CALIFORNIA LEAST TERN HABITAT ENHANCEMENT AND NESTING IN THE EAST BAY REGIONAL PARK DISTRICT, CALIFORNIA

DAVID L. RIENSCHE[1], East Bay Regional Park District, 2950 Peralta Oaks Court, P.O. Box 5381, Oakland, CA 94605, USA

***Abstract*:** Since 2001, the East Bay Regional Park District has been working to enhance and establish a California least tern (*Sterna antillarum browni*) colony at Hayward Regional Shoreline located along the eastern shore of the San Francisco Bay. These efforts are to assist in the recovery of this State and Federally listed endangered species. The District's conservation measures include the removal of dense vegetation, importation of the appropriate nesting substrate, placement of least tern decoys, installation of chick shelters, broadcasting tern vocalizations from a solar-recharged sound system, and site monitoring. This research provides new information on California least tern distribution and methods for constructing nesting sites in potential breeding habitat, and identifies factors that could negatively affect their reproductive success. California gull (*Larus californicus*) depredation may be the major factor limiting California least tern nesting success at Hayward Regional Shoreline and may serve as an early warning for future tern habitat enhancement efforts in the region.

TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 43:62-71; 2007

***Key words*:** California, California least tern, habitat enhancement, nesting success, *Sterna antillarum browni*

The California least tern (*Sterna antillarum browni*) is a migratory species, nesting along the West Coast of North America from Baja California north to the San Francisco Bay (U.S. Fish and Wildlife Service 1980). They establish nesting colonies on sandy soils with little vegetation along Pacific Ocean beaches, lagoons, and bays. Nests are shallow depressions lined with shells or other debris (Massey 1974, Cogswell 1977). Least terns are generally present at nesting areas between mid-April through late September (Massey 1974, Cogswell 1977), often with two distinct waves of nesting during this time period (Massey and Atwood 1981). Nesting density ranges from 3-7 nests per ha (1-3 per ac) (Swickard 1972), but may be much greater; e.g., 145 nests on about 0.75 ha (1.9 ac) in San Diego County, California (Rigney and Granholm 1990). This bird was listed as a federal endangered species in 1970 (U.S. Fish and Wildlife Service 1973) and as a state endangered species in 1971 (California Department of Fish and Game 1976) due to a population decline resulting from loss of habitat (Craig 1971, Cogswell 1977), disturbance of nesting sites, and predation by domestic and wild mammals (King 1981, Massey 1981, Jehl 1984, Vermeer and Ranking 1984).

Many factors affect California least tern breeding success, such as winter storm systems that influence water temperature or salinity which can affect prey availability, resulting in chick mortality (Caffery 1997). Predation, human disturbance, and flooding during spring tides also cause variable nest success for the California least tern (Burger 1984, Kirsch 1996, Thompson et al. 1997, Zuria and Mellink, 2002).

Previous studies on terns and colonial seabirds suggest decoys can be used to successfully attract birds to specific areas during the breeding season. In the United States, decoys have been used to attract Atlantic puffins *(Fratercula arctica)* (Kress 1977), least terns (Massey 1981, Kotliar and Burger 1984, Burger 1989), Arctic terns (*Sterna paradisaea*) (Kress 1983) and common terns (*Sterna hirundo*) (Dunlop 1991, Blokpoel et al. 1997) to abandoned or newly created colony sites. In southwestern Australia, crested terns (*Sterna bergii*) were attracted to artificial colonies of decoys (Dunlop 1987). Jefferies and Brunton (2001) reported that decoys were an effective tool for attracting the endangered fairy tern (*Sterna nereis davisae*) to specific areas in New Zealand. Burger (1988) explains that the presence of conspecifics (decoys) may indicate that an area is a suitable place to breed, thereby serving as effective lures to draw birds to a site. Research on colonial seabirds has shown that the use of recorded sounds in combination with decoys serve as a social attractant, encouraging birds to colonize or re-colonize historic nesting sites (Kress 2000).

The creation of nesting habitat with dredge materials, a popular component of habitat restoration to partially compensate for wetland loss in San Diego County, California, has provided nesting habitat for California least terns and Western snowy plovers (*Charadrius alexandrinus nivosus*) (Powell and Collier 2000). Evidence suggests that dredge-spoil island sites covered with coarse substrates, such as shells, may reduce vegetative cover and enhance nesting success of seabirds (Mallach and Leberg 1999). In the southeastern U.S., dredged-material islands have been shown to be important nesting habitat for least terns and other colonial waterbirds (Parnell 1987, Parnell et al. 1988). The causes of mortal-

[1] driensche@ebparks.org

ity for least terns nesting on dredged-material islands in Georgia include tidal flooding and human disturbance, extreme temperatures, and predation by raccoons (*Procyon lotor)*, dogs, cats, birds and ants.

