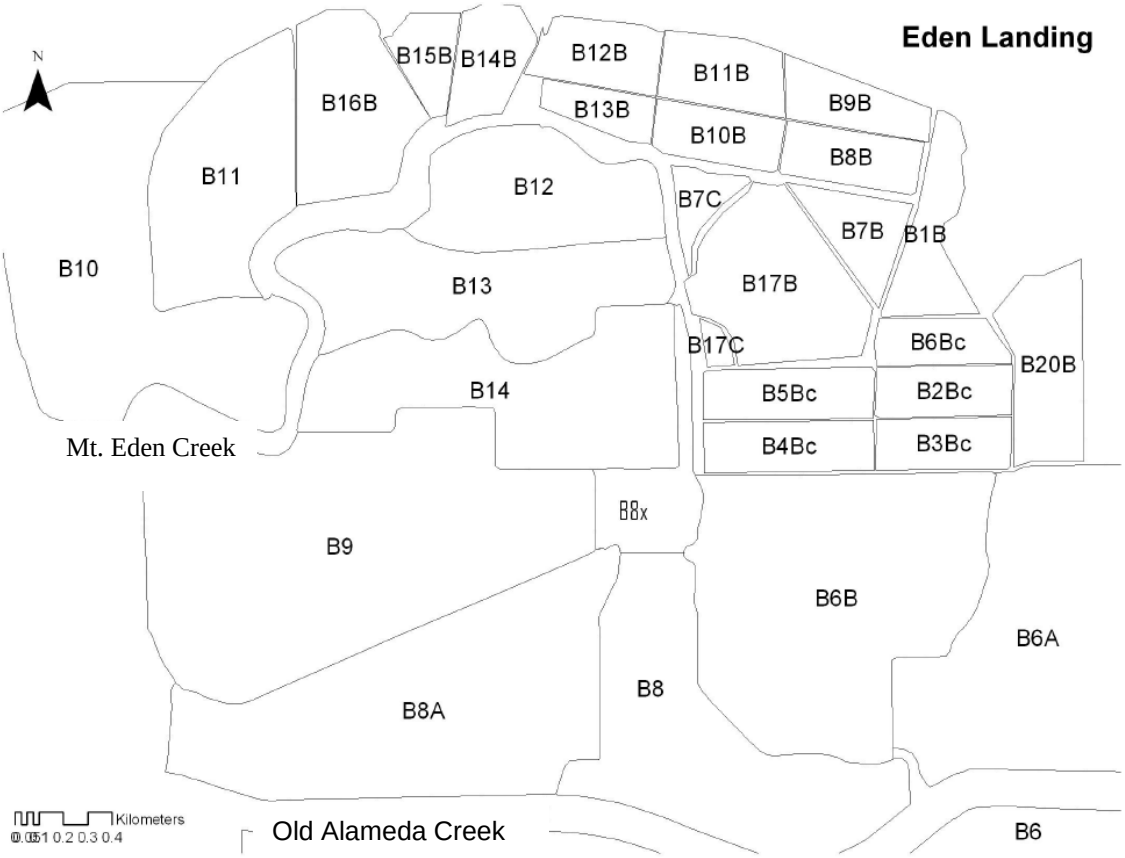


Figure 3: Salt ponds located in the southern part of Eden Landing, south of Old Alameda Creek and north of the Alameda Flood Control Channel.

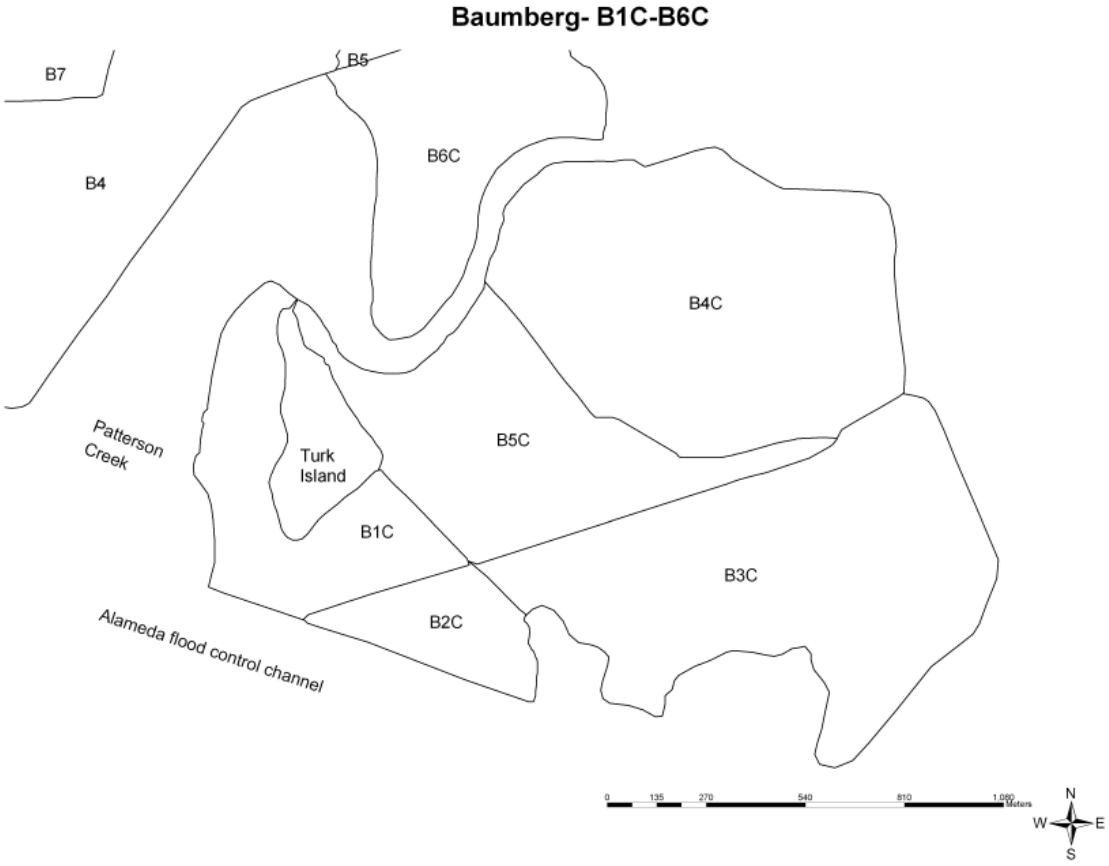


Figure 4: Salt ponds located in the Alviso area, at the southern end of the Bay.

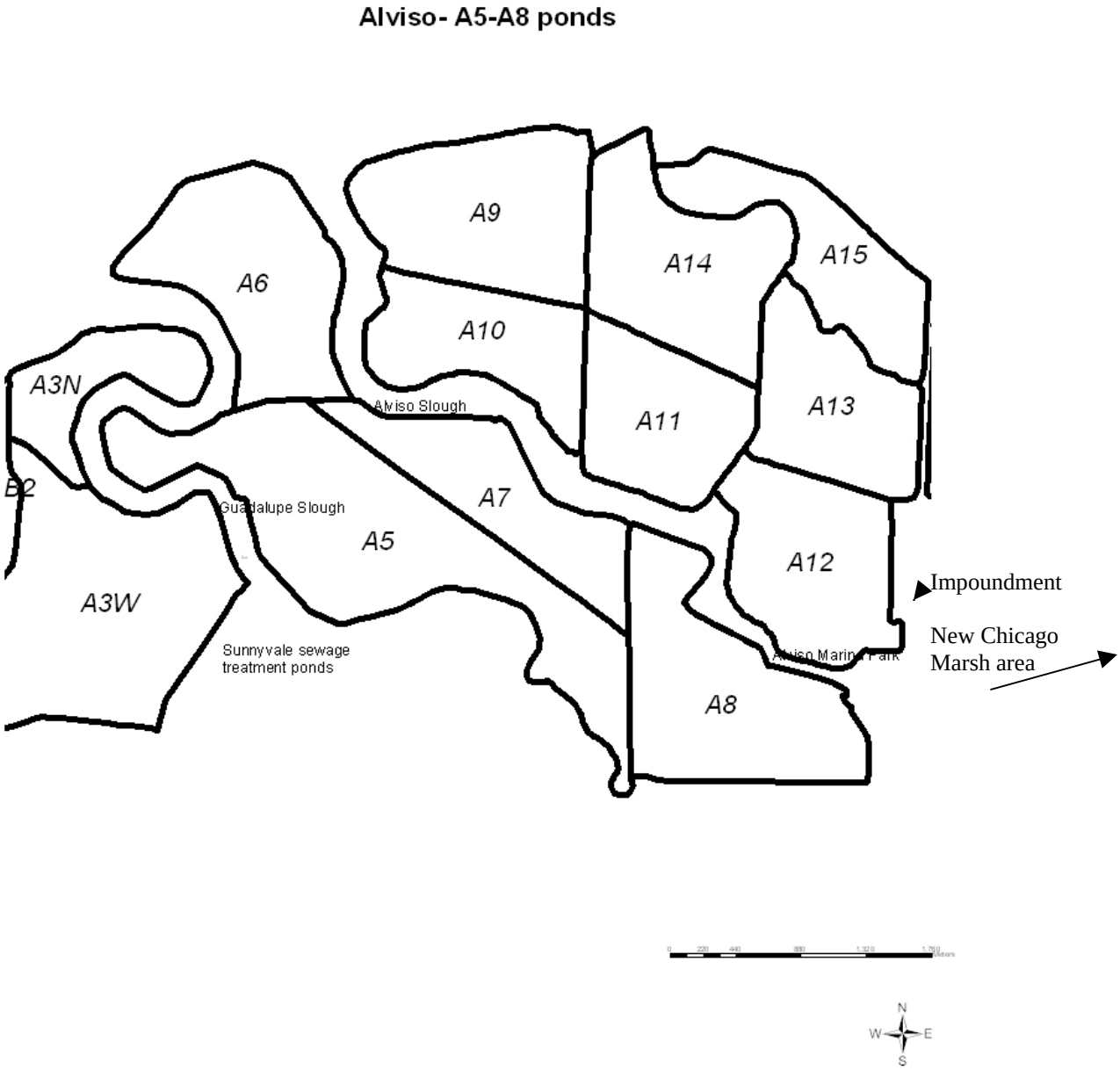


Figure 5: Salt ponds located in the Warm Springs area, near Fremont.

