# Report on Nesting Snowy Plover Response to New Trail Use in the South Bay Salt Pond Restoration Project

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## Introduction

Providing public access and protecting the abundance and diversity of waterbirds in the South Bay Salt Pond Restoration Project (SBSP Restoration Project) area are important but potentially competing goals of the Project Objectives (SPBP FEIS/R 2007). A major focus of the SBSP Restoration Project's first phase is to develop and enhance a number of trails and add amenities, such as overlooks and interpretive displays. The SBSP Restoration Project Plan sited new trails on levees next to ponded habitat used by foraging and nesting waterbirds to avoid impacts to federally endangered tidal marsh species including the salt marsh harvest mouse (*Reithrodontymys raviventris*) and California clapper rail (*Rallus longirostris obsoletus*). Thus, the species using ponded habitat, including federally threatened western snowy plovers (*Charadrius nivosus nivosus*), have the greatest potential to experience negative effects of new and enhanced trails.

Each year, snowy plovers nest from approximately March through August in managed and seasonally dry ponds in the SBSP Restoration Project area. Plovers nest primarily in the Eden Landing complex (Map 1), where there are currently few public access trails. In 2010 and 2011, snowy plovers nested in Eden Landing ponds E11, E16B, E12/13, E14, E8A, E8, E6B, E6A, E6 and E4C. Birds also nested in other parts of the SBSP Restoration Project, including on ponds R1 through R5, SF2, A22, A23 and the pan habitat in New Chicago Marsh (Robinson-Nilsen et al. 2010).

New trails have the potential to affect nesting plovers (Robinson 2007). Snowy plovers use crypsis to avoid predators (Colwell 2000). Once birds flush, their eggs and newly-hatched chicks are susceptible to predation and exposure to weather (Page and Stenzel 1981). Ruhlen, et al. (2003) found that human recreation on beaches negatively impacted snowy plover chick survival. Protection from disturbance can increase breeding success (Lafferty, et al. 2006). Robinson (2007) collected data in the SBSP Restoration Project area on the distances at which plovers flushed when approached directly by researchers. Based on 24 approaches to single birds sitting on a nest, she found birds flushed at an average distance of 175m (SE=45m).

This study assessed the response of nesting birds to tangential approach, as occurs with trail use on levees. We collected data during the 2010 and 2011 nesting seasons and compared the flush rates of snowy plovers exposed to experimental trail use versus birds not disturbed by trail use. We documented the birds' responses and measured the distances at which birds flushed. We also compared flush rate and distance of birds in response to researchers, whom the birds had seen before, and to trail users whom the birds had not seen. We wanted to make this comparison as studies have shown that some birds recognize specific people who have previously disturbed them (Levey, et al. 2009). We addressed these questions: What is the flush rate and flush distance of nesting snowy plovers in response to new trail use around seasonally-dry ponds where birds nest? Do plovers respond differently to people who have disturbed them versus people they have not seen before?

Methods

From March to August 2010 and March to August 2011, we studied the response of nesting snowy plovers to newly introduced trail use on levees that do not have public access. Trials included a trail walker or a researcher walker (a person the bird has seen before) and control observations, i.e. no walkers. We conducted one trial per nest and all nests were within 125 m of a levee. Before trials were conducted, all nests were located and approached one time by a San Francisco Bay Bird Observatory (SFBBO) researcher to confirm the presence of a nest, the number of eggs, and the GPS location of the nest. The GPS unit averaged the waypoints of locations, which gave us an estimated location error of < 6m. We conducted trials on nests within 2-4 days of SFBBO's confirmation that the birds were incubating. Nest age was estimated by floating the eggs during the first visit to the nest (Hays and Lecroy 1971) and on subsequent weekly visits until the fate of the nest was determined (Mabee 1997). Nest age at the time trials were conducted ranged from 2 to 31 days. We collected data at 54 nests, 31 in 2010 and 23 in 2011. Of the 54 nest, 44 were located in ponds in the Eden Landing Complex (Map 1), 5 in pond A22 in Alviso, and 5 in ponds in the Ravenswood Complex (Map 2). All accessible nests were tested; however, nests were not tested if they were near enough to other plover nests to be affected by responses of birds on those nests.