Least tern populations have grown rapidly since the 1980s and this increase has been attributed to protection of breeding areas from human disturbances and predators, and to some extent, creation of new nesting areas (Powell 1998). The USDA Wildlife Services (formerly Animal Damage Control) commenced predator management activities to benefit least terns in the 1980s, because monitors identified predation of least tern chicks as the main cause of poor breeding success, rather than reduced habitat and pair disturbance (Collins, unpublished report). Field experiments conducted at the Salt Plains National Wildlife Refuge in Oklahoma have implicated the coyote (*Canis latrans*) as the major nest predator of least terns and snowy plovers; about 5 to 60% of the monitored nests have been lost to predators annually (Grover and Knopf 1982, Hill 1985, Utych 1993, Koenen et al. 1996). The breeding success of least terns at Sandy Point, Connecticut dropped due to increased predation (on chicks and eggs) by black-crowned night-herons (*Nycticorax nycticorax*), which focused their depredation activities towards the center of the tern colony prior to peak hatching (Brunton 1997). The number of black-crowned night-herons involved in this predation event may have been as low as four individuals (Brunton 1997). In addition, Kirsh (1996) observed one black-crowned night-heron eat a tern chick on the Lower Platte River, Nebraska. Furthermore, by comparing the breeding success to the cause of nesting failures for twelve least tern colonies in Connecticut, Brunton (1999) reported that colonies of approximately 150 nests appeared large enough to withstand low impacts by mammals, gulls and crows, but small enough to be relatively unattractive to black-crowned night-herons.

The research objectives of this project were as follows: (1) enhance and manage habitat to establish a successful California least tern colony at Hayward Regional Shoreline, (2) monitor the tern population reproductive success, and (3) identify and manage the factors that could negatively affect the colony's reproductive success (e.g., predation and disturbance).

STUDY AREA

I conducted the study on Island Five (37.629739N Lat., 122.146039W Long.) within a brackish water marsh at the Hayward Regional Shoreline, located on the eastern shore of the San Francisco Bay, California (Fig. 1). The island is 0.6 ac in size and is one of 15 islands created within this man-made marsh system. The

Figure 1. Location of the study of a California least tern (*Sterna antillarum browni*) colony at Hayward Regional Shoreline located along the eastern shore of the San Francisco Bay, California.

Hayward Regional Shoreline provides habitat for 27 special status species. This property is part of the East Bay Regional Park District, a two-county special district with more than 96,000 ac (237,792 ha) in Alameda and Contra Costa Counties.

METHODS

Beginning in August of 2001, more than 1,600 volunteers placed 165 tons of appropriate substrate on top of a heavy gauge 700x Marify landscape fabric (West Tek Supply, Inc., San Jose, California). The fabric minimizes management by reducing the amount of hand pulling and chemical treatment required to retain a vegetation-free environment. The imported substrate on the island is composed of light colored coarse-grained sand (60%), rock salt (10%), crushed oyster shells and large intact oyster shells (30%). The large oyster shells range in size from 10 to 20 cm in length. The substrate depth currently on the island is 5 to 8 cm thick.

Research has shown that most tern species avoid dense vegetation because it obscures visual contact and recognition between chicks and parents, making delivery of fish more difficult (Kress 2000). The District's vegetation management efforts include both hand-weeding and herbicide treatments between the months of September and March to remove robust annual and perennial weeds. This maintenance activity is necessary, both at the beginning and end of each field season, because of nutrient rich soils (fertilized by geese and other waterbirds), that stimulate the rapid growth of weeds. For herbicide treatments, a solution of Dimension Ultra 40 WSP and Gallery 75DF produced by Dow Agroscience was applied by a qualified pesticide applicator in December of 2004 and 2005. These are pre-and post-emergent chemicals that do not leach into the water column.

In 2003, we placed least tern decoys on the island (Mad River Decoy,Waitsfield, VT) to attract adults, installed cylindrical ceramic tile shelters to protect chicks from predators and weather, and installed a grid system composed of redwood A-frame chick shelters to assist in mapping nests. Interpretive signs were erected to explain access restrictions. Starting in the spring of 2005, a solar-recharged sound system (Murremaid Music Box , Bremen, ME) was installed specifically for attracting California least terns using broadcast tern vocalizations.

Data collection to determine nest distribution, chronology of nesting, and reproductive success has primarily been accomplished using the Type 2 method (monitoring outside colony) (Marschalek 2005). In this type of method passive observations are conducted outside the colony from nearby levees at various times of day, with the majority of the surveys conducted from 0700 to 1700 hours, five to seven days a week. Monitoring was done from within a vehicle, approximately 25 m (75 ft) from the island.

