State of California
The Resources Agency
Department of Fish and Game
Wildlife Management Division

CALIFORNIA LEAST TERN BREEDING SURVEY

1992 SEASON

by

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Nongame Bird and Mammal Section Report, 93-11

FINAL REPORT TO

California Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

CONTRACT FG1431 (FY91/92)

Partially Supported by Section 6 Federal Grant-in-Aid
Funding for Endangered Species, California, EW91, X-1

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ABSTRACT

In 1992, approximately 2,106 pairs of the endangered California Least Tern (*Sterna antillarum browni*) nested at 38 sites along the coast of California, from the San Francisco Bay area in the north, south to the Mexican border. This 15% increase over 1991 breeding population size continues the trend since 1987 of continued growth of the population, and is directly attributable to the efforts of people working on behalf of recovery of the species. The statewide total of 2,106 pairs is the highest number recorded since systematic monitoring began in 1973, and represents a greater than three-fold increase over the estimated 600 pairs of that year. The increase in the number of nesting sites over 1991 (34) and 1990 (30) reflects both the expansion of terns into new areas adjacent to already established sites, and the return of terns to areas used historically but not in the recent past.

The increase in the number of breeders was somewhat eclipsed by the much reduced statewide production of fledglings. The total of 1,362-1,448 fledglings produced in 1992 is lower than the numbers produced by 1,830 pairs in 1991 (1,729-1,839) and 1,706 pairs in 1990 (1,487-1,676). Low fledgling production per pair in 1992 (.65-.69) was attributed to both predation and the deleterious effects of El Niño on food availability. Breeding failure and success was strikingly

[1]Caffrey, C. 1993. California least tern breeding survey, 1992 season. Calif. Dep. Fish and Game, Wildl. Manage. Div., Nongame Bird and Mammal Section Rep. 93-11, Sacramento, CA. 35 pp.

localized, and sites hit hardest by both predation and a shortage of food were located in the southern portion of the State (in San Diego County). Eight sites had relatively high fledgling production per pair (≥ 1); fledglings produced at four of those eight sites (NAS Alameda, Venice Beach, Seal Beach, Santa Margarita River North Beach) comprised 65% of the total produced statewide.

Because an annual fledgling to pair ratio of less than 0.7 results in a decline in the size of the breeding population two years later, and past El Niño events have been shown to affect the population dynamics of terns over a protracted period, the combined effects of predation and low food availability on Least Tern reproductive success in 1992 are likely to hinder population growth for several years to come.

INTRODUCTION

The California Least Tern (Sterna antillarum browni) is a State- and federal-listed endangered species that nests each spring and summer along the coast from the San Francisco Bay area in the north, south into Baja California, Mexico. Annual estimation of Least Tern breeding population size and monitoring of breeding activities in the state of California began in 1973; estimation of total annual fledgling production was incorporated into monitoring protocol in 1978. Habitat loss due to human development and climatic events (e.g., storms and flooding), other types of human-related disturbance, predation, and adverse environmental conditions, particularly El Niño, continue to dampen recovery of the species. However, the concerted efforts at identifying, enhancing, protecting and monitoring Least Tern breeding areas by state and federal agencies, and the many dedicated individuals working therein, have greatly contributed to the three-fold increase in breeding population size from 600 pairs in 1973 to 1830 pairs in 1991. These efforts were continued in 1992, and the data are summarized herein.

METHODS

In a continuing effort to refine and standardize terminology used by monitors and in all future reports, the following criteria are used to distinguish Least Tern breeding "sites" from "colonies" (used interchangeably in the past): A site is the name of the location of a discrete and contiguous group of nesting birds. A colony is the name of the location of a breeding area, where colony members share the same foraging and roosting areas, and the same general nesting areas. If all pairs in the colony nest within a single, contiguous area, then colony name and site are the same. In recent years, terns have expanded nesting ranges within colonies, and particular colonies have come to comprise two or more "islands" of nesting areas, i.e., they now include several sites.

Statewide censuses of known California Least Tern breeding areas have been conducted since 1973. A network of paid and volunteer monitors check all sites on a regular basis and compile data into mid-season and final Site Reports. The present report integrates and summarizes data from all known Least Tern breeding sites in the state of California for 1992. Further details on methodology (e.g., data collection, fledgling counts, and predator-related issues) are available in the California Department of Fish and Game (CDFG) Least Tern Monitoring Packet (Caffrey 1992). Additionally, the actual final Site Reports are also available through CDFG offices in Sacramento. These reports contain many site-specific details regarding site preparation, data collection, and predation and disturbance problem procedures; readers interested in such additional information are encouraged to request copies.

For 1992, data were collected and are reported here for individual sites, except for the following: the three sites at the McGrath Beach colony are pooled throughout this report, and the three sites at the Ormond Beach colony are pooled for 1991 Total Pairs (for comparison, Table 4), and 1992 Total Fledglings and Fledglings/Pair (Table 4).

