

Western Snowy Plover Population, Nesting Success, and Predator Surveys
in the San Francisco Bay – 2005 Breeding Season



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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) together formed Recovery Unit 3 in the effort to monitor the Pacific Coast western snowy plover (*Charadrius alexandrinus nivosus*) breeding population in the South San Francisco Bay. Monitored areas in the south bay are located on Refuge, CDFG Eden Landing Ecological Reserve (Eden Landing), and HARD lands. We recorded plover numbers, nesting success, site use, and avian predator presence during the 2005 breeding season.

During the 2005 breeding season window survey of the California coast in May (5/22-5/29), we counted 124 adult plovers in the Bay, totaling 7.38% of the overall number of plovers (1680) counted along the entire California coast. This is compared to 4.99% (72/1444) in 2003 and 5.93% (113/1904) in 2004. Unlike last year, plovers were found in Alviso. This year plovers were found in only one pond at Warm Springs, and the number of birds at Eden Landing increased. No plovers were found in Coyote Hills or on the Hayward property.

Over the entire 2005 season, we located a total of 20 nests within the study area. Out of the thirteen nests found on Refuge property, 11 (85%) were successful, and two (15%) were predated. All thirteen Refuge nests were found in pond A22 at Warm Springs. We found seven nests at Eden Landing. Of these, 6 (86%) were successful and one (14%) was abandoned. Overall, we saw an 18% increase in nest numbers on Refuge property in 2005, with two more nests than last year (11). Eden Landing, however, had an 85% decrease in nests from the 48 found in 2004. This reduction in nesting is most likely due to high water levels in the ponds from heavy late spring rains that limited the amount of available nesting habitat. Future water management on the ponds should allow for an increase in nesting plovers.

We found 10 nests belonging to five common avian predator species. Eight of these nests were in very close proximity to, or actually in, plover survey areas. While no direct predation of snowy plovers or nests was observed, these predators were seen foraging and hunting in areas used by nesting plovers.

We continued the existing avian predator monitoring and management program at Eden Landing, targeting common ravens (*Corvus corvax*) and American crows (*Corvus brachyrhynchos*) that nest or forage on the plover nesting ponds. No ravens or raven nests were removed this year, and only one adult crow was removed. This program should be continued in 2006 to allow additional refinement of management methods to better protect plovers and plover nests in the future.

INTRODUCTION AND BACKGROUND

On March 5, 1993 the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*) was classified as a federally threatened species (USFWS 1993). The Pacific Coast population is thought to be genetically distinct from interior-breeding western snowy plovers, and is defined as those plovers that nest along or near tidal waters including those in the South San Francisco Bay's salt ponds (Page and Stenzel 1981). Western snowy plover numbers are in decline due to loss and disturbance of nesting sites, resulting in poor reproductive success. As of 1991, 20 plover breeding areas occurred in coastal California, with 8 of them, including the San Francisco Bay, supporting nearly 80% of the entire population (Page et al. 1991).

The United States Fish and Wildlife Service drafted a recovery plan for the Pacific Coast population of the western snowy plover and created six recovery units (USFWS 2001). Recovery Unit 3 is the San Francisco Bay, including Napa, Alameda, Santa Clara and San Mateo counties. To support USFWS recommended actions for recovery, the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) initiated a snowy plover monitoring program on refuge lands in 1992. Its five goals were to 1) identify areas used by nesting, foraging, and roosting plovers, 2) estimate plover numbers, including number of breeding pairs, 3) evaluate nesting success 4) assess predation pressures on snowy plovers, and 5) protect snowy plover breeding areas from disturbance and predation. The California Department of Fish and Game's Eden Landing Ecological Reserve (CDFG, Eden Landing) and property belonging to the Hayward Area Recreation District/East Bay Regional Parks District (HARD, EBRPD) were heavily used by plovers and therefore added to the Refuge's monitoring program. In 2003, the Refuge and San Francisco Bay Bird Observatory (SFBBO) began to survey suitable snowy plover habitat in south San Francisco Bay in conjunction with the other agencies.

The mammalian predator management program was created in 1993 to control predation of snowy plovers, California clapper rails (*Rallus longirostris obsoletus*), and other ground nesting birds by the non-native red fox (*Vulpes vulpes*), feral cats (*Felis felis*), striped skunks (*Mephitis mephitis*), and raccoons (*Procyon lotor*, Harding et al., 1998). This program is conducted throughout the South Bay on the Refuge, Cargill properties, CDFG, and adjacent private and public lands.

Avian predators of snowy plovers have become a major concern in San Francisco Bay. Common ravens (*Corvus corax*) flourish in urban areas, which have landfills and garbage providing a constant food source (Webb et al. 2004). Raven numbers have increased drastically in the Bay Area and throughout California, partly in response to availability of food resources in these increasingly urbanized areas (Boarman and Heinrich 1999). In fact, ravens have caused high levels of predation on plover nests and chicks in California in recent years. For example, during 1988 and 1989 ravens destroyed between 67-69 percent of the plover clutches at Point Reyes National Seashore (Page 1988, 1990). Ravens are also considered the main predator of snowy plovers in Humboldt County (Colwell et al. 2002).

Northern harriers (*Circus cyaneus*) are another predator of concern. They are the primary predator of snowy plovers at the Salinas River National Wildlife Refuge; in 2005 male harriers were seen hunting along the beach over nesting areas (USFWS 2002, K. May pers. obs.). Other avian predators of concern include the American crow (*Corvus brachyrhynchos*), red-tailed hawk (*Buteo jamaicensis*), peregrine falcon (*Falco peregrinus*), loggerhead shrike (*Lanius ludovicianus*), burrowing owl (*Athene cunicularia*) and California gull (*Larus californicus*).

In 2005 the Refuge, SFBBO, CDFG, HARD, and EBRPD continued monitoring plovers and avian predators to gain a better understanding of plover numbers and predation pressures. This report is a presentation and analysis of data collected during the 2005 snowy plover breeding season, including results from plover population level surveys, nest monitoring, avian predator surveys, and avian and mammalian predator management programs.

STUDY AREAS

The Refuge is located in an urban setting and contains about 30,000 acres of salt ponds (as of 2004), tidal salt marsh, mudflat, upland and vernal pool habitats. For this study the Refuge was divided into six geographical areas: Ravenswood, Alviso, Warm Springs, Mowry, Coyote Hills and Dumbarton (Figure 1). All areas were regularly monitored, with the exception of Mowry and Coyote Hills, as these two areas do not have suitable plover nesting habitat. Refuge focus ponds in 2005 included A22 at Warm Springs and RSF2 at Ravenswood (see Methods).

Eden Landing Ecological Reserve (previously named “Baumberg”) is located about 3 miles (5 km) north of the Refuge boundary, on the east side of the bay. In 2005, all Eden Landing ponds north of the Old Alameda Creek were monitored (Figure 2). Early season surveys focused on ponds B12 and B6B, since these areas were heavily used by plovers in 2004. However, since these two ponds were mostly flooded throughout the season, we soon refocused surveys in areas of heavy plover use, including ponds B8A, B8X, and B9.

Hayward Area Recreation District (HARD) owns land north of Highway 92 that includes Franks Dump West and Oliver Brother’s North ponds OBN1-OBN17 (Figure 1). These areas are recent snowy plover nesting and foraging habitats and are co-managed by East Bay Regional Parks District staff.

In addition, two ponds in the North Bay (7 and 7A) were intermittently monitored during the season (Figure 3). This is the only known nesting area for snowy plovers in the North Bay. The Napa salt ponds in the north bay are owned by primarily by CDFG.

Figure 1: The Don Edwards San Francisco Bay National Wildlife Refuge was divided into six geographical areas: Dumbarton, Warm Springs, Ravenswood, Coyote Hills, Mowry, and Alviso. Eden Landing Ecological Reserve is managed by the California Dept. of Fish and Game. The “Hayward” area is the Hayward Area Parks and Recreation Department lands (co-managed by East Bay Regional Parks District) just to north of Eden Landing.