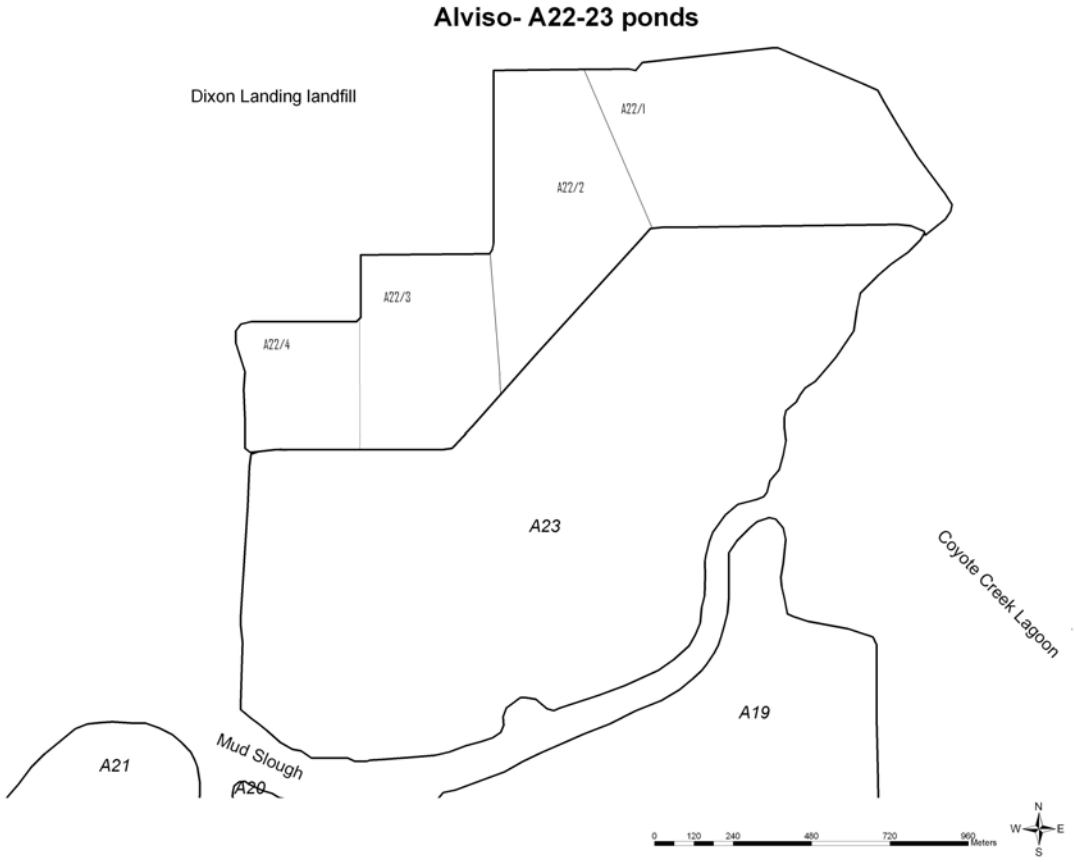
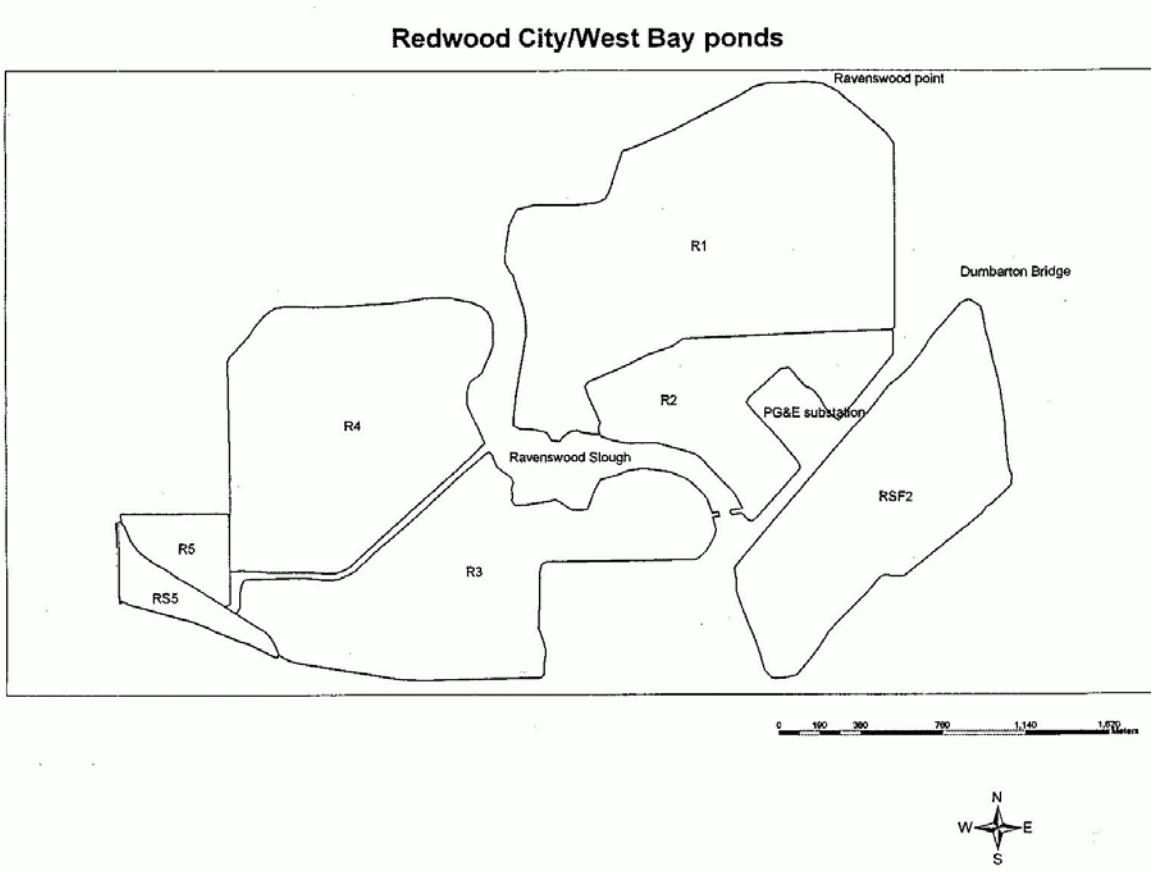


Figure 6: Salt ponds located in the Ravenswood area, at the western end of the Dumbarton bridge.



METHODS

Adult and Nest Monitoring

In San Francisco Bay, plovers nest primarily on the bottom of dry salt ponds adjacent to high-salinity foraging areas. Since most snowy plovers are site-faithful, nesting in the same area every year (Warriner *et al.* 1986), we monitored many of the same ponds and areas where plovers have nested previously. However, since pond water levels may be different from year to year and water levels fluctuate during the season, foraging and nesting values of ponds are constantly changing. As a result, throughout the season we also monitored any additional ponds were we found suitable plover habitat or where plovers were sighted.

The study sites were broken down into two categories: "monthly ponds" and "focus ponds". Volunteers from SFBBO surveyed the monthly ponds once a month, recording adult plover, nest and chick numbers, as well as avian predators in the area. This year monthly surveys were conducted in all areas except for Coyote Hills, which was surveyed once, and Mowry which was not surveyed due to lack of suitable nesting habitat. The ponds that had high plover breeding activity early in the season were chosen as focus ponds. Refuge and SFBBO biologists and interns surveyed the focus ponds weekly for adult plovers, chicks, nests and avian predators. All nests found on focus ponds were monitored weekly until nest fate was determined.

Volunteers, interns and biologists monitored the ponds by slowly driving down the levees and roads within the study site. Plovers are less disturbed by vehicles than pedestrians, so we limited walking surveys to where the levees were impassible by a vehicle or where vehicles were not permitted. We stopped the vehicle approximately every 0.3 miles and scanned for plovers using a spotting scope and binoculars. For every adult plover spotted, we watched the bird for 10 to15 minutes, or until the behavior indicted that a bird was sitting on a nest.

During the focus surveys, interns and biologists would approach the site where a bird appeared to be incubating, to search for a nest. During monthly surveys when volunteers spotted a possible nest from the levee, they recorded the location on a map as closely as possible and documented detailed landmark information. Later, interns and biologists relocated these areas and searched for nests. Volunteers did not approach nests.

This year, fifteen ponds were surveyed on Refuge property, with A8 serving as a focus pond for nest monitoring (Table 1). Sixteen ponds were surveyed for plovers at Eden Landing, with five focus ponds (Table 2). Plover and nest numbers are reported on a weekly basis, starting with week 9 of the 2006 calendar year, which began on 26 February (Table 3).

Table 1: Ponds surveyed within the Refuge. *Denotes focus ponds.

Location	Ponds
Alviso	A5, A6, A7, A8*
Dumbarton	N1, N2, N3, PP1
Ravenswood	R1, R2, RSF2, R3, R4
Warm Springs	A22, A23

Table 2: Ponds surveyed within the Eden Landing Ecological Reserve. *Denotes focus ponds.

Location	Ponds
Eden Landing Ecological Reserve	B6A, B6B*, B8*, B8A*, B8X, B9, B10, B12*, B14*, B15, B16, B1C, B2C, B3C, B4C, B5C,

Table 3: Week numbers referenced in this report and the corresponding first day of that week.

Week Starting Date	26-Feb	12-Mar	26-Mar	09-Apr	23-Apr	7-May	21-May
Week Number	9	11	13	15	17	19	21
Week Starting Date	04-Jun	18-Jun	02-Jul	16-Jul	30-Jul	13-Aug	27-Aug
Week Number	23	25	27	29	31	33	35

Reproductive Success

We monitored nests weekly until we determined nest fate, number of chicks hatched, and the estimated or known hatch date. If the nest was not successful we recorded abandoned or predated eggs. We were not able to closely monitor all nests, since some were inaccessible due to features within the ponds, such as deep channels of water. The nests that were not closely monitored were not included in the nest success or egg hatching data for this report as it was impossible to determine nest fate.