For each trial, an observer with a KOWA 82 mm spotting scope, stationed on the levee at a distance far enough from the nest to avoid disturbance, watched the bird on the nest. One trail walker or researcher would begin at the scope and walk along the levee nearest to the nest. The walker carried a 2-way radio and a hand-held Garmin GPS unit with nest locations recorded in the unit. When the observer saw the bird stand up, the observer radioed the walker, who stopped and recorded her GPS location along the levee. The trial ended at this point and the walker returned to the scope. If the bird did not flush, the walker went past the bird for approximately 30m then turned around and came back. For control nests (no walkers), an observer on the scope watched the nest for 15 minutes and recorded the number of times the bird flushed from the nest. After each researcher or walker trial in which the bird stood up or moved off the nest, the observer watched the bird for up to 10 minutes to determine when the bird returned to the nest. Basic protocols for the study are found in Appendix A.

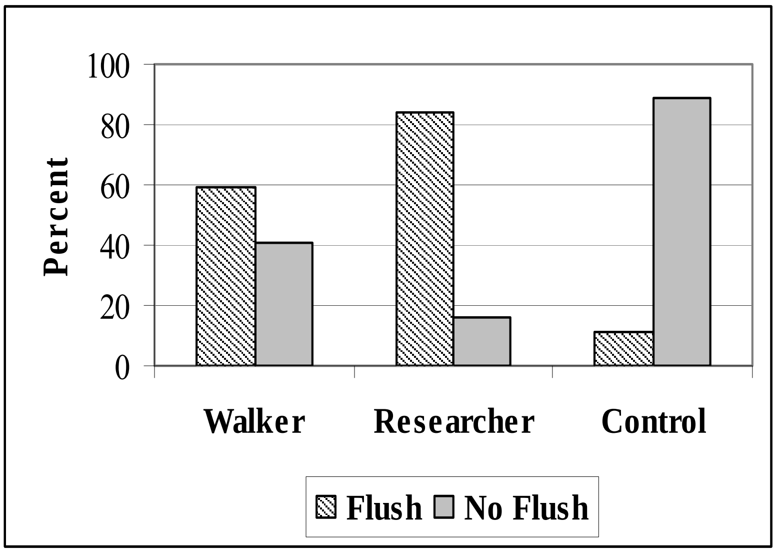
In 2011, SFBBO researchers placed data loggers called "ibuttons" in a number of nests. ibuttons record the nest temperature and have been used to estimate nest attendance in piping plovers (Schneider and McWilliams 2007) and long-billed curlews (Hartman and Oring 2006). Nest temperatures can be used to determine how long birds must be off their nest before the nest temperature become dangerous to egg survival (Yasue and Dearden 2006, AlRashidi et al. 2010). To record the nest temperature, we placed one ibutton in the nest which recorded the temperature once a minute. We placed the ibutton, under the contents in the nest to minimize the disturbance to the incubating plovers as well as to reduce the chance of attracting a predator to the nest if they saw the metal ibutton while the plover was off the nest. To record ambient air temperature, we placed one ibutton approximately one meter away from the nest under about 5 mm of soil, similar to the amount of substrate over the ibutton in the nest. This ibutton also recorded the temperature once a minute. We downloaded the data off the ibutton using Maxim 1-Wire Viewer and converted the data to a Microsoft Excel file.

We used Chi-square analysis (Yates correction for small sample sizes) to assess differences in flush rates in response to trail walker, researcher and control trials. We used Pearson-Product correlations to test relationships between: 1) flush distance and perpendicular distances of nests to the levee, nest to the scope and nest age, and 2) the total time of trials and length of time off nests. The duration of plover time off nest was log transformed for analyses. Mann-Whitney U tests were used to compare groups.

Results and Discussion

*Flush Rates and Durations*. We collected data for 54 trials, composed of 17 trail walker trials, 19 researcher walker trials, and 18 control trials. Birds flushed off their nests 72% (26/36) of the time in response to walkers, but in only 11% of control trials did birds flush. Birds flushed 59% and 84% of the time in response to trail and researcher walkers, respectively (Figure 1).