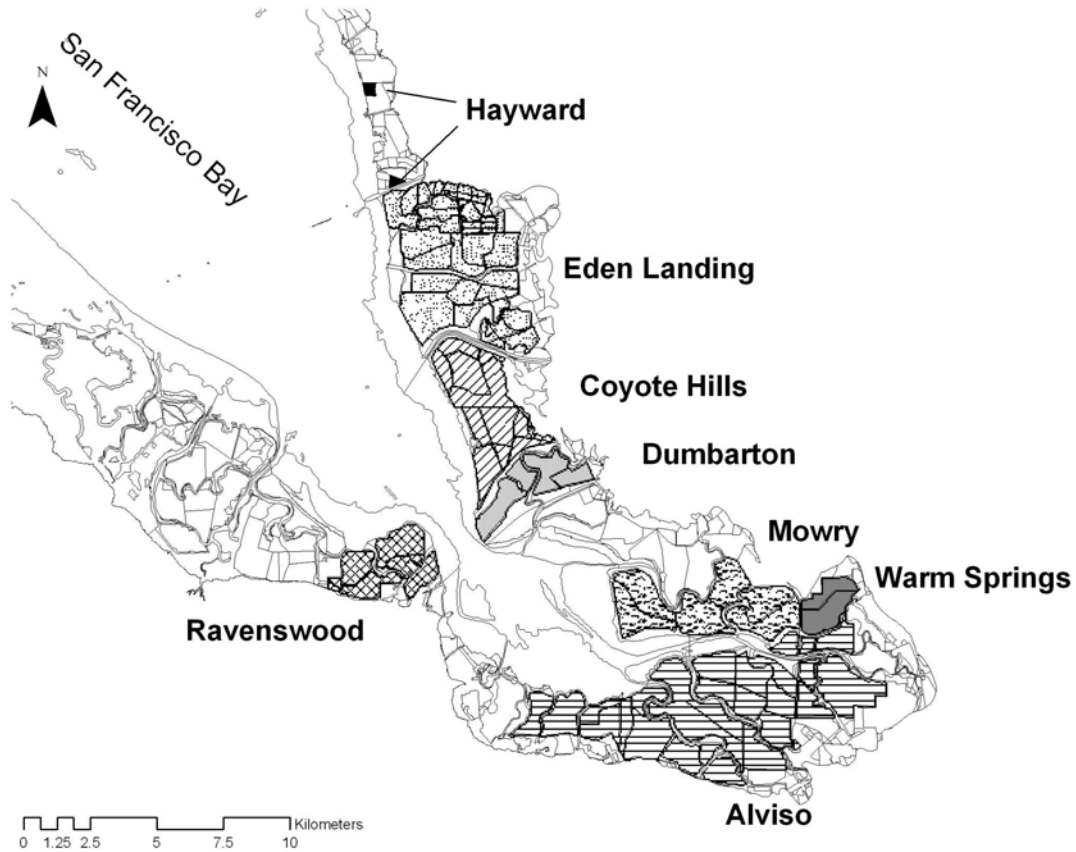


Figure 2: All ponds at Eden Landing are completely closed to the public.

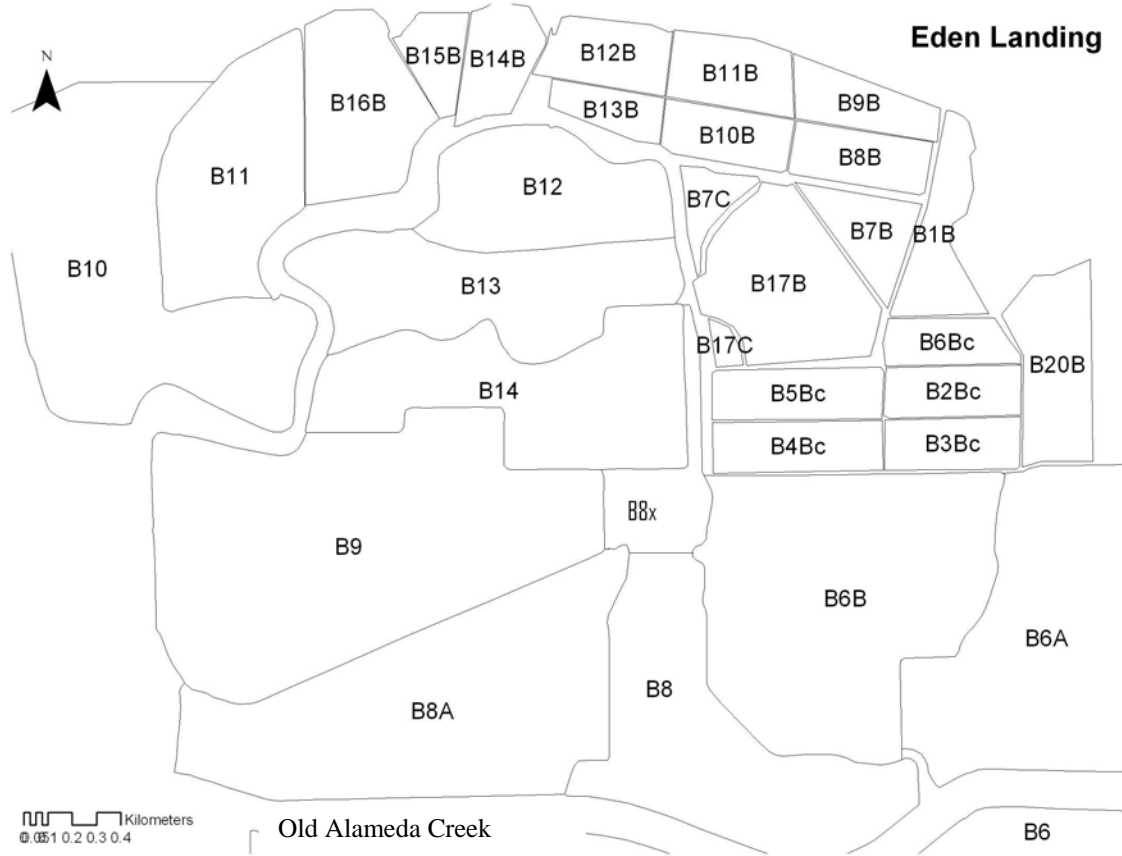
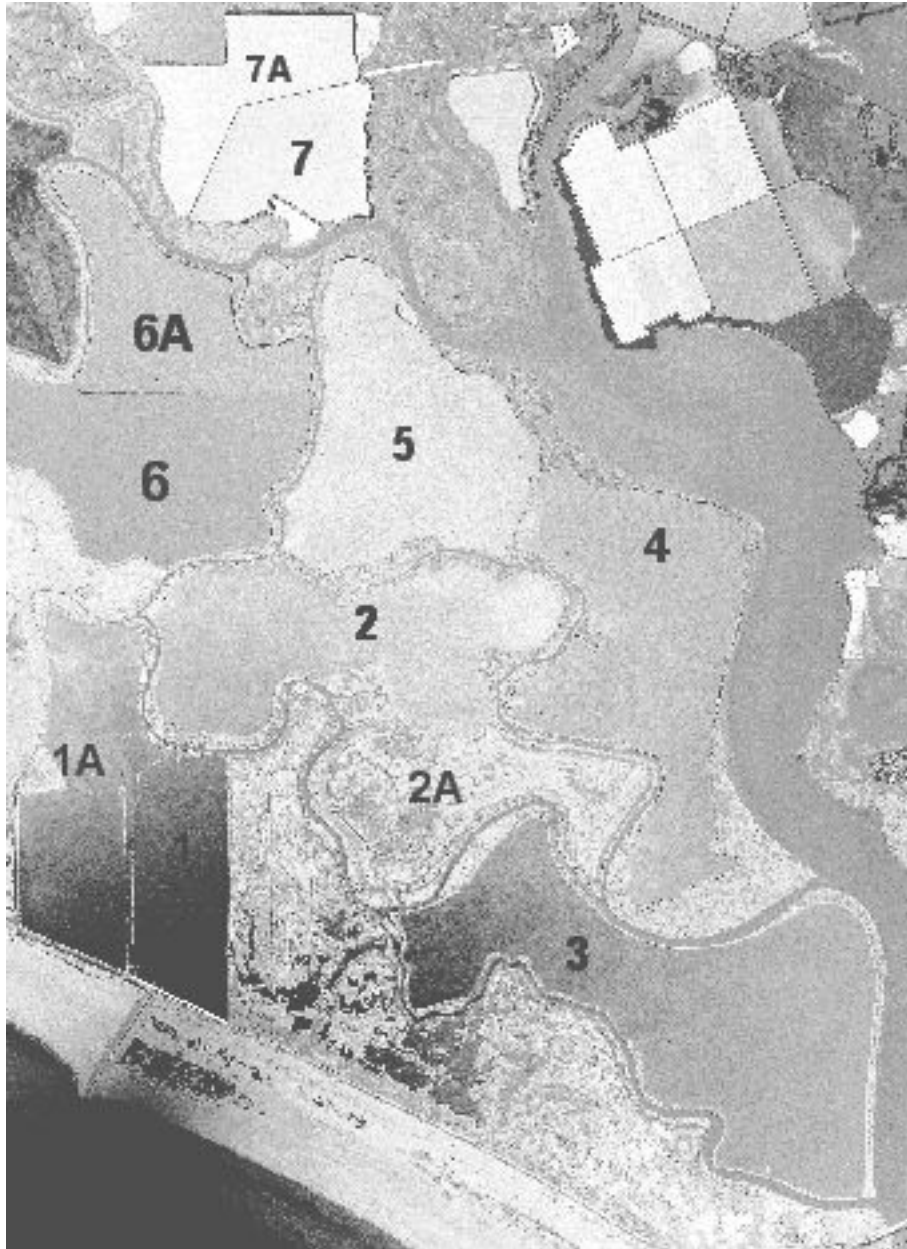


Figure 3: California Department of Fish and Game Ponds 7 and 7A in the North Bay were monitored.