Optical equipment included Cabela's professional 20x60 mm (2.4 in) spotting scope with a car window mount and Swift Audubon 10x42 mm (0.4x1.6 in) high resolution roof prism binoculars, which were used by staff and volunteers to monitor nesting activity, foraging events and intraspecific behavior. Most nests could be observed from the levee road to determine status. All results were recorded on standardized datasheets and submitted to the California Department of Fish and Game.

In October 2005, our aquatic survey indicated that top smelt *(Atherinops affinis)* and rainwater killifish *(Lucania parva)* were abundance in the marsh surrounding the island. The top smelt sampled were primarily young of the year, which indicates spawning in the open water surrounding the tern nesting island. This suggests that the nearby fish populations are sufficient to support a California least tern colony at Hayward Regional Shoreline.

During the non-breeding season, District staff inspected the chick shelters (small wooden A-frames and ceramic tiles) and removed the following documented and suspected hazardous terrestrial arthropods: black widow spider (*Latrodectus mactans*) and various ant species (family *Formicidae*) (Marschalek 2005). District staff also monitored the area for other potential least tern predators including: American crow (*Corus brachyrhynchos*), peregrine falcon (*Falco peregrinus*), American kestrel (*Falco sparverius*), black-crowned night-heron, common raven (*Corus corax*), gulls (*Larus* spp.*)*, Northern harrier (*Cirus cyaneus*), red fox (*Vulpes vulpes*), and raccoon.

RESULTS

Early in the 2003 breeding season, three pairs of terns attempted to nest on the site, but later abandoned the area because of rapid vegetation growth which made the site unsuitable. However, since 2005, California least terns have established nest sites on the island (Fig. 2). In 2005, the site had eight nests concentrated on the northern portion of the island. The nesting chronology for the 2005 season suggests that these were "first wave" breeding pairs (Fig. 3). This portion of the island contained the greatest number of large oyster shells. This was also the "oldest" portion of the imported substrate composed of sand, salt, and crushed shells. The inter-nest distances appeared to be relatively large with distances greater than 5 m (Fig. 4). Early in the 2005 nesting season a small number of California gulls were

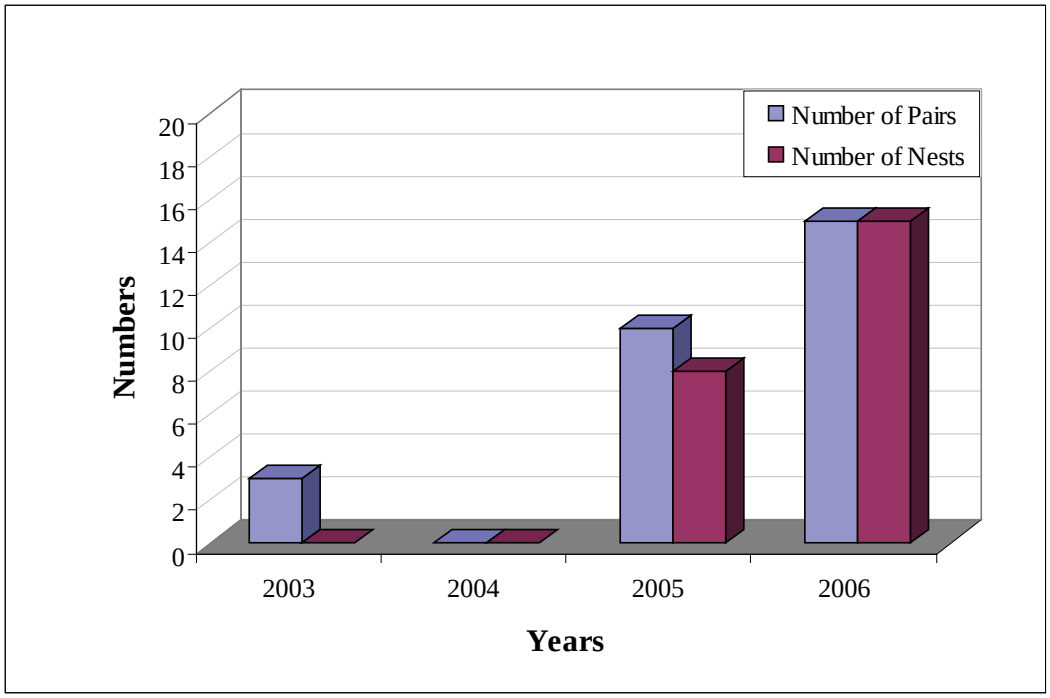

Figure 2. Location of California least tern (*Sterna antillarum browni*) pairs and nests 2003 – 2006 at the Hayward Regional Shoreline, California.