We assigned each nest a unique number using the pond number the nest was located in followed by a sequential number (e.g. B8-1, B8-2, etc.). The exact location of the nest was recorded with a GPS unit (Trimble® Geo XT), to an accuracy of about one meter. We also recorded the pond number, number of eggs and/or chicks in the nest and whether there was an adult incubating or present in the area. To estimate the age of the eggs and the hatch date of a nest, we floated eggs by placing them individually in a cup of distilled, room temperature water. We then recorded the maximum diameter of the egg exposed above the water, then recorded the approximate angle at which the egg was floating in the water, as measured by the angle of the long axis of the egg to a horizontal line. We re-checked nests weekly to record nest status and to re-float eggs.

We used the estimated hatch date from floating the eggs to help determine nest fate. When there were no longer eggs in the nest, we searched the nest cup for small eggshell fragments that indicated that the nest hatched. If no fragments were found, we checked

for signs of predation, including large pieces of eggshell, yolk, and major disturbance to the nest cup. If eggs disappeared from a nest more than two weeks before the estimated hatch date, we recorded that nest as predated even if no evidence of predation was found. If eggs were present a week after the estimated hatch date and there were no adults in the area, we recorded the nest as abandoned.

We used the nest initiation dates to analyze peak nest initiation time. The average lifespan of a nest was 33 days, from initiation to hatching (Page *et al.* 1995). If we saw direct evidence of a nest hatching, such as wet chicks in the nest cup or a chick hatching, we considered that the hatch date. If pipping was observed, we considered the following day to be the hatch date. If we returned to a nest that no longer had eggs or chicks, but had evidence at the nest that indicated that it had hatched, we used the estimated hatch date from the most recent egg float data.

We assessed reproductive success by using nest success and hatching success. We defined nest success as the percentage of total nests that hatched at least one egg. Hatching success is the percentage of eggs hatched per total eggs laid. We estimated Mayfield hatching success as the estimated proportion of nests in which eggs hatch, $P = (1 - Nu /E)^h$, where Nu = number of unsuccessful clutches, E = total exposure-days, and h = clutch age at hatching (33 days for snowy plovers; Mayfield 1961).

Avian Predator Surveys

To estimate potential predator pressure on nesting plovers, we conducted monthly avian predator surveys on all monthly ponds and weekly on all focus ponds. Volunteers, interns and biologists surveyed ponds, levees, power towers, and surrounding areas within the pond areas by driving or walking along levees, stopping approximately every 0.3 miles, or whenever we saw a predator. We recorded species present, number of individuals, their behavior and marked their location on a map. We located predator nests and attempted to determine their fate. An avian predator was defined as a species that could conceivably prey on a snowy plover, such as gulls, herons and raptors. Average numbers of predators sighted per week was used for comparison of predators between areas and throughout the season, and was calculated by dividing total number of individuals counted by the number of surveys conducted in that area.

Management Methods

The mammalian predator management program overseen by the Refuge and conducted by Wildlife Services continued this year. Target mammalian predators including red fox, feral cats, skunks and raccoons were removed on Refuge land, at Eden Landing, and on other adjacent properties. During the snowy plover breeding season, more the control effort was focused in the areas where plovers were breeding.

The avian predator management program targeted the removal of individual ravens, crows, and northern harriers that were foraging in snowy plover nesting areas at Eden

Landing. In addition, several nests of these species in and adjacent to the salt ponds were located and removed. Results of the avian predator surveys were used to identify these problem predators and to locate their nests.

To minimize human impacts on snowy plover nesting areas, several areas of the Refuge are closed to the general public. Marshlands Road at the Refuge headquarters is closed to vehicle traffic from April to August to prevent plover chicks from being run over on the road. In addition, a portion of the Warm Springs pond A22 levee and all levees on Alviso ponds A5-A8 are completely closed to the general public year-round, although researchers from USFWS and USGS traveled the levees and ponds in this area.

There is no public access at Eden Landing, although researchers and CDFG officials travel the levees within the plover nesting area. In 2006, the northern part of Eden Landing was subject to heavy construction traffic due to restoration activities.

RESULTS

Overall Plover Numbers

During the 2006 breeding season window survey of the Pacific Coast (May 24 – June 4) we counted 99 plovers in the San Francisco Bay. This is 5.28% of the total number of plovers (1874) counted along the Pacific Coast.

During our weekly surveys, the total number of individual plovers recorded was between 72 and 188, using totals from the two most comprehensive surveys, week 21 and week 25 respectively (Appendix 1). The number of plovers seen in each pond varied by week throughout the season, and plover use of different ponds and areas varied greatly. However, Eden Landing consistently had the highest number of plovers in the South Bay. Plover use at Eden Landing was first concentrated on ponds B6B and B8, and later in the season on B12 and B14. Plovers were also seen consistently on Refuge property on A8, RSF2, and A22 (Appendix 1).

The ponds with the highest number of plover nests throughout the season were B8, B12, and B6B (Table 4). Chicks were seen on the same ponds as adults. The ponds with the highest number of chicks seen on a single survey were B12 and B8A. The greatest number of chicks counted during one day at Eden Landing was 28 on July 3rd. The maximum number of chicks counted during one week in all areas combined was 49 (Appendix 2).

Table 4: Nest fates in the South Bay.

Location	Hatched	Predated	Abandoned	Flooded	Unknown	Total nests
Alviso						
A8	10	1	0	0	0	10
Eden Landing						
B6B	7	6	1	3	0	17
B8	13	8	1	1	0	23
B8A	0	1	0	0	0	1
B11	0	0	0	0	1	1
B12	14	6	1	0	1	22
B14	3	0	1	0	0	4
B3C	0	0	0	1	0	1
B4C	0	1	0	0	0	1
Total South Bay	47	23	4	5	2	81

Refuge

Alviso had the highest number of plovers on the Refuge, with a mean of adults seen per survey of 13.06, all on pond A8 (Table 5, Figures 7 and 8). On other areas of the Refuge, Warm Springs pond A22 and Ravenswood RSF2 had mean numbers of 5.20 and 3.91 adult plovers, respectively (Table 5). Plovers used Dumbarton pond N1 only after it had dried out, near the end of the season (Figure 8). Plover adults and chicks were also observed in the impoundment east of the Alviso Marina in August (Figure 4).

Eden Landing

On Eden Landing, plovers were seen on all ponds surveyed except B16, B1C, B2C and B5C. Eden Landing had the highest numbers of adult plovers of all areas surveyed with a mean of 109 adults and 10.46 chicks per survey (Table 5; Figure 7). However not every pond was surveyed every week, so averages per pond are based on different numbers of surveys. Throughout the season, pond B8A had the highest consistent use, with a mean of 26.12 adults seen per survey (Appendix 1). The highest average number of plovers seen in a pond, however, was on B14 (57.23; Appendix 1), which dried later in the season and supported high numbers of foraging plovers. Pond B12 had a mean number of 30.31 adults detected, and B8 a mean number of 19.55 adults seen per survey (Appendix 1).

In the beginning of the season, ponds B6B, B8 and B8A had the highest plover use. These ponds were the first ponds to dry (in March) at Eden Landing and had a good mix of dry nesting habitat and nearby water for forage. In June, B12 and B14 began to dry out and thereafter supported the highest number of plovers. In general, plover use moved northerly as the more southern ponds dried out completely and northern ponds dried enough to expose nesting substrate and provide nearby forage habitat.

Hayward Shoreline

Six plovers were seen roosting in the Hayward area in July and three were seen roosting and foraging in August. No plovers nested in the Hayward area in 2006 because of high water levels.

San Leandro Marina

No plovers were observed at the San Leandro location.

Figure 7**:** Sum of snowy plover adults by week and area. The large variation in plover numbers at Eden Landing is due to incomplete surveys of this area on certain weeks. (See Appendix 1 for counts summarized by pond.)

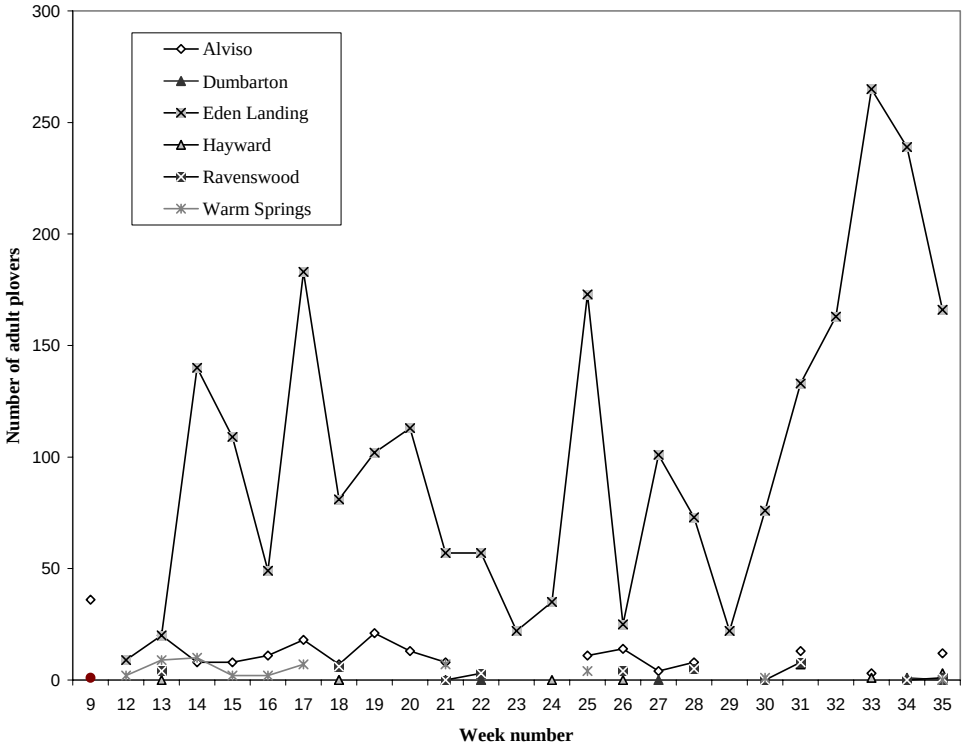


Figure 8: Sum of snowy plover adults by week and area (not including Eden Landing).