METHODS

Adult and Nest Monitoring

Since most plovers are site-faithful, nesting in the same location each year, we monitored areas where nesting plovers have been previously found (Warriner et al. 1986). Nevertheless, because of the fluctuating water levels in the salt ponds, plovers may relocate to more desirable nesting and foraging sites as they become available during the breeding season. Therefore, we monitored any additional ponds where we found suitable plover nesting habitat. In these areas, primary plover nesting habitat is on the edges and bottoms of dry salt ponds, with secondary nesting areas on levee tops.

Study sites were classified as either monthly ponds or focus ponds. SFBBO volunteers surveyed the monthly ponds once per month to document plover numbers, nests, and avian predators. This allowed us to determine which ponds plovers were using throughout the season. The focus ponds consisted of a portion of the monthly ponds that Refuge and SFBBO biologists and interns monitored weekly. These ponds were selected for focused study due to high plover use and were surveyed biweekly for plovers and nests. All nests found on monthly and focus ponds were visited weekly and followed until nest fate was determined. By monitoring focus ponds weekly, we were better able to understand pond use by plovers and to closely track nests. This year we conducted regular surveys in all areas except for Coyote Hills, which was surveyed once, and in Mowry, which was not surveyed at all. These two areas do not have plover nesting habitat and are not included in this report.

Ponds were monitored by slowly driving roads and levees within the site. In addition, because pedestrians more easily disturb plovers than do vehicles, we conducted walking surveys only where vehicles were not permitted or on levees that were not drivable. For either type of survey, we stopped every few hundred yards (0.3 miles) and scanned for adult and juvenile plovers with binoculars and spotting scopes. When an adult plover was spotted, we watched the bird until it appeared to settle on a nest or until 10-15 minutes passed, when we determined that the plover was not incubating a nest. Volunteers, interns and biologists monitored ponds in this fashion.

If a volunteer saw a nest during a monthly survey or suspected a nest based on adult plover behavior, they would record landmark information, mark the location on a map, and place a flag a distance from the spot they saw (or suspected) the nest. Volunteers did not approach nests. Interns and biologists would later visit the area to monitor and look for nests in areas indicated by volunteers. Interns and biologists conducting focus surveys would immediately approach a nest discovered on the focus ponds.

Reproductive Success

Each week, we visited all accessible active nests and recorded number of eggs and stage of incubation. For each nest followed, we determined nest fate, number of chicks hatched, the estimated or known hatch date, and recorded abandoned or predated eggs. Some nests were observed in areas made inaccessible by intervening deep channels; since we were unable to closely monitor these nests, they were not included in the nest data.

Each nest was assigned a number composed of the pond in which it was found and a sequential number (e.g. B12-1, B12-2). We recorded the exact nest location with a GPS unit (Trimble® Geo XT) and took note of surrounding landmarks. We also recorded the time, location (pond #), number of eggs and/or chicks in the nest, and whether or not an adult was present. In order to determine incubation stage of eggs and to estimate days left until hatching, we floated eggs by placing them one at a time into a cup of room temperature distilled water and measured the maximum diameter of shell exposed above the water. We returned to the nest each week to repeat this process.

We used the estimated hatch date to help determine nest fate. When eggs disappeared from a nest, we would search the nest cup for small shell fragments, which indicated that eggs had hatched. If none were found, we would check for signs of predation by looking for yolk or egg substance, large pieces of eggshell, or major disturbance to the nest cup. If eggs disappeared significantly (>2 weeks) before the estimated hatching date, we recorded that nest as predated even without evidence of predation. If eggs were still present a week after the estimated hatch date and we had not seen an adult on or near the nest for two weeks we considered the nest abandoned.

We recorded nest initiation dates to analyze peak nest initiation time. We estimated that an average 'lifespan' of an active nest is 33 days from initiation to hatch date. If we saw any direct evidence of hatching such as wet chicks or a chick emerging from an egg, we considered that the hatch date. If all three eggs were generally intact but we saw some pipping, we would consider the hatching date to be the next day. If we returned to a nest without chicks or eggs, but it was evident that the eggs had hatched, we used the latest estimated hatching date from the most recent egg float data.

Nest success and hatching success were used to assess reproductive success. Nest success is defined as the percentage of total nests that hatch at least one egg. Hatching success is based on the success of the individual egg and is defined as the percentage of the total number of eggs that hatch.

Avian Predator Surveys

Volunteers, interns, and biologists conducted avian predator surveys in conjunction with plover surveys around monthly and focus ponds. This was done in order to estimate potential predator pressure on plovers, to identify areas most used by avian predators, and to find avian predator nests. We surveyed in a manner similar to plover surveys,

searching ponds, levees, towers and surrounding areas. We drove or walked along levees, stopping to observe every 0.3 miles or whenever we saw a predator. Interns and biologists located predator nests and attempted to follow them to determine their fate. An avian predator was considered as any bird species known to prey on plover nests, chicks, or adults, or that could conceivably prey upon them.

Management Methods

The mammalian predator management program with USDA-Wildlife Services continued this year. Target predators, such as red fox, feral cats, skunks and raccoons were managed on Refuge property and Eden Landing to protect not only the snowy plover but also the California clapper rail and salt marsh harvest mouse (*Reithrodontomys raviventris*). During the snowy plover breeding season, additional predator scouting and management was conducted in snowy plover nesting ponds by USDA personnel.

The avian predator management program, first implemented in 2004, targeted removal of problem ravens and crows and their nests at Eden Landing. Results of avian predator surveys were used to assess predator pressure on plovers and to locate predator nests. Additional scouting was done by Wildlife Services to determine which predator was responsible for documented plover depredation, then management was conducted as necessary.

Certain areas on the Refuge are closed to minimize human disturbance in plover nesting areas. Warm Springs was partially open to pedestrians and cyclists—the levee was blocked off from A22 section 3 and beyond (Figure 4). Ravenswood levees are closed to vehicles (Figure 5). Ponds A5-A8 in Alviso are completely closed to the public (Figure 6). Marshlands Road at the Refuge Headquarters is closed to motor vehicles from April 1 to August 31 to protect plovers nesting on salt ponds adjacent to the road.

Eden Landing is completely closed to the public (Figure 2). However levees in this area were heavily traveled this year by researchers, CDFG officials, and construction workers conducting habitat restoration.

Figure 4: Levees at Pond A22 in Warm Springs are closed to the public south of the Refuge gate located at the corner of the pond where Sections A22/2 and A22/3 intersect.

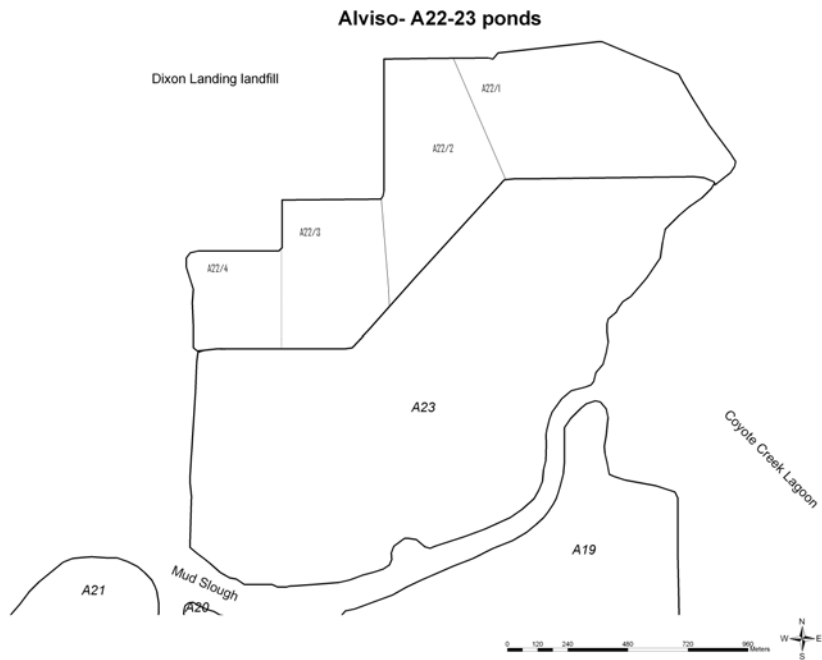


Figure 5: Levees at R1, R2, and RSF2 at Ravenswood are closed to vehicles but open to the public for walking. R3 and R4 are completely closed to the public.