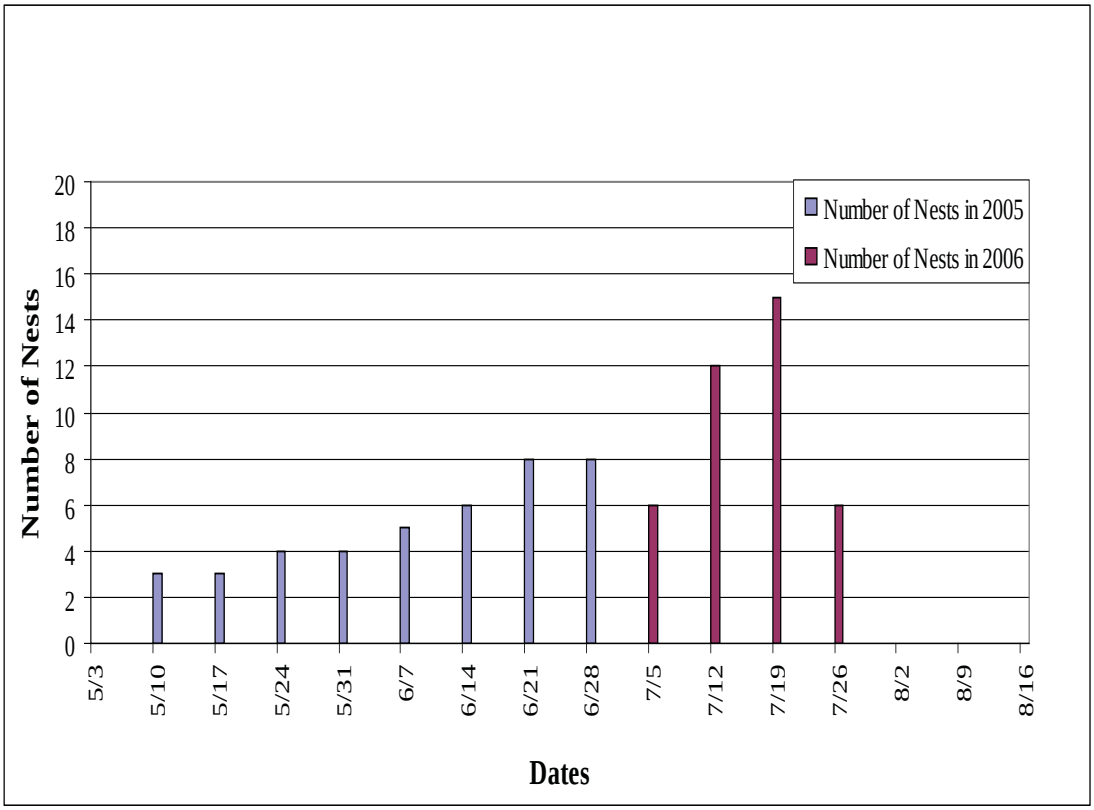

Figure 3. Nesting chronology of California least tern (*Sterna antillarum browni*) at the Hayward Regional Shoreline, California in 2005 and 2006.

present in the area and made several predation attempts on the least tern decoys (Fig. 5), but later dispersed from the area. On 28 June 2005 a large flock of California gulls (100-150) stationed themselves on the island and predated the eggs, causing the terns to abandon the site. From 28 June 28–7 August 2005 only six terns returned to the site with no re-nesting attempts observed. On 22 August 2005, staff observed two adult terns feeding two recently fledged young on the island. It was suspected these new birds were post-fledged young and adults from the California least tern colony approximately 10 miles north at Alameda Point.

California least terns were observed in the area for a brief period early in the 2006 season. On 21 June 2006, they arrived and initiated nesting, and by 19 July 2006, a total of 15 nests were concentrated on the southern portion of the island. The nesting chronology for the 2006 season suggests that these were "second wave" breeding pairs (Fig. 3). By this time an equal amount of large oyster shells covered the entire site. In addition, staff reported that the sand substrate on the south side of the island appeared to be less compact and that there was spotty vegetation on the island ranging in height from 8 to 30 cm. The internest distances appeared to be relatively close with distances of less than 5 m (Fig. 4). Tern chicks were observed using the tiles and large oyster shells for shelter. No predator management measures were under-taken in 2006. However, gulls increased suddenly on an adjacent island. Shortly after this increase, all nesting terns and chicks disappeared with the exception of four fledged young and 20+ adults recorded on 5 August 2006. We found gull tracks in the nesting area of the island after the colony was depredated.

