WESTERN SNOWY PLOVER (CHARADRIUS ALEXANDRINUS NIVOSUS) NEST SITE SELECTION AND OYSTER SHELL ENHANCEMENT

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Abstract.—The Pacific Coast population of Western Snowy Plovers (*Charadrius alexandrinus nivosus*) is federally listed as Threatened and is as a California Species of Special Concern. To manage, increase in number, and expand the distribution of these imperiled birds in the San Francisco Bay requires detailed knowledge about their nest site selection requirements. We measured the percentage of crushed oyster shells, shell dimensions, number of shells, and total shell surface area for 19 nests of Western Snowy Plover that occurred at the Least Tern Colony at Hayward, California, from 2008 to 2015. Using pairwise *t*-tests, we compared these measurements to those obtained from 19 randomly chosen non-nest sites. Results indicate that Western Snowy Plovers at this location select nest sites with a greater percentage of crushed oyster shell substrate, more oyster shells, and a greater surface area of shells than paired random sites.

Key Words.-birds; conservation; experiment; habitat enhancement; nesting

The Western Snowy Plover (Charadrius alexandrinus nivosus; Fig. 1) generally nests on bare ground or sparsely vegetated beaches and salt pans adjacent to tidal waters (Robinson-Nilsen et al. 2011). The Pacific Coast population of the Western Snowy Plover was federally listed as a threatened species in 1993 (U.S. Fish and Wildlife Service 2012) and is currently listed as a California Species of Special Concern (California Department of Fish and Wildlife 2015). Western Snowy Plover numbers have decreased due to habitat loss, increased predation, and human disturbance (U.S. Fish and Wildlife Service 2007). To support shorebird conservation goals, Helmers (1992) recommended the implementation of vegetation and predator management programs. For example, by removing sandbar vegetation at restored sites for Piping Plovers (Charadrius melodus) and Interior Least Terns (Sterna antillarum athalassos), nesting success improved due to the lack of vegetation, which also minimized the effects of predators (Thompson et al. 1997; Kruse et al. 2001). Other researchers have focused on the removal of non-native plants such as the invasive iceplant (Carpobrotus spp.) as an essential tool to encourage Western Snowy Plover nesting (Kelly Melissa, unpubl. report). Previous studies have suggested that Western Snowy Plovers may select nest sites based on the amount of oyster shell substrate (Zarnetske et al. 2010), which provides camouflage for eggs and chicks and potentially protects them from blowing wind and sand (Pearson et al. 2009). At the Hayward Regional Shoreline, on the eastern shore of San Francisco Bay in California, where oyster shell substrate has been added, observers reported the negative effects that Killdeer (Charadrius vociferus) have on Western Snowy Plovers when nesting in close proximity (Riensche et al. 2010).

Since 2001, the East Bay Regional Park District has managed nesting habitat for the California Least Tern (*Sterna antillarum browni*) at the Hayward Regional Shoreline by augmenting the amount of oyster shells at the site annually (Riensche 2007). As has happened elsewhere in coastal California (Powell and Collier 2000), these management efforts have resulted in the attraction of breeding Western Snowy Plovers to the site (Riensche et al. 2010). We used data from 19 nest sites of Western Snowy Plovers that occurred at the Hayward California Least Tern Colony from 2008–2015 to investigate the effectiveness of adding crushed oyster shell addition as habitat enhancement for plovers.



FIGURE 1. Western Snowy Plover (*Charadrius alexandrinus nivosus*) on the eastern shore of the San Francisco Bay, California. (Photographed by Daniel I. Riensche).

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FIGURE 2. Western Snowy Plover (*Charadrius alexandrinus nivosus*) nest with three eggs on crushed oyster shell at Hayward Regional Shoreline on the eastern shore of the San Francisco Bay, California. (Photographed by Daniel I. Riensche).

Methods

Study site.-The study site was at Island Five (37.629739°N, 122.146039°W) within a brackish water marsh of the Hayward Regional Shoreline, located on the eastern shore of the San Francisco Bay, California. Island Five is 0.24 ha (0.6 ac) in size and is one of 15 islands created within a man-made marsh system. We found nests of Western Snowy Plovers (Fig. 2) by systematically walking through the colony during the breeding season while performing Type One In-colony Surveys of California Least Tern nests (Marschalek 2005). In this method, biologists permitted to work on California Least Terns and their assistants enter the colony to mark nests and record the number of eggs and chicks. This type of intensive monitoring is conducted twice a week, yielding data on clutch size, hatching success, and any evidence of predation. We included all 19 nests we found from 2008 to 2015 in the data analysis (Fig. 3). In a 1-m² area surrounding each nest site, we recorded the substrate composition (percentage crushed oyster shell vs. percentage sand), number of oyster shells (with a surface area greater than 8 cm²), and total surface area of oyster shells measured. We also took the same measurements at 19 randomly chosen non-nest sites that were within a 5-m radius of the active nests. To determine whether nest sites differed from paired random sites across these parameters, we used pairwise *t*-tests ($\alpha = 0.05$).