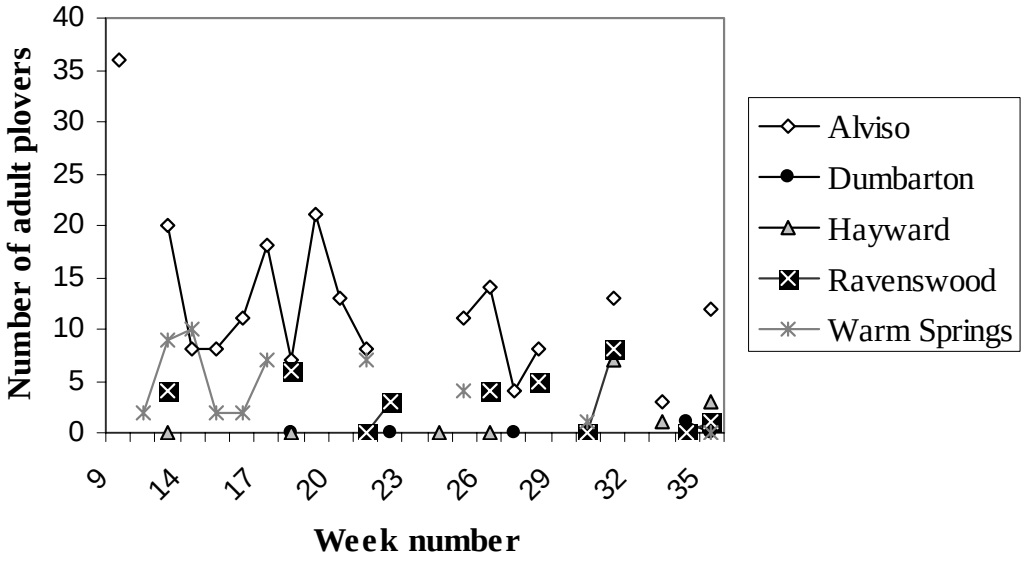


Table 5: Summary statistics of plover numbers by area.

Location	Stat	Males	Females	Unknown Adults	All Adults	Juveniles	Chicks	Juveniles plus chicks
Alviso	Mean (N=17)	3.94	3.13	6.00	13.07	0.29	2.00	2.29
Dumbarton	Mean (N=7)	0.14	0.00	0.00	0.14	0.14	0.14	0.29
Eden Landing	Mean (N=24)	18.17	21.63	70.50	109.96	1.92	10.46	12.36
Hayward	Mean (N=6)	0.00	0.00	1.83	1.83	0.00	0.00	0.00
Ravenswood	Mean (N=11)	0.55	0.45	2.91	3.91	0.36	0.57	1.33
Warm Springs	Mean (N=10)	1.90	1.80	1.50	5.20	0.00	0.70	0.70
Alviso	Std Error	0.96	0.77	1.77	2.02	0.21	0.73	0.78
Dumbarton	Std Error	0.14	0.00	0.00	0.14	0.14	0.14	0.29
Eden Landing	Std Error	3.27	4.20	14.50	14.63	0.75	2.89	3.28
Hayward	Std Error	0.00	0.00	1.14	1.14	0.00	0.00	0.00
Ravenswood	Std Error	0.21	0.25	0.85	0.80	0.28	0.36	0.43
Warm Springs	Std Error	0.48	0.59	0.70	1.34	0.37	0.37	0.37

Reproductive Success

Refuge

We monitored eleven nests on Refuge property, all on A8 in Alviso. Ten of these nests hatched (91%) and one was predated (9%); 29 out 32 eggs hatched (91%; Table 4). One egg did not hatch and had an indentation in the shell. The cause of the indentation is unknown.

Two nests were observed but not monitored on A22 in Warm Springs. Three broods of chicks were seen a month later suggesting that at least three nests were successful. One snowy plover nest was observed on Dumbarton pond N1, and one chick was later observed in the area. The nest was inaccessible and was not included in the nest data. There were also several chicks observed on the Ravenswood ponds RSF2, but no nests were monitored in this pond. In July and August, we also saw adult plovers with fresh hatchlings in the impoundment area east of the Alviso Marina (Figure 4, Appendix 2). This area is typically flooded during nesting season and does not usually contain suitable nesting habitat.

Eden Landing

At Eden Landing we monitored 70 nests in eight ponds (Table 4). Out of these nests, 37 hatched (52%), 22 were predated (31%), 4 were abandoned (6%), 5 were flooded (7%) and 2 had unknown fates (3%). Only one nest was found on B8A but we believe that more birds may have nested there than we detected because of the high numbers of chicks seen there later in the season, although some of these chicks may have originated in pond B8. Three nests were flooded on B6B and one in B8. The nest in B3C was flooded early in the season (Table 4). The single nest found in B11 had three eggs. We did not continue to monitor it after we decided the bridge into the pond was unsafe and therefore the fate of that nest was unknown. The other unknown fate nest was in B12; we could not relocate the nest to determine its fate. Three additional nests were found but not monitored due to access constraints. In B14, one nest was found after it had been predated; this nest was not added into the analysis. Two additional nests were observed in areas we could not access, one each in B3C and B11.

Of the 189 found eggs at Eden Landing, 104 of them hatched (55%; Table 6).

Nest initiation at Eden Landing peaked on weeks 17 and 18 with 22 active nests during those two weeks. There were 15 active nests for the weeks 17 through 19. The earlier initiated nests were almost entirely in pond B6B and B8. Later in the season nests were concentrated in ponds B12 and B14 (Figure 9, Appendix 3).

Figure 9: Number of initiated and active nests per week for entire South Bay.

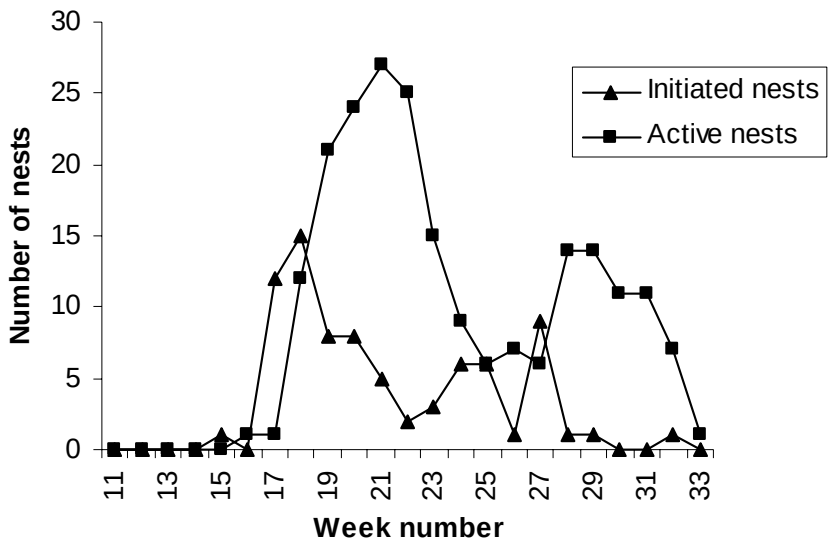


Table 6: Hatching success of all known-fate nests in the South Bay.

Location	Number of Eggs	Eggs Hatched	% Hatched	Total nests with known eggs
Eden landing				
B6B	42	23	55%	17
B8	66	37	56%	23
B8A	3	0	0%	1
B11	3	Unknown		1
B12	62	39	63%	22
B14	10	5	50%	4
B3C	Unknown	0	0%	1
B4C	3	0	0%	1
Alviso				
A8	32	29	91%	11
Total South Bay	221	133	60%	81

South Bay, Overall

We monitored 81 nests in the entire study site in 2006. Out of these nests, 23 of them were predated, 4 were abandoned, 5 were flooded and 47 hatched. One hundred thirty-three chicks hatched from known nests, but since chicks were not banded or followed, we have no information on chick survival or fledging success (Table 6).

Mayfield estimates

We observed a total of 1181.5 nest exposure days. Thirty-two of our nests were lost, therefore mortality was 32/1181.5, or 0.027. Survival was calculated as 1 – 0.027, or 0.973. Therefore, the probability that a nest survived the 33 days between nest initiation and nest hatching was $0.973^{33} = 0.0404$.

Nest density and breeding chronology

To calculate the nest initiation day, we subtracted 33 days from the predicted hatch date. We determined week 18 to be the peak in nest initiation in the South Bay, with an estimated fifteen nests initiated that week (Figure 9, Appendix 3). Weeks 19 through 22 had the highest number of active nests, with the peak of 27 nests on week 21. There was also a second "wave" of nest initiation in ponds B12 and B14. This came later in the season once those ponds had dried, during weeks 24 and 25 and again in week 27 (Appendix 3).

To determine the nest density in each pond, we divided the number of nests in individual ponds by the pond acreage. Using this calculation, pond B12 had the highest density of nests, followed by B8 (Table 7). Nests in pond A8 were concentrated on the two raised berms in the middle of the pond early in the season when water levels were higher, but as water levels dropped nests were initiated in other areas of the pond (Figure 10). Nests in pond B8 clustered in the small, northern "panhandle" of the pond throughout the season, on the dry salt panne substrate of the pond bottom (Figure 11) while nests within B12 were all located on the low berms that run throughout the pond (Figure 12). All nests located in B6B were in the northern part of the pond, primarily on the salt panne areas (Figure 11), and the five nests in pond B14 were all found on dry salt pond substrates in the western part of the pond.

Figure 10: Nest locations within pond A8, Alviso.