DISCUSSION

Habitat restoration involving the public and private sector can be a valuable partnership for enhancing wildlife habitat. The East Bay Regional Park District's aims were to enhance and manage a successful California least tern colony at Hayward Regional Shoreline, while increasing public awareness and involvement for the protection of rare native species. Along the expansive alkaline flat at Salt Plains National Wildlife Refuge, Oklahoma, least terns (*S. a. athalassos*) selected nest sites with coarser soil (loamy sand to sandy loam) and soil that is lighter in color, and terns nested closer to driftwood or debris than random points (Schweitzer and Leslie 1999). Kress (2000) reported that terns may readily colonize islands that are the proper size, shape,

Figure 4. Distribution of California least tern (*Sterna antillarum browni*) nests at the Hayward Regional Shoreline, California in 2005 and 2006.

substrate, topography, and location. Furthermore, these human created islands can mimic the bare and sparsely vegetated habitat preferred by terns (Kress 2000). The District attempted to duplicate those conditions at Hayward Regional Shoreline in order to attract nesting California least terns.

In 2006, we observed the late arrival and nesting of California least terns at Hayward Regional Shoreline. Massey and Atwood (1981) observed that breeding colonies under heavy pressure from predators or human disturbance would abandon a site immediately, and thereafter a similar-sized group would "materialize" at another, nearby site and begin nesting. Their observations might explain why the birds arrived late at the Hayward Regional Shoreline site. Early in the 2006 season, a large colony of California least terns nesting nearby at the former Naval Air Station at Alameda Point, 10 miles from the Hayward Regional Shoreline site, experienced heavy predation pressure by burrowing owls (*Athene cunicularia*). It is possible that the late arrivals at the Hayward site were these "first wave" breeders displaced from Alameda by owl predation. This suggests that the least terns at the shoreline were "second wave" breeders. The "second wave" usually occurs from mid-June through early August and consists of late breeders (those breeding for the first time) and re-nesting pairs (re-laying after a failed first attempt) (Massey and Atwood 1981). "First wave" breeding pairs were present in 2005. "First wave" breeders are older and more experienced and tend to arrive early in May with most chicks hatching by mid-June (Massey and Atwood 1981). It is unclear why a "first wave" nesting attempt in 2006 was not observed. Atwood and Massey (1988) reported that adult California least terns have high site fidelity and first-time breeders tend to select nesting sites relatively near where they were hatched. It is hopeful that the four fledglings produced at the Hayward Regional Shoreline site in 2006 may return to nest in the future.

The impact of various predators on different colony sizes has major implications for the management of least terns (Brunton 1999). In areas where black-crowned night-herons are abundant, smaller least tern colonies may be more productive than larger colonies. Conversely, where heron populations are low or absent, large least tern colonies will be most productive (Brunton 1997, 1999). Approximately 300 black-crowned night-herons nest in the eastern most portion of the Freshwater Marsh at Hayward Regional Shoreline. While not ruling them out as potential tern predators, no evidence of night-herons was found at the tern colony

Figure 5. California gull predation attempt on a least tern decoy (Photo courtesy of Mark Taylor).

site. Given the small size of our least tern colony, the studies of Brunton (1997, 1999) would suggest little impact from black-crowned night-herons.

Predation of eggs can be a major factor affecting the hatching success of least terns (Burger 1984, Massey and Fancher 1989, Butchko and Small 1992, Rimmer and Deblinger 1992, Garcia and Ceballos 1995). On the east coast large gulls are known to impact nesting least terns (Kress 2000). Electrified enclosures will not provide protection to nesting least terns from avian predators such as gulls and may even attract such predators by concentrating nesting terns in a small area and providing a visual attraction (Winton and Leslie 2003). Winton et al. (2000) observed ring-billed gulls (*Larus delawarenis*) taking the eggs and chicks of snowy plovers in 1995-1996 and assumed that gulls also preyed on least tern eggs because of the yolk stains they observed at destroyed nests. The numbers of California gulls appear to be increasing throughout their range (Winkler 1996). It has been reported that Forster's tern (*Sterna forsteri*) colonies in San Francisco Bay were displaced when California gulls colonized the area adjacent to tern colonies, and furthermore that these gulls ate tern eggs and chicks (Strong et al. 2004). By using remote still cameras and remote video cameras aimed at occupied least tern nests, DeVault et al. (2005) reported that ring-billed gulls were the major source of mortality for breeding least terns at Gibson Lake in southwestern Indiana, including predation on tern chicks and eggs. Our 2005 to 2006 data indicates that California gull depredation may be the major factor limiting California least tern nesting success at Hayward Regional Shoreline at this time.