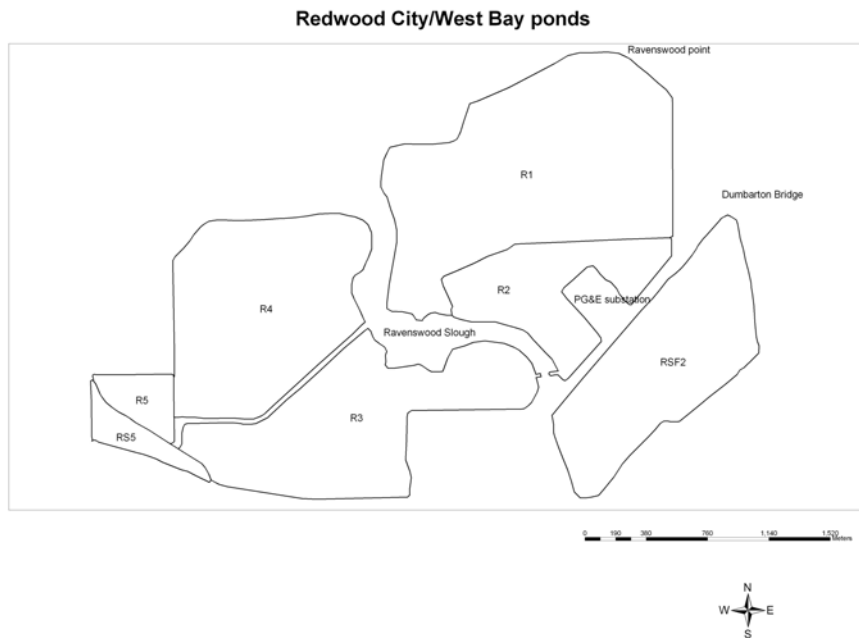
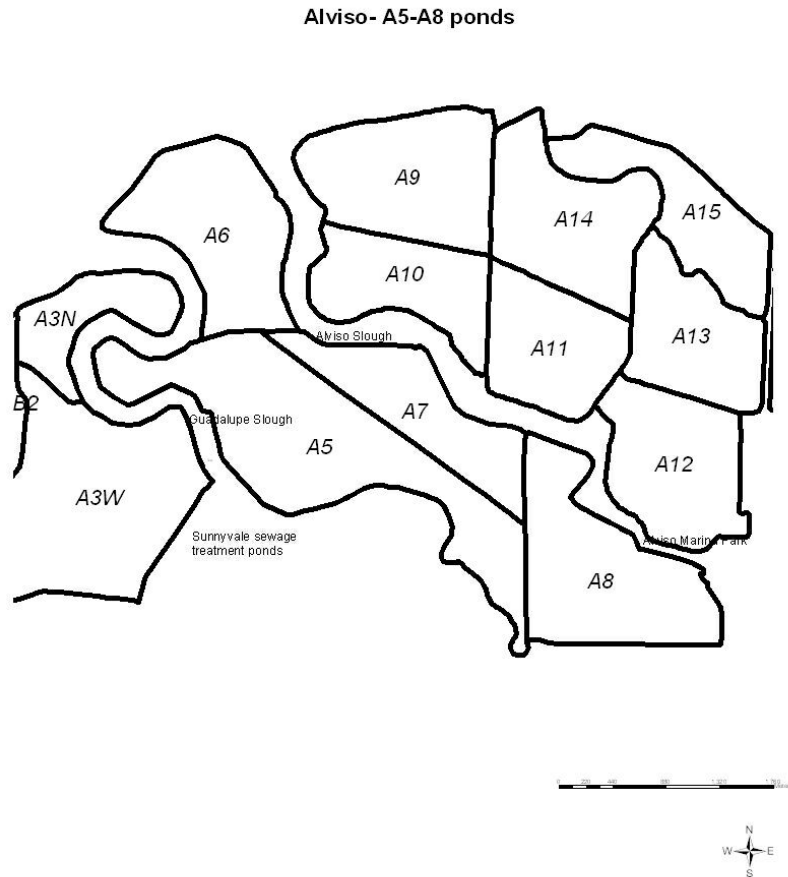


Figure 6: Ponds A5 to A8 in Alviso were surveyed (center of picture). These ponds are entirely closed to the public.



RESULTS

Plover Numbers

During the 2005 breeding season window survey of the California Coast in May (5/22-5/29), we counted 124 plovers in San Francisco Bay. This was about 7% of the total number of plovers (1680) counted along the California Coast.

During weekly surveys, the total number of individual plovers seen in all South Bay areas surveyed was between 78 and 109, using the totals from the two most comprehensive survey weeks, week eleven and week fifteen (Table 1, Figure 7). While weekly plover numbers varied by area and pond, Eden Landing consistently had the highest numbers of

plovers throughout the season, found mostly on pond B8A (Figure 7). High numbers of adult plovers on Refuge property were seen in pond A22 at Warm Springs. Ponds used mainly in the early and late parts of the season were RSF2, A8, B8X, and B9. The timing of use and the low numbers of plover nests found in these ponds suggests that they may not have provided high quality breeding habitat in 2005 (Figure 7). Instead, these ponds were mainly used as foraging areas for migrating plovers and plover broods hatched in nearby ponds. These ponds contained all known nests in the study area.

The most important nesting ponds in 2005 were B12 and A22. High water levels persisted in B6B throughout the 2005 season, providing only limited nesting areas compared to past years. Although only one plover nest was found on B6B this year, more plovers nested may have than were detected because several surveys recorded broods of chicks using the pond.

Chicks were generally seen on the same ponds as plover adults. The pond with the highest number of chicks was B8A. The maximum number of chicks counted during one week in all areas combined was 41.

Table 1: Total number of male, female, and unknown adult plovers counted in each pond/week. Blanks indicate they area was not surveyed. Ponds with no plovers seen the entire season were not included. Week one begins on 3/13 and week 25 beings on 8/28. See tables 2 and 3 for locations of ponds.

Week	A8	A22	B10	B11	B12	B14	B16	B6B	B8	B8A	B8X	B9	PP1	RSF2	7/7A	OBN 4/5	OBN 4/6	Total
wk1						0		0	0					0				0
wk2	20	8				0		0	0	0		2						30
wk3													0	12				12
wk4																0	0	0
wk5	22														3			25
wk6					9	0				0	0	0		1	10	0	1	21
wk7					0	11		11	0	0	14	0		14				50
wk8	8	28	3	0		13	1		4		0		0			1	1	59
wk9		29						7	4		8					0	0	48
wk10		26			22				4									52
wk11	7	22	0	0	55	14	1	0			10	0	0					109
wk12		21			24	3				29	3	1				0	0	81
wk13		12			12	5				52	0	0				0	0	81
wk14		4			2	2		3	1	45	1	8			0			66
wk15	6	5	0	2	12	0	0			44	0	1	3	5		0	0	78
wk16		3			0	3			29	38	7	0		9				89
wk17		7			0	1		3	23	38	7	8						87
wk18		4			0	0				22	55	6				0	0	87
wk19		2																2
wk20	1	6						3	7	34		48		4				103
wk21																0	0	0
wk22																		0
wk23																0	0	0
wk24	24							0		22				6				52
wk25																0	0	0
Mean	12.57	12.64	1.00	0.67	12.36	4.00	0.67	3.00	7.20	27.00	8.75	6.17	0.75	6.38	4.33	0.09	0.18	

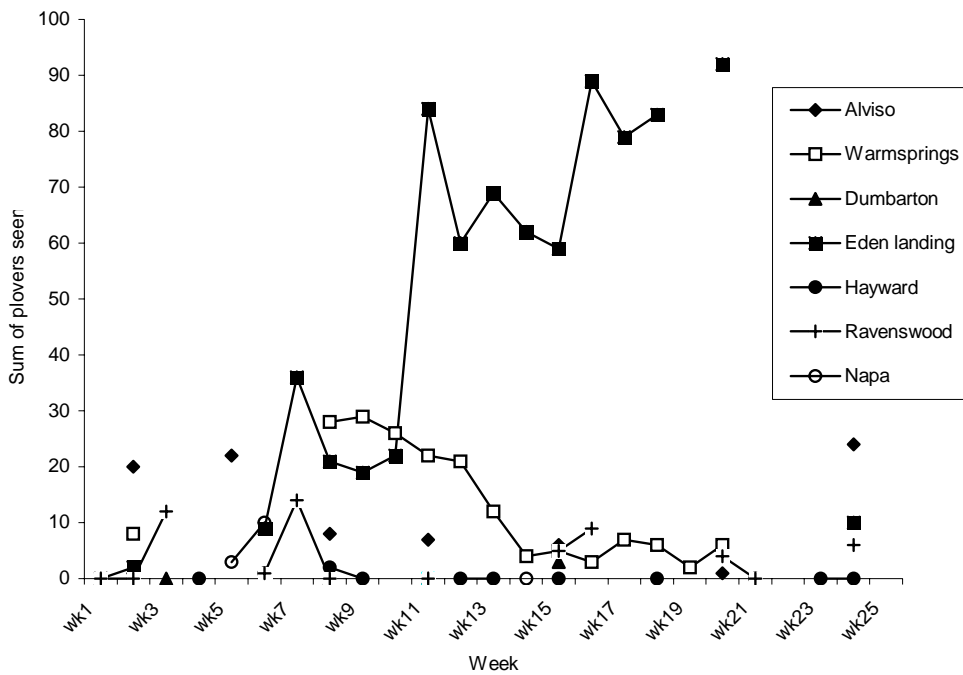
Table 2: Locations and ponds surveyed within the Refuge.