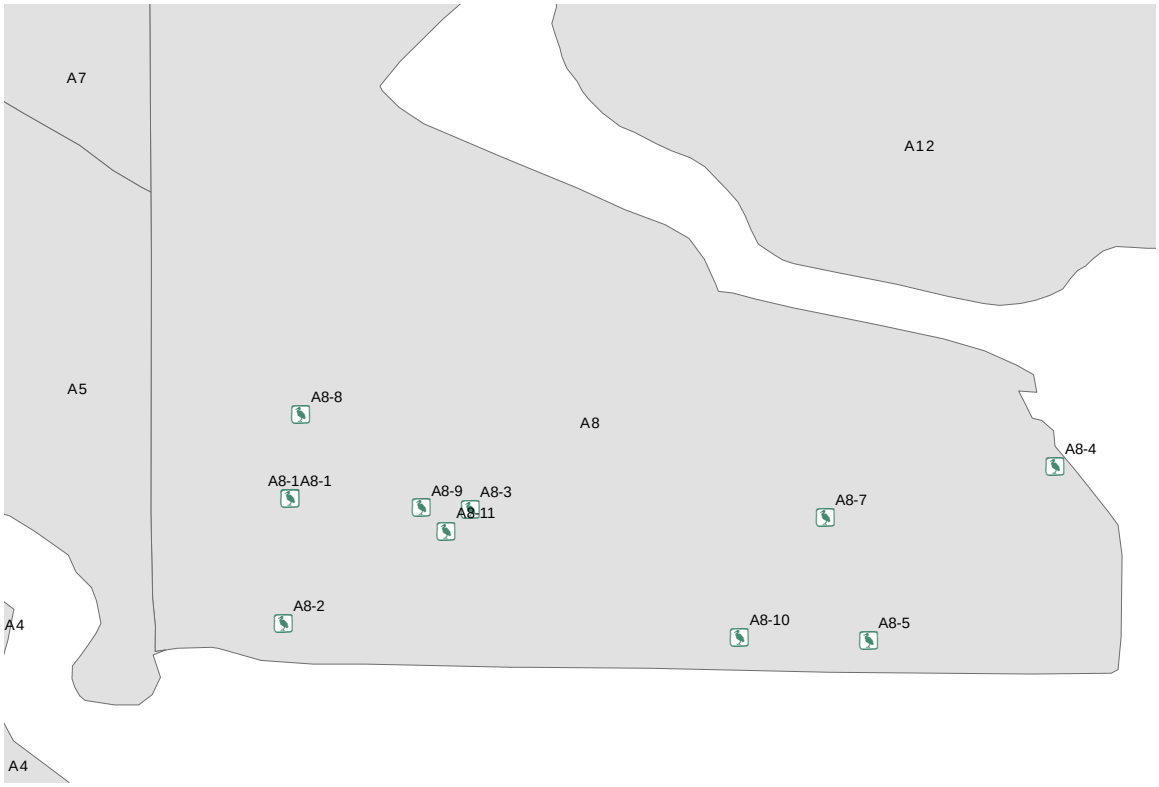


Figure 11: Nest locations within ponds B6B and B8, Eden Landing.

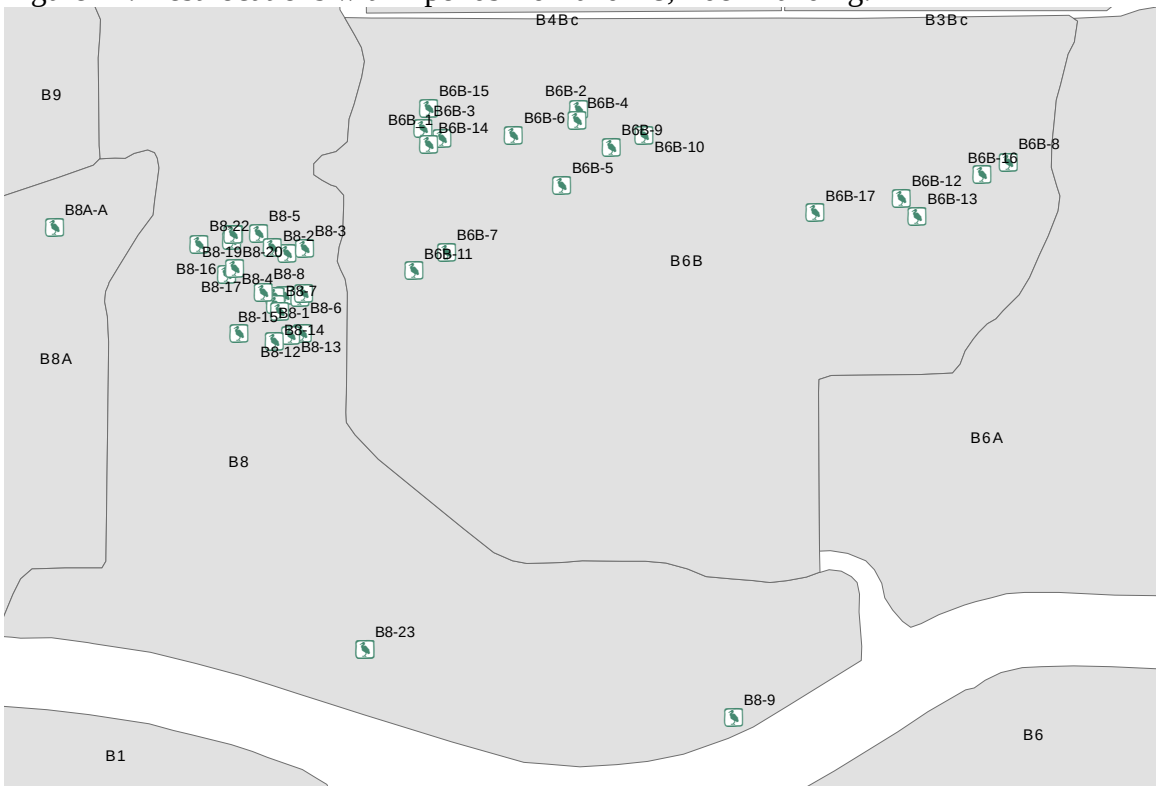


Figure 12: Nest locations within ponds B12-B14, Eden Landing.

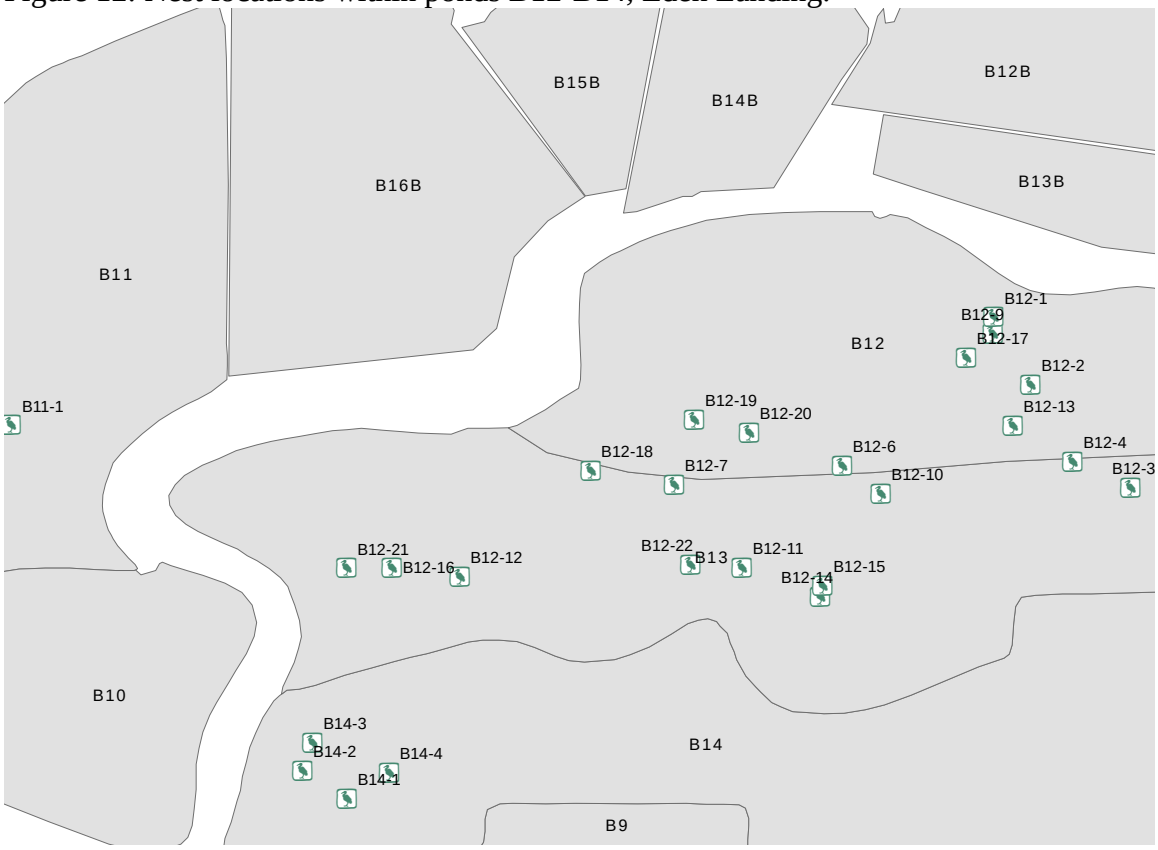


Table 7: Nest densities within each pond, per acre.

	Eden Landing								Refuge
Nests per acre	B6B	B8	B8A	B11	B12	B14	B3C	B4C	A8
	0.059	0.089	0.0005	0.003	0.095	0.032	0.003	0.006	0.027

Avian Predators

Refuge

California gulls were the most frequently seen avian predator in Alviso, with approximately 19,000 adults nesting in the colony on A6. Great egrets (*Ardea alba*), snowy egrets (*Egretta thula*) and common ravens were also commonly observed in the pond A8 area (Table 8). One raven nest was observed on the power towers near pond A6.

At Warm Springs, the most commonly seen predators were California gulls, other gulls, and common ravens. Hundreds of gulls were regularly seen leaving the Newby Island landfill adjacent to A22, and late in the season hundreds were commonly seen roosting on A23 (Table 8). Warm Springs is close to the Mowry California gull colony with 5,068 individuals nesting there (SFBBO unpub. data). Common ravens were regularly seen, with one survey counting 29 individuals foraging on ponds A22 and A23. There were three stick nests visible in PG&E towers in and adjacent to pond A22; two were common raven nests and one was a red-tailed hawk nest. American kestrels (*Falco sparverius*) were regularly seen, but nests were not located.

At the Ravenswood ponds, California gulls were the most commonly seen predator. Also observed were two common ravens, two American crows, one great egret and one great blue heron (*Ardea herodias*). At the Dumbarton ponds, California gulls were also the most frequently seen predators, with counts over 250 at the beginning of the season (Table 8).

No avian predator management was conducted on Refuge property.

Eden Landing

The most commonly seen predators at Eden Landing were California gulls, other gulls, common ravens and northern harriers (Table 8). Gulls were observed roosting on a small island in the western portion on B9 for much of the season. Gulls were also observed foraging in pond B6B during several afternoon predator surveys. A new California gull colony was established in 2005 occurs in the Coyote Hills salt ponds, just south of Eden Landing. In 2006 this gull colony consisted of 7,442 breeding individuals (SFBBO unpub. data).

Common ravens were regularly seen throughout Eden Landing. Very early in the season, groups of 5-10 individuals, primarily sub-adults, were observed in Whale's Tail Marsh. All through the plover breeding season, small groups and individuals were seen foraging and roosting in most ponds. A majority of these birds were identified as sub-adults. Ravens were observed flying low over ponds and walking around in ponds, which are both foraging methods for this species. They were also observed roosting on levees and PG&E towers.