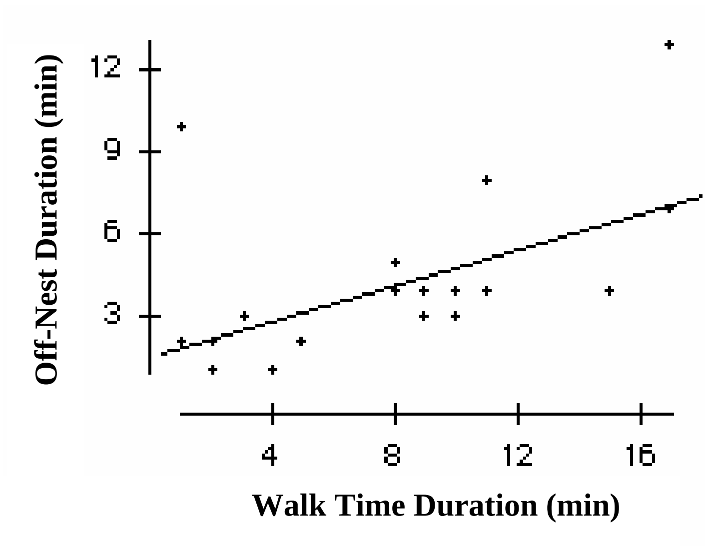
Figure 1. Percent of Flushes versus No Flushes for Three Trial Types




The number of flushes in response to trail walkers versus researchers did not differ significantly (Figure 1; $\chi2 = 1.76$, df = 1, p=0.185). However, birds flushed 84% of the time in response to researchers and only 59% in response to walkers. This difference is relatively large and may be an indication that birds respond differently to people who had previously disturbed them versus people they had not seen before. A focused study is required to test this hypothesis.

We found significant evidence to indicate that the longer the duration of the walk by trail walkers, the longer the time before birds returned to their nest ($r^2$=0.63, df=21, p=0.001, n=24) (Figure 2). These results indicate that the longer a trail disturbance lasts the longer plover nests are exposed and the greater the risk to the nest. This study did not determine if or when birds might become habituated to the presence of people.

Figure 2. Duration of Trail Walks versus Plover Time Off Nest (raw data displayed)