Location	Ponds
Alviso	A5,A6,A7,A8
Dumbarton	N1,N2,N3,P1
Ravenswood	R1,R2,RSF2,R3,R4
Warm Springs	A22,A23

Table 3: Ponds surveyed within the Eden Landing Ecological Reserve.

Location	Ponds
Eden Landing Ecological Reserve	B6A, B6B, B8, B8A, B8X, B9, B10, B11, B12, B14, B15, B16

Figure 7: Sum of snowy plover adults by week and area.



Refuge

Fifteen ponds were surveyed monthly on Refuge lands (Table 2). There was a mean of 4.25 adults seen per survey during the 2005 breeding season on all Refuge property combined during 37 surveys conducted at the four primary survey areas (Alviso, Dumbarton, Ravenswood, and Warm Springs, Table 4). Pond RSF2 at Ravenswood had an average of 6.38 adults per survey. No plovers were seen anywhere else in

Ravenswood. An average of 12.64 adult plovers, the highest average in the Refuge, were seen at Warm Springs on A22. Alviso recorded a high number of plovers per survey in the beginning and end of the season, and had a mean of 12.57 adult plovers per survey. Plovers were found only in pond A8 in the Alviso area. The Dumbarton area recorded 0.75 adults per survey. Warm Springs had the highest mean number of chicks (5.07), followed by Alviso (1.86) then Ravenswood (1.33). No plover chicks were seen in the Dumbarton area (Table 4).

Eden Landing

Twelve ponds were surveyed in Eden Landing with plovers observed in all but ponds B15 and B16 (Table 3). Overall, Eden Landing had the highest mean of all areas surveyed, with 46.82 adults and 6.88 chicks per survey. Not every pond was surveyed during each survey effort, so averages for each pond may be based on data from different numbers of surveys. Pond B8A had the highest number of plovers within Eden Landing, with an average of 28.00 adults seen each time it was surveyed. Pond B12, the Eden Landing pond with the highest number of plover nests, had an average of 12.36 adult plovers seen each survey. Pond B8X was the third most used pond, with an average of 8.8 adults sighted each survey. The highest average number of chicks (6.75) was seen in B8A, despite having only one active nest recorded there (Table 4).

The three ponds with the maximum numbers of plovers recorded during one complete survey were B12 (early in the season), B8A (midseason), and B8X (toward the end of the season). Plovers appeared to favor pond B12 earlier in the season when it was mostly flooded, but with some available dry nesting habitat along the edges of the pond. During the middle of the season, plover activity increased on pond B8A. Later in the season, a large number of plovers used B8X, which had dried considerably since the beginning of the season. In general, plovers used tracked water levels in the ponds through the season, nesting on ponds with a mosaic of dry and wet areas and foraging in shallowly flooded ponds (Figure 8).

Hayward Shoreline

Three adult plovers were seen in the Hayward area early in the season, with one juvenile reported later on. All four plovers were seen on levees. Because of high water levels, plovers did not use this area for nesting in 2005 (Table 4).

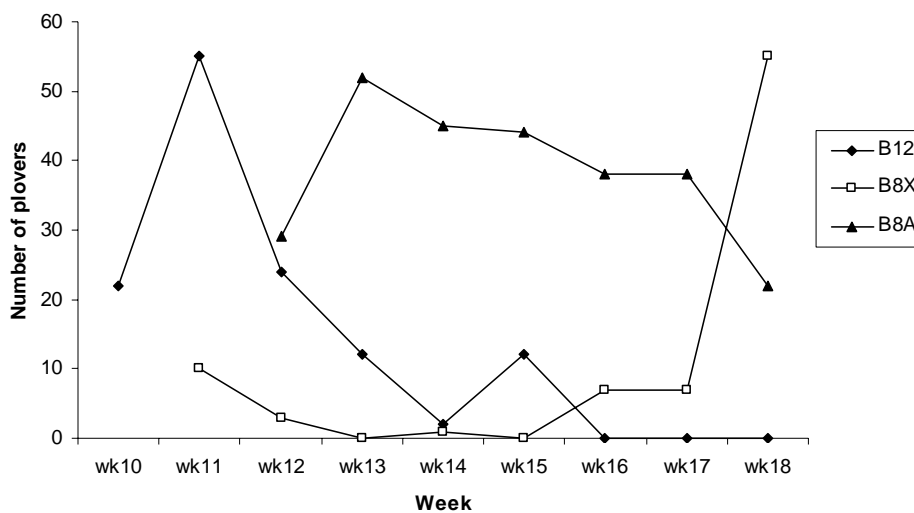
Napa

Napa was surveyed three times this season. The maximum number of plovers seen on one survey was 10; no chicks were seen (Table 4).

Table 4: Summary statistics of plover numbers by area.

Location	Stat	Males	Females	Unknown Adults	All Adults	Juveniles	Chicks	Juveniles plus Chicks
Alviso	Mean (N=7)	4.29	2.57	5.71	12.57	0.00	1.86	1.86
Dumbarton	Mean (N=4)	0.50	0.25	0.00	0.75	0.00	0.00	0.00
Eden Landing	Mean (N=17)	3.82	4.47	38.53	46.82	0.35	6.88	7.24
Hayward	Mean (N=11)	0.00	0.27	0.00	0.27	0.09	0.00	0.09
Napa	Mean (N=3)	2.00	2.33	0.00	4.33	0.00	0.00	0.00
Ravenswood	Mean (N=12)	1.50	1.67	1.08	4.25	0.17	1.33	1.50
Warm Springs	Mean (N=14)	4.79	3.07	4.79	12.64	0.00	5.07	5.07
Alviso	Std. Error	1.34	1.63	3.25	3.46	0.00	1.42	1.42
Dumbarton	Std. Error	0.50	0.25	0.00	0.75	0.00	0.00	0.00
Eden Landing	Std. Error	0.90	0.75	8.12	8.08	0.30	1.81	1.77
Hayward	Std. Error	0.00	0.19	0.00	0.19	0.09	0.00	0.09
Napa	Std. Error	1.53	1.45	0.00	2.96	0.00	0.00	0.00
Ravenswood	Std. Error	0.57	0.75	0.43	1.46	0.17	0.71	0.70
Warm Springs	Std. Error	1.63	0.93	1.15	2.72	0.00	1.00	1.00
Alviso	Sum	30	18	40	88	0.00	13.00	13.00
Dumbarton	Sum	2	1	0	3	0.00	0.00	0.00
Eden Landing	Sum	65	76	655	796	6.00	117.00	123.00
Hayward	Sum	0	3	0	3	1.00	0.00	1.00
Napa	Sum	6	7	0	13	0.00	0.00	0.00
Ravenswood	Sum	18	20	13	51	2.00	16.00	18.00
Warm Springs	Sum	67	43	67	177	0.00	71.00	71.00

Figure 8: Pond use by plovers for weeks 10 through 18. Pond usage correlated with the drying of ponds. Plovers left ponds after they became very dry.



Reproductive Success

Refuge

This year we found 13 nests on the Refuge, all in pond A22 at Warm Springs: eleven (85%) were successful, and two (15%) were predated (Table 5). Within pond A22, 33 out of 39 eggs hatched (85%, Table 6). Several chicks were also seen at RSF2 in Ravenswood and A8 in Alviso, however there were no nests seen in the areas. A22 in Warm Springs had an increase in nesting activity from the previous year. Nest initiation was at its highest between weeks 6 and 9 (Figures 9, 10).

Eden Landing

We found seven nests at Eden Landing; six nests in pond B12 and one in B8A. Out of these nests, six (86%) were successful and one (14%) was abandoned. One possible nest was sighted in pond B9, however water levels were raised before we were able to confirm this. The one abandoned nest was caused by researcher error (Table 5).

Of the 21 eggs found at Eden Landing, 18 hatched (86%, Table 6).

Nest initiation at Eden Landing peaked between weeks five and eight (between April 10 and May 7), with an estimated one nest initiated per week (Figure 10).

Table 5: Nest fates in the South Bay. (Note: This table shows one more nest in B12 than is shown in Table 6. This nest was monitored but could not be accessed, and we were unable to determine the number of eggs in the nest. Nonetheless, it was considered a successful nest because chicks were later seen in this area.)

Location	Hatched	Predated	Abandoned	Total nests
Warm Springs				
A22	11	2	0	13
Eden Landing				
B12	5	0	1	6
B8A	1	0	0	1
Total South Bay	17	2	1	20

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				
B12	18	15	83%	5
B8A	3	3	100%	1
Warm Springs				
A22	39	33	85%	13
Total South Bay	60	51	85%	19

Figure 9: Number of initiated nests, active nests, and chicks for weeks 5 through 25.