Successful predator management for nesting birds is often dependent on identifying the particular species responsible for mortality to eggs and chicks (Kruse et al. 2001), because many predator management techniques (e.g., exclusion fences, fear-provoking stimuli, poison bait) are effective only for a limited group of potential predator species (Conover 2002). Active "Positive Management," designed to benefit the birds (e.g., posting, wardening, and/or entering the colony to control predators), often involves some intrusion into the nest area and consequent disturbance (Nisbet 2000). A proactive predator management plan at Hayward Regional Shoreline including hazing techniques, and if necessary, the lethal removal of gulls from the site by USDA Wildlife Services may be required. This approach will require annual management into the foreseeable future. For some tern restoration programs, the amount of effort directed at gull control is inevitably highest during the first few years before terns build up a strong tradition of nesting on the site (Kress 2000). In addition to managing tern predators, maintaining the habitat on the island by periodically replenishing the site with a fresh supply of coarse, clean sand mixed with shells, as well as maintaining the current vegetation management program may be required.

California gull populations have increased more than 33-fold over the past two decades in the South San Francisco Bay, to over 33,000 breeding birds, while the Caspian tern (*Sterna caspia*) and Forster's tern populations have declined significantly (Ackerman et al. 2006). Because the California gull population continues to increase steadily in South San Francisco Bay, the San Francisco Bay Bird Observatory does not recommend further tern habitat enhancement or encouragement until a management plan is in place in order to limit depredation by California gulls (Strong, unpublished report). Furthermore, Ackerman et al. (2006) reported that California gulls depredated at least 61% of their study's radio-marked American avocet (*Recurvirostra americana*) chicks and 23% of their black-necked stilt (*Himantopus mexicanus*) chicks. Given the evidence presented by other researchers and the District's observations, it appears that the California gull predation may be the major factor limiting California least tern nesting success at the Hayward Regional Shoreline and that this may serve as an early warning for future tern habitat enhancement efforts in the region.

ACKNOWEDGMENTS

I would like to express my sincere gratitude to the following people and institutions that made this work possible. The Regional Parks Foundation, U.S. Fish & Wildlife Service Coastal Program, Alameda Countywide Clean Water Community Stewardship Program, New United Motor Manufacturing, Orchard Supply Hardware, and Johnston's Oyster Farm together provided more than $50,000 in grant funds and donations to enhance California least tern habitat at Hayward Regional Shoreline. This project has provided an opportunity to involve 1,600 members of the public, who have collectively donated more than 6,000 hours of volunteer services towards this restoration effort. A special thanks goes to all those listed below who helped create and monitor the site: P. Alexander, N. Baglietto, B. Beckett, D. Bell, P. Beitz, K. Bloom, G. Bloom, S. Bobzien, W. Bolden-Ross, N. Brownfield, A. Calcagno, R. Cameron, R. Canright, N. Cavagnaro, M. Clark, R. Dawson, J. DiDonato, P. Dramer, J. Hamilton, B. Hamilton, C. High, H. High, K. High, S. High, B. Hill, C. Johnson, C. Kitting, S. Lewis, N. MacKay, C. Madden, J. Mena, M. Marrow, B. Pinomaki, R. Pinomaki, T. Pinomaki, B. Pinomaki, L. Powell, M. Schynert, P. Shawen, A. Shawen, H. Thomas, P. Thompson, P. Thompson, S. Wiley, M. Riensche, S. Riensche , D. Riensche, N. Riensche, R.

Riensche, J. Sheppard, G. Still, M. Taylor, A. Theile, N. Tracy, H. Van Austen, and P. Zierman.

LITERATURE CITED

Ackerman, J. T., J. Y. Takekawa, C. Strong, N. Athearn, and A. Rex. 2006. California gull distribution, abundance, and predation on waterbird eggs and chicks in South San Francisco Bay. Unpublished final report, U. S. Geological Survey, Western Ecological Research Center, Davis and Vallejo, CA. [Available at: Western Ecological Research Center, U.S. Geological Survey, 3020 State University Dr. East, Modoc Hall, 3rd Floor, Room 3006, Sacramento, CA 95819]

Atwood, J. L., and B. W. Massey. 1988. Site fidelity of least terns in California. Condor 90:389 -394.

Blokpoel, H., G. D. Tessier, and R. A. Andress. 1997. Successful restoration of the Ice Island common tern colony requires ongoing control of ring-billed gulls. Colonial Waterbirds 20:98-101.

Burger, J. 1984. Colony stability in least terns. Condor 86:61-67.

Burger, J. 1988. Social attraction in nesting least terns: effects of numbers, spacing, and pair bonds. Condor 90:575-582.

Burger, J. 1989. Least tern population in coastal New Jersey: monitoring and management of a regionally-endangered species. Journal Coastal Research 5:801-811.

Butchko, P. H., and M. A. Small. 1992. Developing a strategy of predator control for the protection of the California least tern: a case history. Pages 29-31 *in* Borrecco, J.E., and R.E. Marsh, editors. Proceedings of the fifteenth vertebrate conference. University of California, Davis.

Brunton, D. H. 1997. Impacts of predators: center nest are less successful than edge nest in large nesting colony of least tern. Condor 99:372-380.