In June, at least two adult and three juvenile ravens (likely a family unit) began to be observed in the old crystallizer ponds just behind the industrial park. One raven was observed eating a freshly killed American avocet (*Recurvirostra americana*) on the levee between B8 and North Creek, when there were 16 active snowy plover nests and numerous avocet nests in the northern section of B8. Throughout the season, Wildlife Services removed 15 common ravens from Eden Landing: one adult, eight sub-adults, three juveniles, one unknown age bird, and 2 chicks. The chicks were removed by Wildlife Services from a stick nest on a PG&E tower near the San Mateo Bridge toll plaza.

American crows were seen primarily around the business parks and housing surrounding the Eden Landing property. Occasionally an individual would perch on the PG&E towers or forage near ponds B6A and B6B. Two American crows were removed from Eden Landing this year by Wildlife Services.

Northern harriers nested in Old Alameda Creek and the diked pickleweed area just north of pond B6A, and were seen with nesting material in Mt. Eden Creek. Harriers were frequently seen hunting over ponds B6B, B8, B8A, B9, B12 and B14 and along levees between most ponds. Up to six harriers were seen during a survey in Eden Landing. During predator surveys; individuals were observed foraging over large areas of Eden Landing, from the uplands on the east to the bay on the west. Several harriers were observed harassing nesting American avocets in B6B and B8. One adult male, two adult females, and four sub-adult male northern harriers seen actively foraging in plover nesting areas were removed from Eden Landing by Wildlife Services. In addition, five chicks from a nest in the pickleweed north of B6A were removed. This nest was associated with the single adult male and one of the adult females that were removed.

Red-tailed hawks were not seen nesting in Eden Landing this year, after PG&E crews removed a former red-tailed hawk stick nest from a PG&E tower. Individuals were regularly observed soaring and roosting around B6A, but they were not seen foraging over ponds. The number of white-tailed kites increased at Eden Landing compared to 2005, and juveniles were seen foraging over ponds B12 and B6B at the end of the season. American kestrels were also seen later in the season, foraging over B6A, B6B, and the old crystallizer ponds behind the business park. Peregrine falcons were seen foraging over ponds, and perching on PG&E towers and duck blinds throughout Eden Landing. At least a dozen great blue herons nested on the old duck hunting cabin in B6B again this year. Four great blue heron nests were on a hunting blind in B9, all with chicks.

Table 8: Mean numbers of predators per survey in each area (not including the Alviso gull colony).

	Species	Alviso	Dumbarton	Eden Landing	Hayward	Ravenswood	San Leandro	Warm Springs
Predators of Concern	Northern Harrier	1.29	2.00	1.15				1.20
	Common Raven	2.56		2.35	1.00	2.00		2.17
	Red-tailed Hawk	1.33	1.00	1.13	0.50			1.00
	Peregrine Falcon	1.00		1.00				1.00
	White-tailed Kite	1.83	2.00	1.14	1.00			1.00
	American Kestrel	2.00		1.22				1.33
Other Predators	California Gull	932.11	53.13	18.09		12.87	3.00	547.22
	Black-crowned Night Heron	2.63		2.37				1.67
	Great Blue Heron	1.54		2.29	1.25	1.00		2.00
	Great Egret	8.29	1.67	2.60	1.00	1.00	2.00	1.33
	American Crow		1.00	5.50		2.75		1.75
	Other Gull	20.00		18.94	19.58	4.00		134.46
	Loggerhead Shrike			1.00				
	Burrowing Owl			1.00				1.33
	Coopers Hawk			1.00				1.00
	Unidentified Corvid	1.00			1.00			10.33
	Golden Eagle			1.00				1.00
	Unidentified Hawk		1.00	1.00				1.00
	Prairie Falcon	1.00			1.00			
	Snowy Egret	5.00	1.00	3.21				1.75
	Number of Surveys	9.00	3.00	52.00	6.00	6.00	4.00	11.00

Hayward Shoreline

At Hayward Shoreline, gulls were the most frequently seen predator. One red-tailed hawk and one white-tailed kite were observed there as well (Table 8).

Mammalian Predators

Although we were not conducting mammalian predator surveys in Eden Landing, several mammals were recorded during our other surveys and activities in the area. We saw one gray fox with one kit by the northeast corner of B6A. Cats were regularly seen by the Veasy Street entrance (west of B6A), both inside the complex as well as by the houses outside the gate; they are either feral or outside pets. Three small black and white dogs were seen in the flood control channel numerous times. Two skunks were seen three times on the levee north of B6A and B6B. Wildlife Services removed feral cats, raccoons, skunks, and opossums from snowy plover breeding areas (Table 9). Gray foxes were captured but released, since they are not targeted for removal.

Table 9: Mammalian predators removed from plover breeding areas.

Location	Feral Cat	Raccoon	Skunk	Opossum	Gray Fox
Eden Landing	11	0	21	2	4
Refuge	1	5	6	0	9

DISCUSSION

Plover Numbers

It is difficult for us to accurately estimate the exact number of breeding snowy plovers in the San Francisco Bay, since very few adult plovers are banded and single surveys of an area sometimes took several days to complete. However, a rough estimate of the number of breeding plovers in the South Bay would be approximately 100 birds.

Compared to 2005, higher mean numbers of plovers were seen at the Eden Landing ponds and in pond A8 in Alviso, while numbers at Warm Springs and Ravenswood declined. This shift in pond use reflects differences in location and quality of available nesting habitat from year to year. One nest was found in pond N1 in the Dumbarton area this year when water levels decreased due to a broken pump. Ponds and levees in this area were historically used by plovers but have not been utilized in the past few years as pond water levels are kept high and little dry nesting substrate is available.

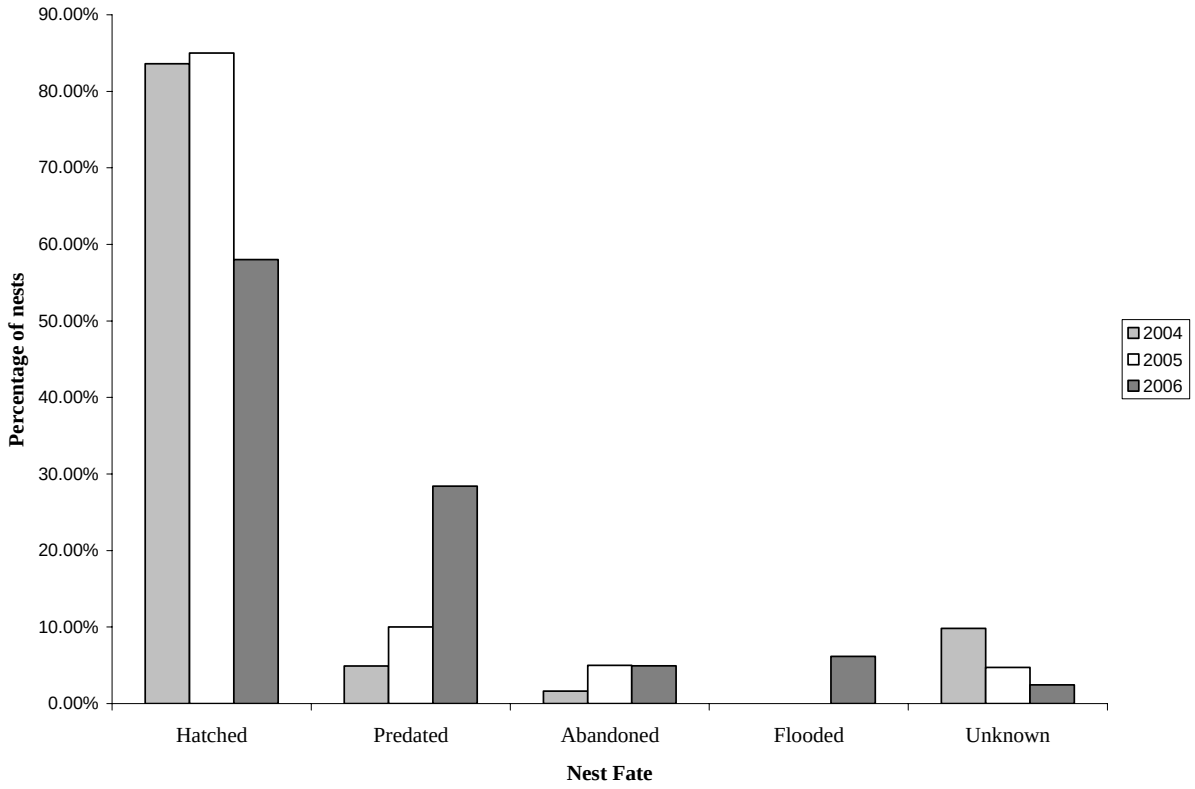
Plovers continue to be seen foraging at Hayward in very small numbers, but none nested there this year due to high water levels in the ponds. Water levels cannot be adequately controlled to provide consistent dry nesting substrate in the breeding season with existing infrastructure. Until other water management options are available, it may be better to manage this area as snowy plover and shorebird foraging habitat rather than as snowy plover nesting habitat. Other areas in the San Francisco Bay, such as Napa County and South Bay ponds in Mowry, Coyote Hills, and San Leandro, are not actively managed for snowy plovers and currently provide very little if any snowy plover nesting habitat.

Reproductive Success

We found a total of 81 nests (with at least five more not monitored on A22 and RSF2) in the South Bay. This is a 305% increase the 20 nests found in 2005. The number of nests found on Refuge land decreased slightly from 13 in 2005 to 11 in 2006. The number of nests at Eden Landing increased dramatically from 7 in 2005 to 70 in 2006. The low number of nests in 2005 is attributed to the high water levels in Eden Landing ponds due to late spring rains. In general this years' nesting was more comparable to the nesting season of 2004, when 61 nests were found in the Bay area: 11 on the Refuge and 50 in Eden Landing.

Nest success for the Bay decreased from 83.6% in 2004 and 85% in 2005 to 58% this year due to high levels of predation (Figure 13, Strong *et al.* 2004, Tucci and Strong 2005). Twenty-three of our nests were predated, compared to two nests in 2005, and three nests in 2004. At most predated nests, eggs were missing from the nest, but no other sign of predation was in evidence. While we know the impact predators are having on the nests, we cannot quantify predator impact on chicks and adults since we do not band plovers.