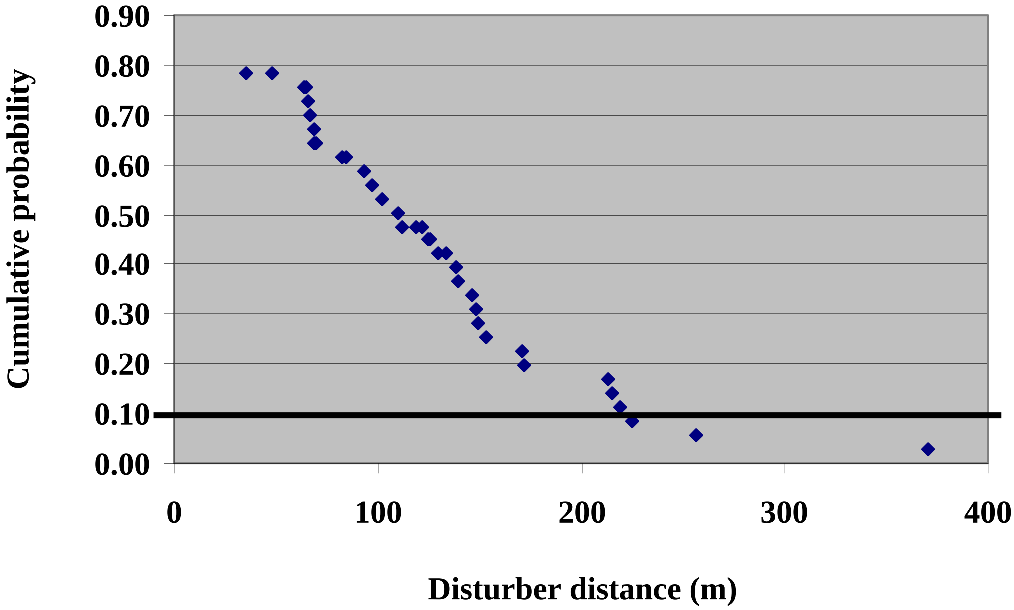

*Flush Distances and Factors*. The average flush distance for birds in response to walkers and researcher (n=26) was 145m (SE 14m). This estimated distance is somewhat less than the 175m flush distance found by Robinson (2007) for direct approach. For birds that flushed, we found no relationship between flush distance and nest distance to the levee ($r^2$=0.072, p=0.726, n=26). Thus, whether a nest was relatively close or far from the levee, the birds still tended to flush at approximately 145m from the disturbance. We found no relationship between flush distance and nest age ($r^2$=0.100, p=0.536, n=36) or distance to scope ($r^2$=0.300, p=0.076, n=36).

In our tangential approach trials, 10 of 36 birds (28%) did not flush, but remained on their nests as walkers passed by. These birds typically flattened their profile and remained still. The average distance of these nests from the levee was 93.1m (SE 9.6), while the distance of nests for birds that did flush (n=26) was 73.0m (SE 7.0). A Mann-Whitney U test comparing these flush distances did not produce a significant result (p=0.112). However, birds that did not flush were an average of 20m (or 27%) further from the levee than birds that did flush, which is a relatively long distance. These findings may suggest that birds that are closer to the levee are more likely to flush than those further away. More data testing this hypothesis are needed.

We plotted the cumulative percent of birds flushing from a nest as a function of the distance between the nest and the disturbance (Figure 3). This assumes that shorter distances between the disturbance and nest are more likely to disturb birds, and it allows for variation in sensitivity to birds. Because birds flushed from the nest 11% of the time in the absence of disturbance, we compare this background rate (solid line) with the cumulative plot. Figure 3 suggests that birds will flush at background rates (11%) if the disturber is approximately 200m or further from a nest. The probability of disturbance rises steeply when the walker reaches approximately 150m from the nest. At closer disturbance distances, birds are less likely to stay on their nest than if the disturbance was at a greater distance.

It is important to realize that the type of disturbance we used was the most benign possible--just one person walking quietly on the levee. Larger groups, dogs, and more intensive activities could lead to greater disturbance reactions by plovers, such as longer flush distances or longer times off the nest.

Figure 3. Cumulative percent of birds flushing plotted against distance of a disturber at the time of the disturbance (points) compared to the background probability of flushing in the absence of a disturber (line at 11%).




*Nest Temperatures*. Data from the ibuttons provided information on how nest temperature changes over the day and how long birds must be off their nest before the nest temperature become dangerous to egg survival. The ideal temperature for a developing bird embryo ranges between 96.8°F and 104°F (Webb 1987). The nest temperatures we recorded for were constantly lower than this range because we put the ibutton under the eggs and under some of the nest contents; therefore, they were not touching the incubating plover's brood patch and yielded lower temperatures. Ambient temperatures recorded during this study ranged from 56.3°F to 110.3°F. Previous studies have found that hyperthermia (high temperatures) is more damaging to embryonic survival than hypothermia and that no embryo can survive temperatures above 111.2°F (Webb 1987). Although air temperatures this high do not occur often in the San Francisco Bay, the substrate where plovers nest does heat up during the summer months.

While we were only able to conduct trail disturbance trials on three nests with ibuttons, we did record that when a plover was off the nest less than 15 minutes at an air temperature of 65.3°F, the nest temperature dropped two degrees. We placed additional ibuttons at non-trail disturbance nests and found that at an air temperature of 68°F, a nest temperature dropped 5.7° in 9 minute. Plover incubation behaviors change during extreme weather conditions as males increase their nest attendance with increases in temperature to relieve females sitting on the nest (AlRashidi et al. 2010). A study of Malaysian plovers (*Charadrius peronii*) found these birds returned to their nests faster after human disturbance on hot days than on cooler days (Yasue and Dearden 2006); these birds were nesting on a beach with regular human disturbance, while the Snowy Plovers on the salt ponds are not subject to recreational disturbance and may react differently when trails are open in nesting areas. We found that the longer trail disturbances lasted the longer the birds stayed off their nests; thus, trail disturbance has the potential to keep incubating birds off their nests, exposing the nest to unsafe temperatures. Whether birds may become habituated to trail use and return to nests quickly (or not leave them at all) or return to nests more quickly on warmer days are questions for further investigation.