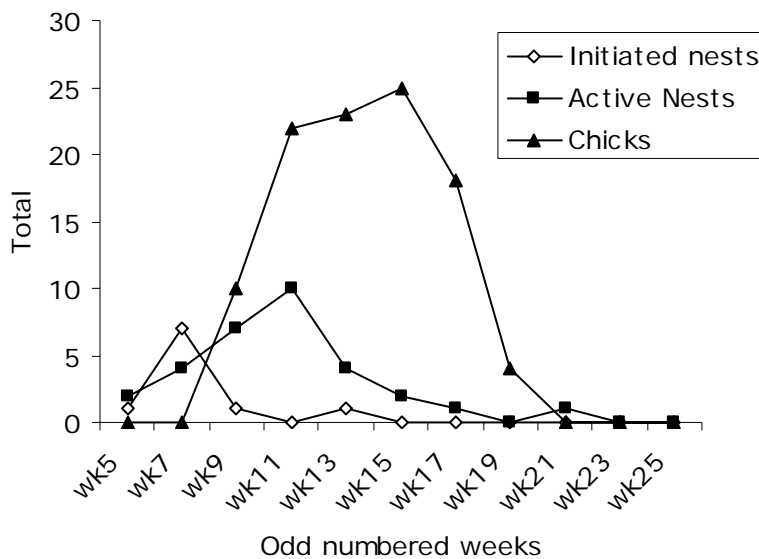
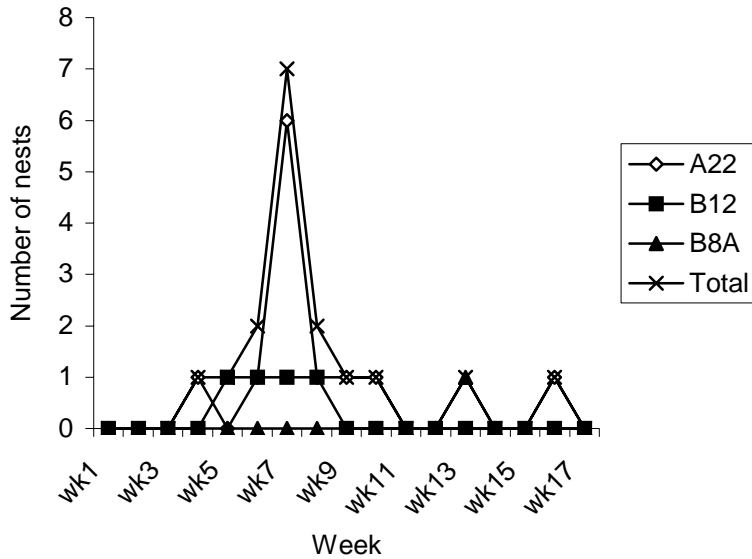


Figure 10: Number of monitoring nests initiated per week. Nest B8A-1 was initiated on week 16 and is not shown here.



South Bay, Overall

We found 20 nests in the entire study area in 2005. There were only two known incidents of nest predation this year, both at Warm Springs. Evidence at one nest included dried yolk, no sign of eggshell, and a dug up nest cup. In the other nest, the eggs disappeared much earlier than the estimated hatching date, and there was no trace of eggshell. Fifty-one chicks hatched from known nests, but we have no information on chick survival.

Mayfield Estimates

We observed a total of 324 nest days, from the finding to the day of hatching for each nest fund. Three nests were lost (two depredated, one abandoned), therefore the mortality rate is: 3/324, or 0.009 per nest day. Survival is calculated as 1- 0.009, or 0.991/nest day. The probability that a nest will survive during the 33 day incubation period is $0.991^{33} = 0.742$.

Nest Density and Breeding Chronology

Since the construction, incubation, and hatching of a nest takes approximately thirty-three days, we calculated the approximate nest initiation date by subtracting 33 days from the nest fate date. We determined week seven to be the peak in nest initiation, with an estimated seven nests initiated that week. Weeks 9 through 12 had the highest number of active nests, peaking at 13 known active nests during week 10 (Figure 9, Table 7).

We determined nest density by dividing the number of nests in a certain pond by that pond's total number of acres. Pond B12 at Eden Landing had a nest density of 0.06 nests per acre. Pond B8A had a nest density of 0.004, although the actual nest density may have been slightly higher. The large number of chicks found on B8A suggests that we may not have detected all nests on that pond. Pond A22 at Warm Springs had approximately 0.05 nests per acre.

Figure 11: Nest fates in the South Bay in 2004 and 2005 in all areas.

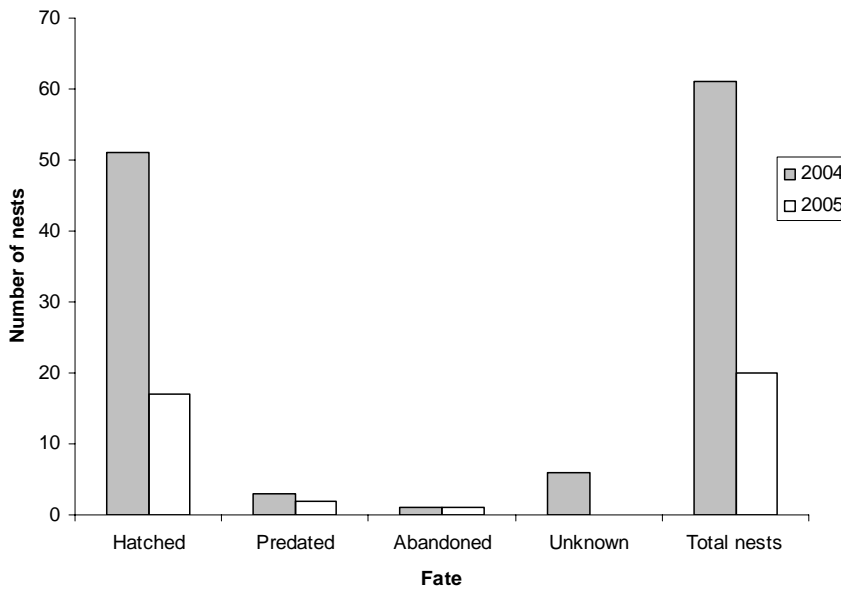


Table 7: All known nests for 2005; X indicates that the nest was active during that week.

Area	Pond	Nest#	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Wk13	Wk14	Wk15	Wk16	Wk17	Wk18	Wk19	Wk20	Wk21
Warm Springs	A22	A22-2	x	x	x														
Warm Springs	A22	A22-1	x	x	x	x	x												
Warm Springs	A22	A22-3			x	x	x	x											
Warm Springs	A22	A22-5				x	x	x	x	x									
Warm Springs	A22	A22-4				x	x	x	x	x									
Warm Springs	A22	A22-6					x	x	x	x	x								
Warm Springs	A22	A22-7						x	x	x									
Warm Springs	A22	A22-9						x	x	x									
Warm Springs	A22	A22-10							x	x									
Warm Springs	A22	A22-12									x	x							
Warm Springs	A22	A22-11									x	x	x	x					
Warm Springs	A22	A22-13										x	x						
Warm Springs	A22	A22-14																	x
Eden Landing	B12	B12-1		x	x	x	x	x											
Eden Landing	B12	B12-2					x	x											
Eden Landing	B12	B12-3						x	x	x									
Eden Landing	B12	B12-5						x	x	x									
Eden Landing	B12	B12-6						x	x	x									
Eden Landing	B12	B12-4						x	x	x	x								
Eden Landing	B8A	B8A-1													x	x			

Avian Predators

Refuge

In Alviso, the most commonly sighted avian predators were California gulls, great egrets (*Ardea alba*), snowy egrets (*Egretta thula*) and black-crowned night herons (*Nycticorax nycticorax*). Thousands of California gulls were consistently sighted in pond A6, where they breed during the summer. Egrets and herons were spotted sometimes in the hundreds, and mainly in ponds A7 and A5 (Table 8).

At Ravenswood, two red-tailed hawks and two northern harriers were reported (Table 8).

At Warm Springs the most commonly seen avian predators were gulls (*Larus* spp.), common ravens, American kestrels (*Falco sparverius*), and burrowing owls. Very early in the season hundreds to thousands of gulls were regularly seen roosting in A22, however as the season progressed these roosting areas were abandoned. There was a common raven nest in a PG&E tower along the northern shore of A22. It fledged four young, and later in the season the family of six was often seen with a group of up to 20 more ravens foraging in A22. One red-tailed hawk nest was observed in a PG&E tower on the vernal pool area of Warm Springs, but the fate was undetermined. One pair of American kestrels were repeatedly seen, but it is unknown if they nested (Table 8).