Figure 13: Nest fates in the South Bay in 2004, 2005 and 2006 in all areas.



Plovers nested on a greater number of ponds than they have over the past two years. They nested on four ponds within the Refuge area (A8, A22, N1, and RSF2) and at the impoundment near the Alviso Marina. The impoundment area was drier than usual and provided sufficient nesting habitat. Use of this area indicates that plovers are able to nest in new areas as habitat becomes available. In addition, nests had not been found on Refuge pond A8 in the Alviso area for a number of years. In the beginning of the season, all nests were concentrated on the two raised berms in the middle of this pond. As water levels dropped throughout the season, they nested in other dry areas of the pond as well. The California gull colony located at A6 just north of pond A8 could have a significant impact on plovers nesting in this area; in 2006, 74% of American avocet chicks from this area were predated by California gulls (J. Ackerman, USGS, pers. comm.). Snowy

plovers also nested in several of the Ravenswood ponds this year. Although this area was not surveyed regularly, local birders and volunteers located one potential plover nest on Ravenswood pond R4 (July 7) and two chicks on pond R1 (June 24). On July 17th, 29 adult plovers were counted on pond R1. Since the Ravenswood ponds annually support at least a small number of nesting plovers, this area should be surveyed regularly in future years to better detect nesting activity.

Although we found three broods of plovers on pond A22, indicating nesting in that pond, vegetation encroachment in the west end of this pond is reducing the quality and quantity of available nesting habitat (A22/4 in Figure 5). The western section of the pond contains a "leaky" well that supplies the only source of water to the pond at the end of the nesting season, when all other sections of A22 have dried. California gulls roost in very large numbers on pond A23, just south of A22 and are a potential source of predation on plovers in this area.

Plovers nested on eight ponds at Eden Landing. The highest numbers of nests were found on B8 and B12. Although only one nest was found on B8A, this pond had the highest number of chicks observed, indicating that a few nests may have gone undetected. In addition, plover broods likely moved onto pond 8A when foraging conditions in other adjacent ponds were not met. Chicks and adults are often seen on the levee between pond B8A and B9, further evidence that broods travel on levees and move around in search of appropriate foraging habitat.

At Eden Landing, use of ponds by nesting plovers changes from year to year and even within a breeding season, as the availability of suitable nesting habitat in each pond changes due to varying water levels. This year, CDFG started to actively manage the water levels in five ponds (B6A, B6B, B8, B8A, BX) at Eden Landing as part of the South Bay Salt Pond Restoration Project. Water levels in these ponds were drawn down, starting in February, to create dry areas for nesting plovers and yet maintain some shallow foraging areas for migratory shorebirds. Three of these ponds (B6B, B8 and B8A) were among the first ponds to have plovers nest in them this year, since they were fairly dry early in the season. In fact, the northern section of pond B8 dried out before the rest of the pond and hosted 21 of the 23 nests found on this pond. During the breeding season, as water evaporated from the ponds, water was added to maintain suitable foraging areas for plover broods and adults.

Mid-way through the season, when ponds B12 and B14 started to dry out, many plovers began to initiate nests on those ponds. Much of pond B12 stayed damp, and plovers nested primarily on the slightly raised berms running throughout the pond, which are structures left over from the historic salt works. The berms are elevated enough that they dried out much sooner than did the bottom of the pond. Because these berms are narrow, linear features, plover nests on the berms were easy for researchers to find, and are likely easily found by predators such as northern harriers which hunt by following linear features. In fact, most of the nest predation in this pond occurred on the first few nests, prior to removal of several harriers from the area. The four nests on B14 were found on

the dry salt panne substrate in the western end of the pond. No nests in B14 were predated.

Five nests at Eden Landing were accidentally flooded when water levels were raised in ponds B6B and B8 to maintain water quality requirements. A new water control structure was installed between B6A and B6B in the fall of 2006 to allow independent management of water levels in these two ponds. This will reduce the chances of flooding active nests during regular water management activities conducted to benefit plovers in B6B, while maintaining water quality in B6A. Pond B6A, which has historically been used by nesting plovers, has not been used for the past few years, likely due to increased amounts of vegetation in the pond. In the immediate future, this pond will be managed as shallowly flooded habitat for foraging plovers and other shorebirds.

Restoration and Snowy Plover Nesting Success

The vast majority of snowy plover nesting habitat is located within the South Bay Salt Pond Restoration Project area. The main objective of the Project is to restore large areas of salt ponds to tidal marsh, while maintaining some managed ponds as snowy plover nesting and foraging habitat and other ponds as migratory waterfowl and shorebird foraging habitat. Salt ponds, with their variety of dry nesting habitats and flooded high salinity foraging areas, are vital to support nesting plovers and their broods. During the restoration effort and in the future, special efforts should be made to maintain sufficient amounts of plover habitat. Ponds managed for nesting plovers should be spread out in different areas of the bay, and locations of dry ponds should be varied by year. This "rotational" pond management style may reduce plover nest predation levels by changing the potential foraging areas for predators from year to year to prevent individuals from "learning" the locations of the plovers and potentially teaching their young to hunt for plovers. In addition, we have noticed that snowy plovers in San Francisco Bay seem to prefer large areas of open salt pannes for nesting, this type of habitat should be maintained in the landscape to support nesting plovers. Unless future research shows that plovers are able to utilize other types of nesting habitat (such as created islands within managed ponds) as successfully as they use salt pannes, salt pannes should be maintained as the primary plover nesting habitat in the Bay.

As public access increases within the South Bay Salt Pond Restoration Project area, additional protection measures such as fencing and borrow ditches as "moats" may need to be constructed and maintained in order to limit human disturbance in plover nesting areas. Public access may need to be prohibited in certain sensitive plover nesting areas if research shows human disturbance impacts on reproductive success, survival, or plover behavior.

The active water management in five salt ponds at Eden Landing in 2006 was one of the first steps in attempting to manage ponds for nesting plovers and migratory shorebirds in the Project area. These ponds were some of the first ponds of the season to dry out in the south Bay, and to have plovers nest on them. However, later in the season there was very

little plover use on two of these ponds, B6B and B8, likely because water levels had become too low and the ponds no longer provided high quality plover foraging habitat. The existence of other nearby drying ponds (B12 and B14) available later in the breeding season, allowed plovers to move around and find other suitable nesting and foraging habitat. In order to maximize plover breeding opportunities, it will be important to maintain ample nesting and foraging opportunities throughout the breeding season so that plovers have alternate habitat available when pond water levels change.

Avian Predators

Northern harriers were one of the primary predators of concern this year. They were seen feeding over many ponds where plovers nested at Eden Landing. Pairs were seen nesting in Old Alameda Creek and in the pickleweed marsh north of pond B6A. Individuals were frequently observed hunting in ponds B6B, B8, and B12 when there were large numbers of active plover nests present. Subsequently, these ponds had high numbers of nests depredated and very few chicks were observed from the few nests that hatched. Conversely, after several harriers were removed from the area, nest success increased and more plover chicks were regularly observed on the ponds.

Since future tidal marsh restoration will greatly increase the potential nesting habitat for northern harriers, local populations of this native predator are likely to increase, resulting in higher predation pressure on salt pond nesting birds such as plovers. In order to reduce these predation effects, further investigations on how best to manage both harriers and snowy plovers on a landscape level will be necessary.

The Alviso California gull colonies at pond A6 and Coyote Hills continued to grow exponentially in 2006 (SFBBO unpub. data). There was also a dramatic increase in the number of roosting and foraging gulls seen at Eden Landing this past year. Gulls are opportunistic feeders and a known predator of shorebird eggs and chicks in the South Bay (USGS unpub. data). The expansion of the California gull population endangers nesting habitats of plovers, terns, avocets, stilts, and black skimmers. In order to preserve these populations nesting in the Bay, gull management will be necessary in the near future, particularly as the gulls initiate new colonies near or in Eden Landing, where the highest concentration of nesting plovers exists.

Common ravens nested on one of the PG&E towers along the northern boundary of Eden Landing, but this nest was removed prior to fledging. Adults associated with this nest likely foraged in salt ponds and other areas near the nest site, but may have occasionally foraged in plover nesting ponds farther to the south. Foraging groups of sub-adults moved throughout the plover nesting areas in the early part of the breeding season and were likely responsible for a large part of plover nest and chick predation attributed to this species. Many of these individuals were removed during the early part of the plover breeding season, so predation pressure from this species was greatly reduced later in the season. Future predator management should focus on removal of raven nests from towers early in the season to reduce foraging by adults feeding chicks, as well as removal of individuals foraging in plover nesting ponds.

Road Closures and Barriers

Barriers and signs were unable to prevent some people from entering areas where snowy plovers nested. There is a well-used bike path leading into the southern portion of A8 and people were seen walking in the area from the nearby businesses. On three occasions, bicyclists were seen on the interior levees at Eden Landing. Two pedestrians walking dogs were also observed at Eden Landing. Two individuals entered Eden Landing on ATVs and rode on the dry salt ponds; these people were apprehended by the authorities.

RECOMMENDATIONS

Research Recommendations

Future research surrounding plovers and their nesting areas should include:

a) Experimental design to determine if South Bay plovers can successfully nest on islands within managed ponds as successfully as they nest on expanses of dry salt pannes.
b) Northern harrier territoriality and how it may relate to the effectiveness of the current predator management program should be investigated.
c) Determine how landscape level changes can effect northern harrier, gull, and corvid nesting success and foraging patterns.
d) Studies to more closely correlate water level and snowy plover pond use, and pond water management to improve conditions for plovers.
e) Foraging site studies to determine importance of ponds and mud flats
f) Nest site density studies.
g) Banding and tracking of plover chicks, broods and adults to determine movements, habitat use and fledging success.
h) Studies to determine the impact of avian predator management on nest success.
i) Research into tower designs and alterations to reduce predator use of electrical towers.

Monitoring Recommendations

1. Surveys should be conducted in the early morning or late afternoon when lighting is good and it is easier to see plovers. Areas should also be surveyed at high tide when possible to ensure plovers are not foraging on mudflats in the Bay.

2. The nest monitoring program should continue to include egg floating to estimate incubation stage and hatching date.

3. The plover banding program should be re-established to help determine chick survival, fledge rates and movement. Banded chicks should be re-sighted daily to track their movements. A plover program using radio-telemetry would be even more useful in following chick movement, pond use and the survival rate of chicks. Only

by banding plovers can we determine if we are meeting the Recovery goal of 1.0 chicks fledged per male.