Management Considerations

- Trail walkers resulted in birds flushing off nests at rates 7 times greater than the background rate of flushing.
- Locating new trails at least 150m from plover nesting habitat should reduce disturbance to background levels.
- Existing trails during the breeding season may bring people close enough to nests to increase disturbance rates (per walker) to unacceptable levels. For instance, trails within 150 m of nests may cause rates of response higher than background rates.
- Birds may respond differently to people who have disturbed them previously compared to people they have not seen before.
- Disturbing birds on hot days may put nests at greater temperature risk than disturbance on cool days.
- Bird response to existing trails may differ from their response to new trails.

Study Suggestions

- Quantifying nesting plover response to existing trails would be useful, as snowy plovers can become habituated to human trail use (Lafferty et al. 2006), where use is relatively constant and non- threatening.
- Determining the source of background disturbances would be useful in understanding the relative impact of humans compared to other sources of disturbance and could indicate additional means of reducing disturbance rates.
- Research on the consequences of disturbance on nest success would help verify the assumption that disturbance rates (which are easy to measure) are a good proxy for threats to nesting success.
- Understanding factors that promote birds to remain on nests versus move in response to disturbance would be useful.
- Research on how long birds will stay off nests in response to disturbance, temperature, and habituation will help characterize conditions that result in the greatest threat to nests.