RESULTS

We found that Western Snowy Plover nest sites differed from paired random sites for composition of the substrate, number of oyster shells, and total shell surface area. Nest sites exhibited significantly more oyster shell and less sand than paired random sites (t = 0.0087, df = 18, P < 0.001), showing 73% crushed oyster shell and 27% sand on nest sites and 42% oyster shell and 58% sand on the random sites. Nest sites showed a significantly higher number of shells surrounding the nest within 1-m² than did random sites (t = 0.00026, df = 18, P < 0.001). On average, occupied nests had 11 more oyster shells than random sites (Fig. 4), with oyster shells averaging 42.7 cm² in size regardless of site. Nest sites averaged 28.1 oyster shells and paired random non-nest sites averaged 16.8. Total shell surface area was also higher by approximately 562.5 cm² when compared to the random sites (t = 0.00096, df = 18, P < 0.001).

DISCUSSION

Essential habitat requirements for breeding water birds include nest sites that provide cover in arrangements that minimize predation while also supplying adequate nutritional resources (Kadlec and Smith 1992). Shorebird species such as the American Avocet (Recurvirostra americana) and Black-necked Stilt (Himantopus mexicanus), which nest among Western Snowy Plovers at the Hayward Regional Shoreline site, require open flats or the sparsely vegetated edges of shallow marshes to breed (Cogswell 1977; Paulson 1993). It has also been suggested that Western Snowy Plovers may choose to nest among California Least Terns due to the increased predator protection provided by the tern colony to the plover chicks through the use of alarm calls and other group defense behaviors (Powell 2001). Understanding the ecological mechanisms that control population dynamics is crucial to successfully managing listed species (Schuetz 2011).

Western Snowy Plovers, a federally listed threatened species and a California Species of Special Concern, select nest sites with unobstructed views of their surroundings to provide more time to leave the nest as soon as a predator is spotted (Colwell 2010). Thus, upon leaving



FIGURE 3. Map of Island Five at Hayward Regional Shoreline on the eastern shore of the San Francisco Bay, California, showing 19 nests of Western Snowy Plovers (*Charadrius alexandrinus nivosus*) found from 2008 to 2015.

the nest, they depend on their cryptic eggs to blend into the surrounding environment and to hopefully go undetected by predators. Western Snowy Plovers select for heterogeneous substrates that include rocks the size of their eggs to help better camouflage their nests (Colwell 2010).

The area around the San Francisco Bay contains the largest breeding Pacific Coast population of Western Snowy Plovers (Small 1994). The Western Snowy Plover Recovery Plan calls for the creation, management and enhancement of breeding habitat and the maintenance of an average of 500 breeding adults in the San Francisco Bay, California for a 10-y period (U.S. Fish and Wildlife Service 2007, 2012). The mechanisms by which these threatened shorebirds select nesting sites in this local area have received little attention in the literature. We focused on the importance of nesting habitat; specifically, how oyster shell enhancement effects Western Snowy Plover nest site selection.

While this study had a relatively small sample size, with mostly unmarked birds (with the exception of two



FIGURE 4. Number of oyster shells at each nest site (blue bars) of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) and randomly chosen comparison sites (red bars).

males), within an active California Least Tern colony, these results could have important nesting habitat management applications for the Pacific Coast population of Western Snowy Plovers. Western Snowy Plovers are facultatively polyandrous and polygynous (Warriner et al. 1986). In this mating system, females typically choose, mate, deposit eggs, and then desert the males with their broods within a few days after hatching (Page et al. 1995). While the males rear their broods, females are free to find new mates. So, for example in the years of multiple nesting attempts (2008 to 2012, and 2014) at the Hayward site, we had as many as three separate nests all establishing, maintaining, and hatching within the same time period. Therefore we feel it is reasonable to assume that these are all separate breeding birds (with the exception of a female or two who may have had two male partners) and not the individual preference of one re-nesting bird. Females are cryptic and no more than three were seen at any one time, while as many as four separate males were observed. During the course of this study, only two of these males were banded, but no females were banded. The banded males were not seen again in subsequent nesting seasons. The estimated life span of these birds is only 2.7 y (Patton 1994). While males are more likely than females to retain the same territory in consecutive years (Warriner et al. 1986), it doubtful that the same birds would survive long enough to nest at this site for eight years.

With continued research, our findings may be used to better manage Western Snowy Plover habitat by attracting breeding pairs, thereby supporting the Recovery Plan goals for this threatened species. Our results indicate that the addition of crushed and whole oyster shells could improve nesting habitat for Western Snowy Plovers in the San Francisco Bay. This may be a valuable management tool in creating better nesting habitat. Future research could focus on the optimum amount of oyster shell by looking at plover nesting success in relationship to amount of oyster shell at the nest site (Fig. 5). Western Snowy Plover nest site selection • Riensche et al.



FIGURE 5. Recently hatched Western Snowy Plover (*Charadrius alexandrinus nivosus*) chick next to oyster shells at the Hayward Regional Shoreline, on the eastern shore of the San Francisco Bay, California. (Photographed by Daniel I. Riensche).

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