4. The most likely plover habitat should be located early in the season. This will be determined by historical use, water levels, and other variables within the ponds. Assuming water levels in 2007 are similar to 2006, A8, B6B, B8, B8A, B12 and B14 should be monitored two to four times a week. These ponds hold the highest levels of plovers in the South Bay. More effort should be put into monitoring A22, R1, and RSF2 if resources are available.

5. More volunteers should be recruited and trained to conduct plover surveys to insure that all potential plover nesting areas are thoroughly surveyed throughout the season.

Management Recommendations

1. Management should give special consideration to snowy plover habitat requirements, including: 1) the availability of drying salt ponds with nearby high salinity foraging habitat, 2) the need to manage several pond complexes in different parts of the South Bay for plovers to reduce predator impacts, 3) vary the location of snowy plover nesting ponds from year to year to reduce predation levels. The restoration project should also include the removal of man made structures that can serve as perches for predators. No new perches should be placed in plover (or other ground nesting bird) habitat.

2. The potential impact of avian predators such as northern harriers, red-tailed hawks and kestrels should continue to be investigated. The growth of the gull colonies needs to be addressed as they expand and affect nesting birds in the area. This is especially important in Alviso where the large gull colony at A6 is adjacent to the plover nesting area at A8, and at the Coyote Hills gull colony that is just south of Eden Landing.

3. The mammalian and avian predator management program in the South Bay should continue. The program should investigate additional methods to reduce common raven and northern harrier predation of plovers, including nest removal and lethal removal of adults when necessary.

4. Vehicle access should be limited on the levee between B8A and B9 during breeding season. This levee serves as a “highway” between foraging areas for broods.

5. Discussions with PG&E regarding tower design modifications should be continued to decrease the use of towers by nesting predators such as ravens and red-tailed hawks. The Refuge should continue to work with PG&E and Wildlife Services to remove raven nests and other stick nests from towers near snowy plover habitat.

6. More resources should be put into law enforcement to maintain regulations and area closures around snowy plover breeding areas to minimize human disturbance. This will become increasingly important as the Salt Pond Restoration Project continues and more areas are open to the public.

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APPENDICES

Appendix 1. Total number of adult snowy plovers per pond and averages for all weeks. Blanks indicate the pond was not surveyed that week.

week number	A22	A8	B10	B11	B12	B14	B16B	B3C	B4C	B6A	B6B	B8	B8A	B8X	B9	IMPOUNDMENT	N1	NEW CHICAGO MARSH	OBN10	OBN13	OBN4	OBN6	OBN7	OBN8	R1	R4	RSF2
9		36																									
12	2												9														
13	9	20	0	0			0					5	15						0	0	0	0	0	0			4
14	10	8							0		1	82	57														
15	2	8							0	4	22	83															
16	2	11							0	3	6	21	19	0													
17	13	18						1	0	9	61	24	88														
18		7	0	0	0	0	1		0	5	38	11	26	0	0		0		0	0	0	0	0	0	4	0	2
19		21							0		50	17	35														
20		13							1		27	37	49														
21	7	8			0	0			1		19	14	24	0	0				0	0	0	0	0	0	0	0	
22			0	0	2	8	0		0	0	56	12					0										3
23									0		1	13			8												
24									0		35								0	0	0	0	0	0			
25	4	11			44	18			3	0	20	32	44		12												
26		14	0	3	17	5	0	0	0										0	0	0	0	0	0			4
27		4			52	6		0	0	8	11	8	12	1	3		0										
28		8			24	19			0		10	3	12		5											5	
29								0	0		6	6	6		4												
30	1		1	0	23	34	0		0		8	4	6												0		
31		10			52	71			0		3	6	0	0	1	3			0	1	2	0	1	3			8
32					20	107			0		6	3	27				1										
33					100	153			0		8	4				3			0	0	0	1	0	0			
34					40	199			0																0		
35	0	6			20	124					1	6	15	0		5	0	1	3								1
Mean	5.00	12.69	0.20	0.60	30.31	57.23	0.20	0.25	0.24	4.14	19.45	19.55	26.12	0.17	4.13	3.67	0.20	1.00	0.38	0.14	0.29	0.14	0.14	0.43	1.00	1.67	3.67

Appendix 2. Total number of snowy plover chicks per pond and averages for all weeks. Blanks indicate the pond was not surveyed that week.

Week number	A22	A8	B12	B14	B6B	B8	B8A	B8X	B9	IMPOUND MENT	N1	RSF2
9		0										
12	0						0					
13	0	0				0	0					0
14	0	0			0	0	0					
15	0	0			0	0						
16	0	0			0	0	0	0				
17	0	0			0	0	0					
18		0	0	0	0	0	0	0	0		0	0
19		0			0	0	0					
20		0			0	0	0					
21	0	0	0	0	0	0	0	0	0			
22			0	0	3	3					0	0
23					0	3			0			
24					3							
25	2	7	0	0	6	13	21		0			
26		10	0	0		0						4
27		5	9	0	1	9	28	0	3		0	
28		6	6	2	5	3	7		7			
29					0	4	0		4			
30	2		13	5	3	1	3					
31		2	20	2	1	4	2	0	0	3		0
32			10	0	3	3	7				2	
33			10	12	5	2				4		
34			16	23								3
35	3	0	3	8	0	1	0	0		2	0	1
36												
Mean	0.70	1.88	6.69	4.00	1.50	2.19	4.00	0.00	1.75	3.00	0.40	1.14

Appendix 3. Nest activity by nest, by week for all nests monitored during 2006.

Area	Pond	Nest #	Week:15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Alviso	A8	A8-1				X															
Alviso	A8	A8-2				X	X	X	X	X											
Alviso	A8	A8-3				X	X	X	X	X											
Alviso	A8	A8-4					X	X	X	X											
Alviso	A8	A8-5				X	X	X	X	X											
Alviso	A8	A8-6				X	X	X	X	X											
Alviso	A8	A8-7			X	X	X	X	X	X											
Alviso	A8	A8-8						X	X	X	X	X	X								
Alviso	A8	A8-9							X												
Alviso	A8	A8-10									X	X	X	X	X	X					
Alviso	A8	A8-11										X									
Eden Landing	B6B	B6B-1			X	X	X	X	X	X											
Eden Landing	B6B	B6B-2			X																
Eden Landing	B6B	B6B-3					X														
Eden Landing	B6B	B6B-4				X	X	X	X	X	X										
Eden Landing	B6B	B6B-5				X															
Eden Landing	B6B	B6B-6				X															
Eden Landing	B6B	B6B-7					X														
Eden Landing	B6B	B6B-8			X	X	X	X	X	X											
Eden Landing	B6B	B6B-9						X													
Eden Landing	B6B	B6B-10				X	X	X	X	X	X	X									
Eden Landing	B6B	B6B-11						X													
Eden Landing	B6B	B6B-12						X													
Eden Landing	B6B	B6B-13					X	X	X	X	X										
Eden Landing	B6B	B6B-14						X	X	X	X	X									
Eden Landing	B6B	B6B-15					X														
Eden Landing	B6B	B6B-16								X											
Eden Landing	B6B	B6B-17						X	X	X	X	X									
Eden Landing	B8	B8-1			X	X	X	X	X	X											
Eden Landing	B8	B8-2			X	X	X	X	X	X											
Eden Landing	B8	B8-3			X	X	X	X	X												
Eden Landing	B8	B8-4			X	X	X	X	X												
Eden Landing	B8	B8-5					X														
Eden Landing	B8	B8-6			X	X	X	X	X												
Eden Landing	B8	B8-7			X	X	X	X	X	X											
Eden Landing	B8	B8-8				X	X	X	X	X	X										
Eden Landing	B8	B8-9	X	X	X	X															
Eden Landing	B8	B8-10				X	X	X	X	X	X										
Eden Landing	B8	B8-11					X														
Eden Landing	B8	B8-12			X	X	X	X	X												
Eden Landing	B8	B8-13					X	X	X	X	X	X									
Eden Landing	B8	B8-14				X	X	X	X	X	X										
Eden Landing	B8	B8-15			X	X	X	X	X												

Appendix 2. Continued.

Area	Pond	Nest #	Week:15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Eden Landing	B8	B8-16						X													
Eden Landing	B8	B8-17				X															
Eden Landing	B8	B8-18				X															
Eden Landing	B8	B8-19				X	X	X	X	X	X										
Eden Landing	B8	B8-20							X	X	X	X	X	X							
Eden Landing	B8	B8-21							X												
Eden Landing	B8	B8-22						X													
Eden Landing	B8	B8-23															X				
Eden Landing	B8A	B8A-1										X									
Eden Landing	B11	B11-1																			
Eden Landing	B12	B12-1									X										
Eden Landing	B12	B12-2										X									
Eden Landing	B12	B12-3											X								
Eden Landing	B12	B12-4									X	X	X	X	X						
Eden Landing	B12	B12-5										X									
Eden Landing	B12	B12-6										X									
Eden Landing	B12	B12-7											X								
Eden Landing	B12	B12-8								X											
Eden Landing	B12	B12-9											X								
Eden Landing	B12	B12-10											X								
Eden Landing	B12	B12-11											X	X	X	X	X				
Eden Landing	B12	B12-12							X	X	X	X	X	X							
Eden Landing	B12	B12-13										X	X	X	X	X	X				
Eden Landing	B12	B12-14													X	X	X	X	X		
Eden Landing	B12	B12-15												X	X	X	X	X	X		
Eden Landing	B12	B12-16													X	X	X	X	X	X	
Eden Landing	B12	B12-17													X	X	X	X	X	X	
Eden Landing	B12	B12-18														X	X	X	X	X	
Eden Landing	B12	B12-19													X	X	X	X	X	X	
Eden Landing	B12	B12-20													X	X	X	X	X	X	
Eden Landing	B12	B12-21													X	X	X	X	X	X	
Eden Landing	B12	B12-22													X	X	X	X	X		
Eden Landing	B14	B14-1											X	X	X	X	X				
Eden Landing	B14	B14-2													X	X	X	X	X		
Eden Landing	B14	B14-3													X	X	X	X	X	X	
Eden Landing	B14	B14-4																		X	X
Eden Landing	B4C	B4C-1							X												