Acknowledgements

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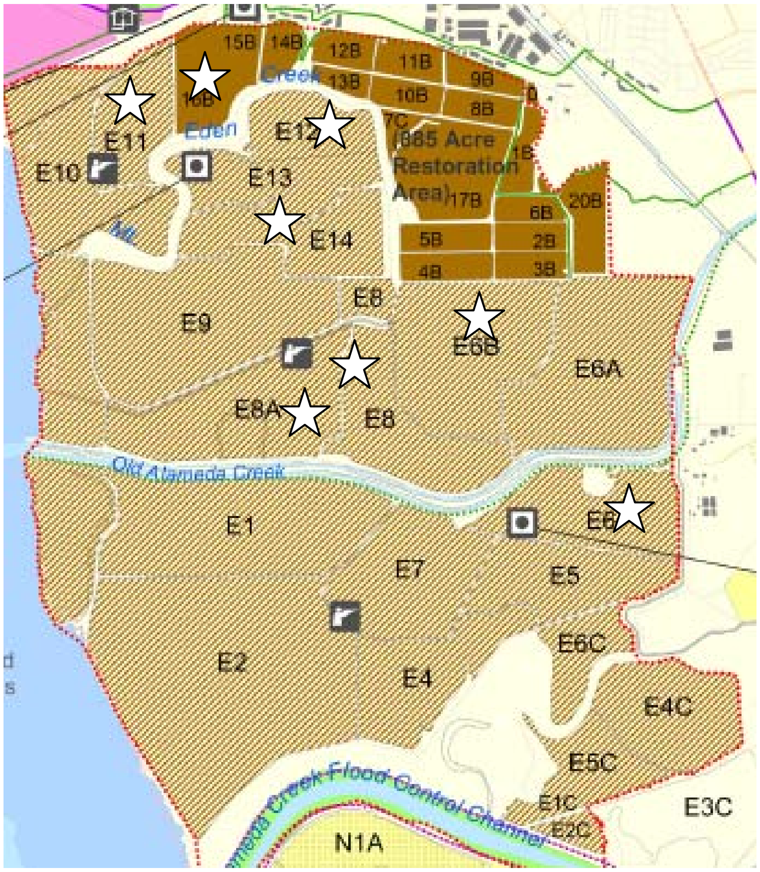
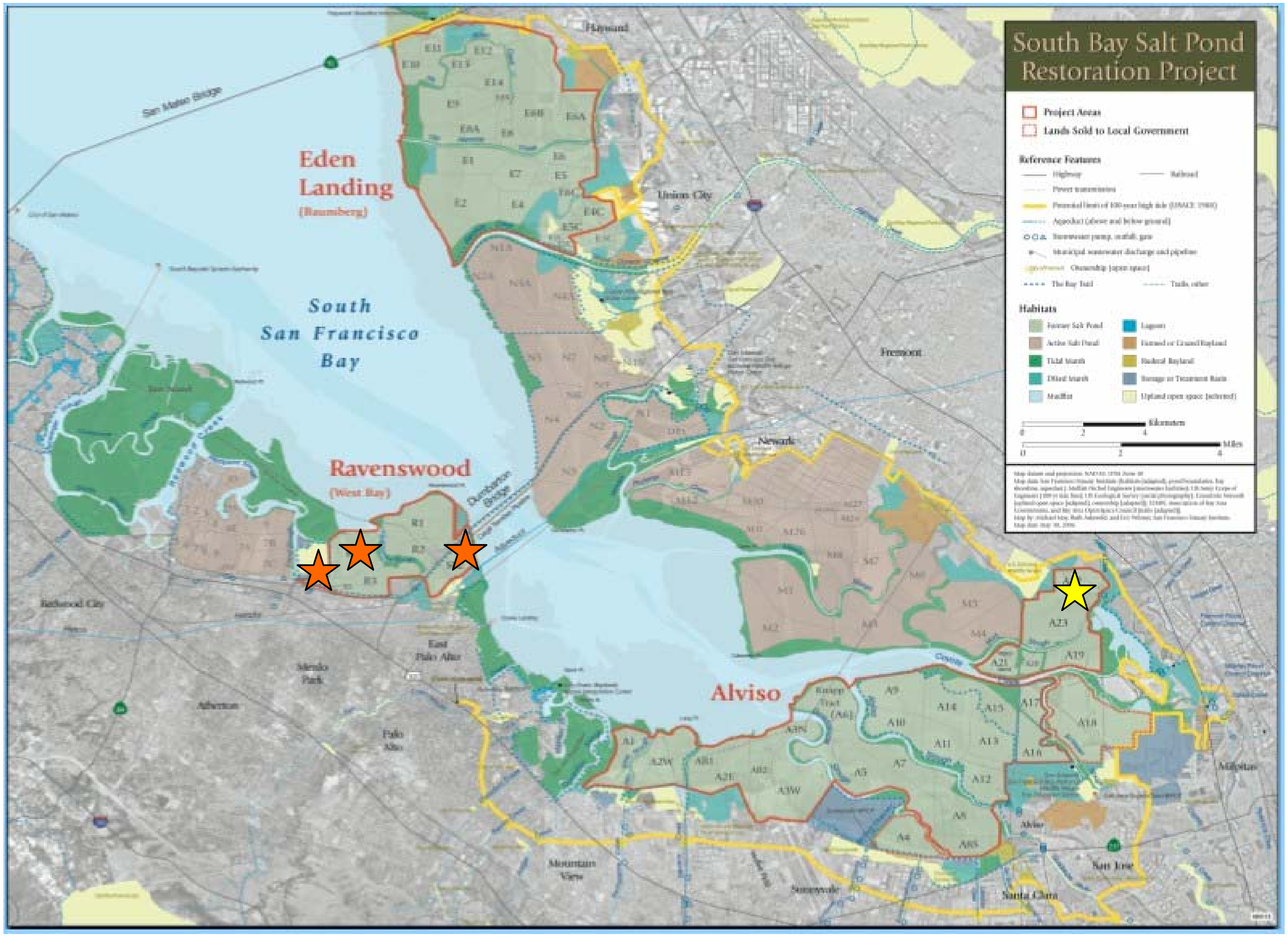



Map 1. Study sites in Eden Landing—Ponds E6, E6B, E8, E8A, E11, E12, E14, and E16B.




Map 2. Three study sites outside Eden Landing—SF2 and R4 (orange stars) in Ravenswood and A22 (yellow star) in Alviso.

Appendix A. **Protocols for the Snowy Plover Response to Trail Use Study**

Methods for the Snowy Plover Study are as follows:

1) We will study the response of nesting plovers to both trail walkers and SFBBO researchers and will compare to bird activity at control nests, with no walkers.