Brunton, D. H. 1999. "Optimal" colony size for least terns: An inter-colony study of opposing selective pressures by predators. Condor 101:607-615.

Caffrey, C. 1997. California least tern breeding survey, 1995 season. Wildlife Management Division. Bird and Mammal Conservation Report 97-6. California Department of Fish and Game, Sacramento, CA.

California Department of Fish and Game. 1976. At the crossroads: a report on California's endangered and rare fish and wildlife. State of California, Sacramento, CA.

Cogswell, H. L. 1977. Water Birds of California. University Press, Berkeley and Los Angeles, CA.

Conover, M. R. 2002. Resolving Human-Wildlife Conflicts: the Science of Wildlife Damage Management. CRS Press, Boca Raton, FL.

Craig, A.M. 1971. Survey of California least tern nesting sites. Special Wildlife Investigations, Project W-54-R-4, Job Final Report 11-5.1. California Department of Fish and Game, Sacramento, CA.

DeVault, T. L., M. B. Douglas, J. S. Castrale, C. E. Mills, T. Hayes, and O. E. Rhodes, Jr. 2005. Identification of nest predators at a least tern colony in Southwestern Indiana. Waterbirds 28:445-449.

Dunlop, C. L., H. Blokpoel, and S. Jarvie. 1991. Nesting rafts as a management tool for a declining common tern (*Sterna hirundo*) colony. Colonial Waterbirds 14:116-120.

Dunlop, J. N. 1987. Social behavior and colony formation in a population of crested terns (*Sterna bergii*) in south-western Australia. Australian Wildlife Research 14:529-540

Garcia, A., and G. Ceballos. 1995. Reproduction and breeding success of California least terns in Jalisco, Mexico. Condor 97:1084-1087.

Grover, P. B., and F. L. Knopf. 1982. Habitat requirements and breeding success of charadriiform birds nesting at Salt Plains National Wildlife Refuge, Oklahoma. Journal of Field Ornithology 53:139-148.

Hill, L. A. 1985. Breeding ecology of Interior least terns, snowy plovers, and American avocets at Salt Plains National Wildlife Refuge, Oklahoma. M.S. thesis, Oklahoma State Univ., Stillwater, Oklahoma.

Jefferies, D. S., and D. H. Brunton. 2001. Attracting endangered species to 'safe' habitats: responses of fairy terns to decoys. Animal Conservation 4:301-305.

Jehl, J. R. 1984. Conservation problems in Baja California and the Pacific Northwest. Pages 41-48. *in* J. P. Croxall, P.G. Evans, and R. W. Schreiber, editors. Status and Conservation of the World's Seabirds. ICBP Technical Publication No. 2, Cambridge, U.K.

King, B. W. 1981. Endangered Birds of the World. The ICBP bird red data book. Smithsonian Institution Press, Washington, D.C.

Kirsh, E. M. 1996. Habitat selection and productivity of least tern on the lower Platte River, Nebraska. Wildlife Monographs 132:1-48.

Kress, S. W. 1977. Establishing Atlantic puffins at a former breeding site. Pages 373-377 *in* S. A. Temple, editor. Endangered Birds: Management Techniques for Preserving Endangered Species. University of Wisconsin Press, Madison, WI.

Kress, S. W. 1983. The uses of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6:185-196.

Kress, S. W. 2000. Colony Site Management Techniques. National Adubon Society, Ithaca, NY.

Koenen, M.T., R.B. Utych, and D.M. Leslie, Jr. 1996. Methods used to improve least tern and snowy plover nesting success on alkaline flats. Journal of Field Ornithology 67:281-291.

Kotliar, N. B., and J. Burger. 1984. The use of decoys to attract least terns (*Sterna antillarum*) to abandoned colony sites in New Jersey. Colonial Waterbirds 7:134-138.

Krogh, M. G., and S. H. Schweitzer. 1999. Least tern nesting on natural and artificial habitats in Georgia, USA. Waterbirds 22:290-296.

Kruse, C. D., K. F. Higgins, and B. A. Vander Lee. 2001. Influence of predation on piping plover, *Charadrius melodus*, and least tern, *Sterna antillarum*, productivity along the Missouri River in South Dakota. Canadian Field Naturalist 115:480-486.

Mallach, T. J., and P. L. Leberg. 1999. Use of dredged material substrates by nesting terns and black skimmers. Journal of Wildlife Management 63:137-146.

Marschalek, D. A. 2005. California least tern breeding survey, 2004 season. Habitat Conservation and Planning Branch, Species Conservation and Recovery Program Report, 2005-01. California Department of Fish and Game, Sacramento, CA.

Massey, B. W. 1974. Breeding biology of the California least tern. Proceedings of the Linnean Society of New York 72:1-24.