Two red-tailed hawks and three northern harriers were seen at Dumbarton, and one red-tailed hawk and three northern harriers were seen at Napa. Gulls were seen at both areas in the hundreds (Table 8). No avian predator control was conducted on Refuge lands.

Eden Landing

At Eden Landing the most frequently sighted avian predators were gulls, great blue herons (*Ardea herodias*), great egrets, snowy egrets, and northern harriers. Northern harriers were mainly seen hunting along the length of Old Alameda Creek. Except in the very beginning and end of the snowy plover breeding season, gulls were not seen roosting in any of the ponds (Table 8).

There were several avian predator nests in Eden Landing. One red-tailed hawk nest located in a PG&E tower along the northern shore of pond B6B fledged one chick. The young red-tailed hawk was frequently seen hunting in Eden Landing after fledging. Great blue herons once again nested on the old duck hunting cabin in pond B6B. At mid-season, there were 6 nests, all with chicks, and 16 adults were recorded. There were two stick nests belonging to either common ravens or red-tailed hawks in PG&E towers near the San Mateo toll plaza, but it was not determined whether or not they were active nests this year.

No raven nests were removed from the Eden Landing area, since the nests weren't near nesting plovers. One adult American crow was removed from Eden Landing.

Hayward Shoreline

Gulls were the only predators seen in significant numbers at the Hayward Shoreline (Table 8).

Table 8: Mean numbers of predators per survey in each of the areas.

Predators of Concern	Species	Alviso	Dumbarton	Eden Landing	Hayward	Napa	Ravenswood	Warm Springs
Predators of Concern	Common Raven	11.00	0.25	0.29	1.00	0.50	0.00	3.67
	Northern Harrier	5.17	0.75	1.53	0.00	2.00	0.29	0.27
	Red-tailed Hawk	2.00	0.50	0.76	0.40	0.50	0.29	0.73
	Peregrine Falcon	2.17	0.00	0.24	0.10	0.00	0.00	0.07
	White-tailed Kite	0.50	0.25	0.06	0.00	0.00	0.14	0.00
	American Kestrel	0.33	0.00	0.12	0.00	0.00	0.00	0.87
Other Predators	Black-crowned night heron	20.00	0.75	1.18	0.00	2.50	0.00	0.60
	California Gull	11699.83	176.75	4.17	0.80	0.50	0.00	107.73
	Great blue heron	13.00	0.50	2.41	0.30	0.00	0.00	0.13
	Great Egret	137.50	1.25	2.29	0.50	0.00	0.29	0.47
	Other Gull	8.33	29.50	11.65	107.60	0.00	0.00	26.53
	Loggerhead Shrike	0.33	0.00	0.00	0.00	0.00	0.00	0.53
	Snowy Egret	123.00	2.00	4.24	0.00	0.00	0.14	0.67
	Golden Eagle	0.00	0.00	0.06	0.00	0.00	0.00	0.13
	American Crow	0.00	0.50	0.00	0.70	0.00	0.00	0.20
	Burrowing Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Osprey	0.00	0.00	0.00	0.00	0.00	0.14	0.47
	Ferruginous Hawk	0.00	0.00	0.00	0.00	0.00	0.00	0.07
	Red-shouldered hawk	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Number of Surveys		6	4	17	10	2	7	15

Direct Avian Predation

No predation of snowy plovers was directly observed in 2005.

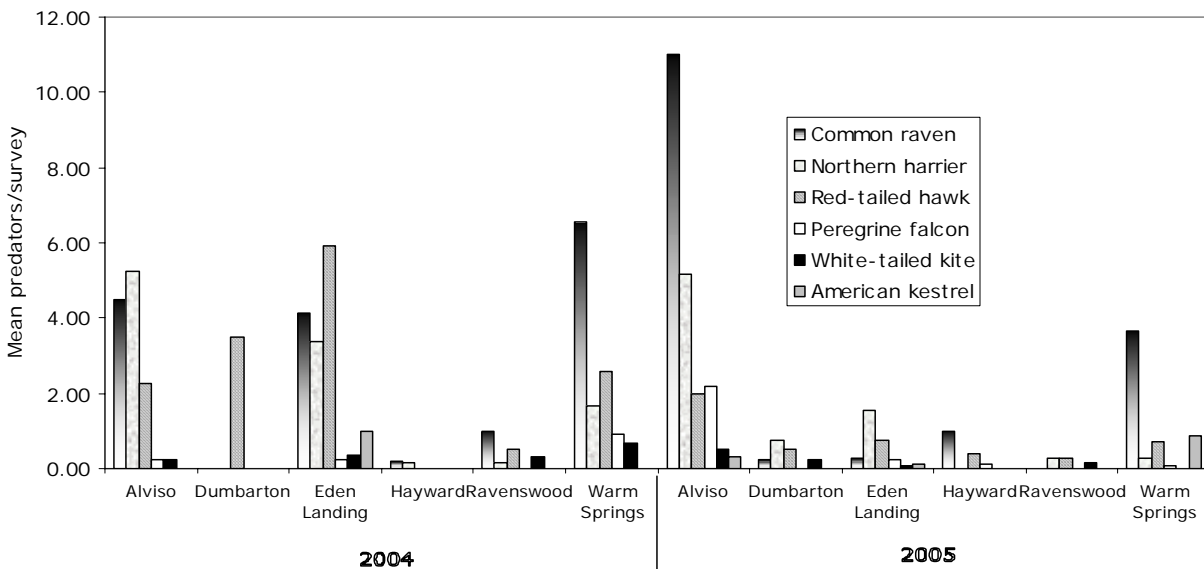
Mammalian Predators

One grey fox (*Urocyon cinereoargenteus*) with four kits was sighted hiding in the broken cement along the eastern levee of B6A in Eden Landing. One feral cat and three kittens were sighted along the same levee. Several cats were seen entering and exiting Eden Landing through the Veasy Street entrance, north and east of B6A. These same cats were seen on porches of the neighborhood houses, suggesting that they are either feral and being fed by the residents or are outdoor pets. Other mammals observed were striped skunks and California ground squirrels (*Spermophilus beecheyi*). Animal Services removed five striped skunks, and four cats (including the three kittens) from Eden Landing during the plover breeding season. In addition two Virginia opossums (*Didelphis virginiana*) and five grey foxes were caught and subsequently released since they are not target animals.

At Warm Springs a family of skunks was seen entering a burrow on the levee between A22 and A23. Seven striped skunks and three feral cats were caught and removed, and one Virginia opossum was caught and released.

Feral cats were also seen in the Alviso ponds, but none were removed during the breeding season.

Figure 12: Mean numbers of predators of concern per survey in 2004 and 2005



DISCUSSION

Plover Numbers

Since most adult plovers weren't banded and single surveys of an area could take several days to complete, it is difficult to accurately estimate breeding snowy plover numbers within the study area. Compared to 2004, higher mean numbers of adult plovers counted per survey were found in the Eden Landing areas. All other areas saw a decline in plovers, Dumbarton and Ravenswood saw more dramatic declines (from 9 to 0.75 adults and from 14.42 to 4.25 adults, respectively). Although all areas with plover habitat were surveyed, survey coverage was not equal.

Reproductive Success

The total number of nests found during 2005 in the South San Francisco Bay was 20. This is a 74% decrease from 78 nests in 2001 and a 66% decrease from 59 nests in 2004. Although the total number of plover nests in the South Bay declined, the number of nests on Refuge land increased slightly. Eleven nests were found on Refuge property in 2004, and 13 in 2005. There were 7 nests in Eden Landing this year, down from 59 in 2001 and 48 in 2004. Low nest numbers in 2005 are most likely due to high pond water levels at the Eden Landing Ecological Reserve.

Plovers have once again nested in fewer areas on the Refuge than in the early 1990's, when plovers were first monitored. In the past five years, plovers have nested on Ravenswood ponds, Warm Springs ponds, some Dumbarton and Coyote Hills ponds, and A8 in Alviso. In 2004, plovers nested on RSF2 in Ravenswood and A22 in Warm Springs; this year nests were only found at A22. Nonetheless, a small number of chicks were also seen both at A8 and at RSF2, indicating that both areas were used by a small number of nesting plovers with undetected nests.

Plovers also nested in fewer ponds at Eden Landing than in 2004, with nesting confirmed in only two ponds, B12 and B8A. In addition, there may have been some nesting on B6B, but no nests were confirmed on that pond. Chicks were also seen foraging in ponds B9 and B8X, but since those ponds did not have much suitable nesting habitat it is believed that chicks were led there to forage by adult plovers.

In 2005, we saw a slight increase in overall nest success, with a rate of 85% for the South Bay. This is a slight increase from 2004. Although nest success remains quite high, total nest numbers have fallen sharply in the South Bay for the past several years. Much of this decrease may be attributed to high pond water levels, but it is very possible that this decline may be partly a result of avian predator presence in and around prime nesting habitat. While nest (egg) predation levels remain low, chick and adult predation have been documented and may be affecting plover use of certain ponds. Since we do not band chicks or adults, we are not able to quantify fledging success or assess the level of predation on adult plovers.