2) The study will occur during the 2010 nesting season, which begins in mid-March and ends in late August. The study period will not extend beyond March 15 to September 30, 2010.

3) We will study plover nests in any part of the SBSP Project area. Nests must be within 100m of a levee where there is no formal trail, and at nests where cameras are not set up (SFFBBO has cameras at some nests to record nest fate). Nests must be approximately 100m from other nesting birds, either plovers or other species.

4) Because nests are hard to see, all nests will be visited initially by an SFBBO researcher in advance of our research trial to determine whether birds are actually sitting on a nest and to collect GPS location information if it is a nest. They will place a flag on the levee directly across from the nest to help us find the nest later.

5) We will collect bird responses to three types of trials types: 1) nests approached by 1 researcher, 2) nests approached by 1 trail user, and 3) nests not approached by anyone (control). Approaches will all be tangential and on the levee. Before these trials, all nests will have been handled once by a researcher (point 4 above).

6) Before conducting each trial, we will survey the area for predators; no trials will be conducted when predators are close enough to threaten a nest.

7) The timing of the observations will be:
i) SFBBO researchers find and visit nest to confirm that it is a nest and to GPS the location.
ii) We will conduct the walker disturbance and control trials 2-3 days later to give us the best chance possible to test nests before they fail or disappear.
iii) The researcher disturbance will also be 2-3 days after the nest location is confirmed and the same researcher that collected the GPS data will be the walker in the researcher trial.

8) Our goal is to observe responses at 30 nests, 10 nests for each trial type. In 2009, SFBBO found 163 plover nests in the area, so we expect a minimum of 30 nests that meet our criteria is a reasonable goal. While we expect 10 nests per trial type, we will collect data on as many nests as possible to maximize sample size and stabilize the variance. We will collect data on all nests feasible as soon as they are found in an attempt to collect adequate data in one year. Data will be collected only once at each nest.

9) If multiple nests are found together near a particular levee, we will collect data on the nest closest to the beginning of the trail walk. Other nests may be affected by the response of birds nearby and thus would not be independent observations. Nests near others that establish after we conduct a trial or that are far enough away from the nest that was exposed to a trial may be independent and acceptable for data collection. Exact criteria for testing additional nests in an area will be developed based on field data.

10) An SFBBO researcher will be the nest observer using an SFBBO scope (60X) at a distance of 100-150m for all three trial types to ensure a seasoned plover researcher is watching the birds and to ensure inter-observer reliability.

11) Walkers will carry a walkie-talkie and a hand-held Garmin GPS unit with nest locations recorded in the program. This equipment will be provided by SFBBO. Caitlin Robinson-Nilsen collected some data on the distance at which plovers are not disturbed by walkers, and the walkers for this study will begin their walk at that distance. When the observer (with the scope) sees the bird stand up, she/he will inform the walker who will stop and record her GPS location along the levee. The program will calculate the distance from the bird to the walker. The trial ends at that point. For the control nests (no walkers of any sort), the observer will watch the nest for a specified period of time and record the number of times the bird stood up.

12) After each researcher or walker trial in which the bird stands up or moves off the nest, the observer will continue watching the bird for 10 minutes to determine if the bird returns to the nest in that period of time.

10) We will pilot test methods and data sheets in March 2010, before plover nesting begins.

11) We will work with Cheryl Strong, at USFWS, to be sure volunteers are covered under SFBBO's 10(a)1(a) permit.

12) We will always conduct a predator survey before starting trial and record results under comments. Trials will not be conducted if a predator is near enough to threaten a nest.

13) Bird head turns are not considered a disturbance response in this study. Bird responses include:

1 – stand up
2 – walk away from nest
3 – run away from nest
4 – fly
5 – alarm call

14) The control observer will watch the nesting bird for 15 minutes at a distance far enough away to avoid disturbing the bird. Whenever a bird exhibits one of the behaviors listed above, she will record the time and the behavior. If the bird leaves the nest, the observer will record the time when the bird returns to the nest, if that occurs within the 15 minute observation period.