Massey, B. W. 1981. A least tern makes a right turn. Natural History 11: 61-71.

Massey, B. W., and J. L. Atwood. 1981. Second-wave nesting of the California least tern: age composition and reproductive success. The Auk 98:596-605.

Massey, B. W., and J. M. Fancher. 1989. Re-nesting by California least terns. Journal of Field Ornithology 60:350-357.

Nisbet, I. C. T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23:312-331.

Parnell, J. F. 1987. Habitat development applications the use of dredged-material islands by birds in North Carolina. Pages 140-144 *in* M.G. Landin and H.K. Smith, editor. Beneficial Uses of Dredged Materials. Proceedings First Interagency Workshop Waterways Experiment Station, Corps of Engineers, Pensacola, FL.

Parnell, J. F., D. G. Ainley, H. Blokpoel, B. Cain, P. W. Custer, J. L. Dusi, S. Kress, J. A. Kushan, W. E. Southern, L. E. Stenzel, and B. C. Thompson. 1988. Colonial waterbird management in North America. Colonial Waterbirds 11:129-169.

Powell, A. N. 1998. Western snowy plover (*Charadrius alexandrinus nivosus*) and California least tern (*Sterna antillarum browni*). Pages 626-631 in M.J. Mac, P.A. Opler, C.E. Puckett Haecker, and P.D. Doran, editors. Status and Trends of the Nation's Biological R esources. Biological Resources Division, U.S. Geological Survey, Reston, Virginia.

Powell, A. N., and C. L. Collier. 2000. Habitat use and reproductive success of western snowy plovers at new nesting areas created for California least tern. Journal of Wildlife Management 64:24-33.

Rigney, M., and S. Granholm. 1990. Least tern (*Sterna antillarum*). Pages 278 -279 *in* D.C. Zeiner, W.F. Laudenslayer Jr., K.E. Mayer, and M. Marshall, editors. California's Wildlife, Vol. 2, Birds. California Statewide Habitat Relationships System, California Department of Fish and Game, Sacramento, California.

Rimmer, D. W., and R. D. Deblinger. 1992. Use of fencing to limit terrestrial predator movements into least tern colonies. Colonial Waterbirds 15:226-229.

Schweitzer, S. M., and D. M. Leslie, Jr. 1999. Nesting habitat of least terns (*Sterna antillarum athalassos*) on an Inland Alkaline Flat. American Midland Naturalist 142:173-180.

Strong C.M., L.B. Spear, T.P. Ryan, and R.E. Dakin. 2004. Forester's tern, Caspian tern, and California gull colonies in San Francisco Bay: habitat use, numbers and trends, 1982-2003. Waterbirds 27:411-423.

Swickard, D. K. 1972. The status of the least tern at Camp Pendleton, California. California Birds 3:49-58.

Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch, and J. A. Atwood. 1997. Least tern (*Sterna antillarum*). Pages 1-28 *in* A. Poole and F. Gill, editors. The Birds of North America, No. 290. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists Union, Washington, D.C.

U.S. Fish and Wildlife Service. 1973. Threatened Wildlife of the United States. Bureau of Sport Fisheries and Wildlife. Resource Publication 114.

U.S. Fish and Wildlife Service. 1980. California Least Tern Recovery Plan. U.S. Fish and Wildlife Service, Region 1. Portland, Oregon.

Utych, R. B. 1993. Compatibility of selenite crystal digging with breeding ecology of least terns and snowy plovers at Salt Plains National Wildlife Refuge, Oklahoma. M.S. thesis, Oklahoma State University, Stillwater, Oklahoma.

Vermer, K., and L. Ranking. 1984. Influence of habitat destruction and disturbance on nesting seabirds. Pages 726-733 *in* J. P. Croxall, P. G. Evans, and R. W. Schreiber, editors. Status and Conservation of the World's Seabirds. ICBP Technical Publication No. 2, Cambridge, U.K.

Winton, B. R., J. Rupert, and D. M. Leslie, Jr. 2000. Breeding ecology and management of snowy plovers in north-central Oklahoma. Journal of Field Ornithology 71:573-584.

Winton, B. R., and D. M. Leslie, Jr. 2003. Nest sites and conservation of endangered Interior least terns (*Sterna antillarum athalassos*) on alkaline flat in the south-central Great Plains (USA). Acta Ornithologica 38:135-141.

Winkler, D. W. 1996. California gull (*Larus californicus*). Pages 1-28 *in* A. Poole, and F. Gill, editors. The Birds of North America, No. 259. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists Union, Washington, D.C.

Zuria, I., and E. Mellink. 2002. Natural and human impacts on two least tern colonies in northwestern Mexico. The Southwestern Naturalist 47:617-623.