Primary nesting ponds within the Eden Landing area change from year to year, with availability of suitable nesting habitat in each pond dependant upon the extent of spring rain and other factors. For instance, nesting in Eden Landing was consistently high on B16B from 1989 through 2000, but plovers have not recently nested in that pond due to high spring water levels, increased vegetation, and increased presence of common ravens. (J. Albertson, pers. obs.). Pond B6A has also been used for nesting, however parts of this pond have become heavily vegetated and no plovers were seen there during the entire 2005 season. Also, although B6B was the primary plover nesting pond in Eden Landing in 2004, high water levels and strong winds during the 2005 breeding season kept most of the pond flooded and the limited amount of exposed pond substrate very wet and mostly unsuitable for nesting.

In 2005, B12 contained the majority of nests within Eden Landing (Table 5). All of these nests were found in the “Old Oliver” site of the pond, which contains the remnants of an old salt works building, including bricks, broken glass, and wood pilings. All of the plover nests found in this area used some sort of man made object either as a nest cup, nest lining, or to form a “wall” of the scrape. As this pond dried through the season, however, plover use quickly dropped off, coinciding with a sudden rise in plover adult and chick use of B8A, which was beginning to dry. Much of the plover use in B8A can likely be attributed to these B12 adults and broods that moved into B8A looking for better foraging habitat. There was only one documented nest in B8A. Once this nest hatched, CDFG raised water levels approximately 5 inches in B8A as part of an overall water management regime for the Eden Landing ponds. This water level increase in B8A was followed by a decrease in plover use on that pond and an increase on plover use of B8X (Figure 8).

Another heavily used pond in 2005 was A22 at Warm Springs (Figure 3). A22 is divided into four sections: A22/1, A22/2, A22/3 and A22/4. In the beginning of the season, A22/1 and a small portion of A22/2 contained most of the dry nesting substrate in the pond and supported most plovers and nests. As A22/1 became drier, plovers began nesting in A22/2 and A22/3. Finally, in the last few weeks of the breeding season, plovers were observed only in A22/4, around the last remaining area of water in A22.

Breeding season generally begins mid-March and extends through mid-September, with nest initiation and egg laying ending in mid-July (Wilson, 1980; Warriner et al. 1986). The 2005 breeding season started later than usual, with the first known nest initiated in week 4 (April 3-9), and the last known nest hatching the first of August. This year had unusually late rains that continued into June, causing pond water levels to remain high through the spring. These conditions caused a delay to the start of the breeding season (Figures 9, 10) and likely caused fewer plovers to nest in San Francisco Bay ponds in 2005.

Restoration and Snowy Plover Nesting Success

Since the majority of snowy plover nesting and foraging habitat is located in project areas of the South Bay Salt Pond Restoration Project (www.southbayrestoration.org), with the main focus of tidal marsh restoration, special efforts should be made to retain sufficient habitat for snowy plovers in the future. Salt ponds with a mosaic of dry nesting areas and flooded high salinity foraging areas are crucial to support nesting adult plovers and their broods. In addition, managed plover habitats should be spread out in different parts of the bay, and varied from year to year, in order to reduce predation levels.

Avian Predators

For the second year in a row, sightings of common ravens increased significantly in Alviso, but fell at Eden Landing and Warm Springs. Northern harrier detections decreased at Alviso, Eden Landing, Hayward, and Warm Springs. There was also a slight increase in sightings of American kestrels at Warm Springs, which were documented attacking snowy plovers in 2004 (Figure 12).

Common ravens were again the primary avian predator of concern in 2005 and successfully nested in A22 at Warm Springs, a favored plover nesting area. We suspect that ravens preyed upon the last three plover chicks at A22. Also, a pair of American kestrels was repeatedly seen around pond A22, indicating that they may be nesting nearby. Northern harriers were often seen foraging along the slough channels near the railroad track, rather than in the ponds themselves.

Numerous species were included in avian predator surveys even though they were not considered predator species of particular concern for plovers. Herons and egrets mainly forage in slough channels and dredged areas. Burrowing owls were included due to the proximity of their burrows to A22.

Due to the exponential growth of the world's second largest California gull colony in A6 and establishment of a new colony at Coyote Hills (Strong et al. 2004, SFBBO unpub. data), gulls should be added as a predator of concern. Gulls are a known cause of mortality on shorebird nests and chicks in the Alviso area. California gulls depredated many American avocet nests at Alviso salt pond A8, and 15 radio transmitters from avocet chicks were found within the A6 gull colony (Schwarzbach et al. 2005). Snowy plover chicks were seen at pond A8 in Alviso but disappeared shortly thereafter. We suspect gulls took them. Not only do their opportunistic feeding habits pose a threat to plovers, their expansion jeopardizes plover, tern, avocet, and skimmer nesting habitats. Gull management may be necessary in the very near future.

Road Closures and Barriers

Barriers and signs were unable to prevent people from entering some snowy plover nesting areas. People were seen crossing the brown pipe gate at Warm Springs to jog and watch birds. Other disturbances included a transient camp set up in the southern portion of Eden Landing that was eventually dispersed by the authorities. In addition, a fence barrier may be necessary between Highway 84 and RSF2, as male plovers were seen leading their chicks onto the highway to avoid pedestrians, cars, and bicycles along the road at the northern edge of RSF2.

RECOMMENDATIONS

Research Recommendations

Monitoring and management programs and avian predator surveys should continue year round at all available plover habitat. Future research should include:

- a) Foraging site use studies
- b) Nest site density studies
- c) Banding and tracking of chicks, broods, and adults
- d) Studies to more closely correlate water level and pond use, and pond management to improve conditions for plovers
- e) Studies to determine impact of avian predator management
- f) Continuing to look for new plover areas
- g) Studies to determine impact of nest exclosures on nesting success
- h) Research into tower designs to reduce the use of electrical towers by nesting predators

Management Recommendations

1. The South Bay Salt Pond Restoration Project should give special consideration to snowy plover habitat requirements, including: 1) the availability of drying salt ponds with nearby high salinity foraging habitat, 2) need to manage several pond complexes for plovers in different parts of the South Bay, and 3) vary location of snowy plover nesting ponds from year to year by manipulating water levels in managed ponds to reduce predation levels. The restoration project should also include the removal of man made predator perches, and limitation on new perches placed in snowy plover habitat.
2. Surveys should be conducted in the early morning, or late afternoon/early evening when the lighting is good and it is easier to distinguish the camouflaged plovers. Surveys should also be done during high tide when possible to ensure that plovers are not out foraging on bay mudflats.
3. The nest monitoring program should continue to include egg floating to estimate incubation stage and hatching date.

4. The banding program should be reinstated to help determine chick survival, fledging success and movement. Banded chicks and broods should be re-sighted daily to track their movement; however, a brood-tracking program using radio telemetry would be even more beneficial for following chick fate and pond use.
5. An effort should be made to locate the most likely plover habitat early in the season, which will be determined by water levels and other pond conditions. Assuming that habitat values of the ponds are the same in 2006, ponds A22 and RSF2, and B8A, B12, and B8X should be monitored two to four times per week, since these ponds seem to support the largest percentage of the Refuge and Eden Landing populations, respectively.
6. Because of a potentially significant plover presence in the Napa ponds, this area should be monitored on a regular monthly basis. In addition, more extensive surveys should be done in the North Bay to determine if there is more potential plover habitat elsewhere.
7. Further investigation of the potential impact of red-tailed hawks, northern harriers and American kestrels on plover success is warranted. The growth of gull colonies in the South Bay will need to be addressed as they expand and affect other nesting birds, particularly in Alviso where the large gull colony at A6 is adjacent to plover nesting habitat at A8.
8. The existing mammalian and avian predator management conducted in the South Bay should continue. This program should investigate additional methods to reduce common raven predation on plovers, including nest removal and lethal removal of adults when necessary. Management of other problem predators, such as Northern Harriers, should be investigated.
9. Vehicle access should be limited on the levee between B8A and B9 during breeding season, as adults lead broods across this levee to search for foraging areas.
10. Some sort of barrier, such as a low fence, should be constructed between Highway 84 and the bike path along RSF2 to prevent plovers from getting run over. In the future, it may not be advisable to manage ponds adjacent to roads for ground-nesting birds without barriers.
11. Discussions with PG&E regarding tower design modification should be continued to decrease the use of towers by nesting predators such as ravens. In the absence of such modifications, the Refuge should work with PG&E and Wildlife Services to remove raven nests from towers near snowy plover habitat.
12. Measures should be taken to increase enforcement of regulations and area closures around snowy plover breeding areas, thereby minimizing human disturbance.

13. More volunteers should be recruited and trained to conduct plover surveys, which will ensure that all potential snowy plover nesting areas are thoroughly surveyed throughout the breeding season.

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