Least Terns breed along the coast of California from the southern border north to the San Francisco Bay. Breeding site characteristics vary from site to site. Nesting sites are located in areas that experience high levels of human activity to little or none. Fences may be permanent, temporary, or nonexistent. Nests may be approached close enough to mark them and actually count eggs/chicks directly, or simply observed from afar. Thus monitoring protocol varies from site to site as well, although at all sites the following information is determined: occupancy status, and estimates of total number of breeding pairs and fledglings produced. Fledgling counts are generally made at nocturnal roosting areas at three-week intervals, and summed for the season (Massey 1989, Caffrey 1992). Attempts are also made at identifying the type and outcome of predation or other disturbance.

Given the diversity of site types, two very general monitoring approaches can be described. Type 1 sites are those that have historically been monitored quite closely. Monitors walk through nesting areas regularly, mark nests with tongue depressors, and record data regarding the status of nests. Monitoring of this type throughout the season provides detailed information on the timing of nesting, the number of active nests, clutch size, hatching success, and the number of chicks produced. In contrast, monitor presence within Type 2 sites is kept to a minimum or does not occur at all. Monitors at these sites observe terns from a distance, therefore many types of data are unavailable, e.g., clutch size and hatching dates.

Site preparation, prior to the arrival of terns, also varied from site to site. From information included in mid-season and final Site Reports, vegetation was cleared by hand (NAS Alameda, Oakland Airport, Bolsa Chica, FAA Island, North Fiesta Island, D Street Fill), mechanically (Seal Beach), or with the use of herbicides (NAS Alameda, Seal Beach). Accumulated litter was removed (Venice Beach), fencing was repaired (Seal Beach, FAA Island, Tijuana River Estuary), and sand was cleared away from fencing to expose chick fence (Venice Beach) or pushed into berms to restrict human access (Tijuana River Estuary). Sand was provided to enhance the site at North Fiesta Island, and decoys were laid out to attract terns to particular areas at Dockweiler Beach (Playa del Rey), North Fiesta Island, Crown Point, NAS North Island, Delta Beach, D Street Fill, and Chula Vista Wildlife Reserve.

Site preparation also included predator removal at several sites. All military sites have permanent Animal Damage Control

(ADC) personnel who trap and relocate, or exterminate, a majority of actual or potential predators from Least Tern nesting areas prior to and throughout the breeding season. In 1992, these sites included NAS Alameda, Vandenberg AFB S-5, Purisma Point (VAFB), Point Mugu, White Beach, Santa Margarita River North Beach, Saltflats and Saltflats Island, NAS North Island, and Delta Beach.

Regarding mortality suffered by terns as a result of predation, the following distinction is made between documented and suspected predator species. A documented predator is one actually observed taking a Least Tern egg, chick, fledgling, or adult, or one indicated according to the following criteria: (1) identifiable tracks led to Least Tern remains or empty nest where eggs were not expected to hatch for at least three more days, (2) if expected hatching date was unknown, tracks led to more than one empty nest, and (3) any evidence left had to be consistent with that expected from the indicated predator. Suspected predators are animals believed to have preyed on terns or eggs, based on substantial but not conclusive evidence (e.g., tracks throughout the site, tern remains characteristic of a particular predator, or predators observed foraging at the site).

Differences in dates of first egg for 1992 vs. 1990 and 1991 were analyzed using the Sign test. Descriptive statistics are presented as mean ± SE, unless otherwise indicated.

RESULTS

Distribution - In 1992, California Least Terns were reported to have nested at 38 sites from the San Francisco Bay area south to the Mexican border (Table 1). This increase in the number of nesting sites over 1991 (34) and 1990 (30) in part reflects the expansion of terns into new areas adjacent to previously occupied sites (e.g., Vandenberg AFB S-5, the "Middle Site" at Ormond Beach, and Newport Slough), but also reflects the return of terns to areas used historically but not in the recent past (Buena Vista Lagoon, North Fiesta Island, and San Diequito Lagoon). In addition, a brief mention of the fact that five Least Terns, including a dive-bombing pair, were observed at the Salinas River mouth through June of 1992 suggested that terns may have made their first nesting attempt in Monterey County since 1955 (American Birds, Winter 1992, volume 46, no. 5, p 1175). The incipient site at Dockweiler State Beach, Playa del Rey, had a fence up, decoys out, and taped vocalizations playing by April 20; they experienced several close fly-bys and at least one landing but no nesting activities.

Several recently used sites were unoccupied in 1992 (Table 1). For some unused sites, lack of nesting by terns could be attributed to (1) alteration of the site by storm damage prior to the breeding season (Santa Clara River, Batiquitos Lagoon Park and Ride), (2) an

abundance of resident predators apparently causing arriving terns to desert prior to the onset of nesting (Terminal Island), or (3) prohibitive levels of general human-related and/or predator disturbance (Port Chicago, Lindbergh Field, Grand Caribe Island). Causal reasons underlying lack of nesting at other sites, however, were not obvious (San Antonio Creek, Santa Ynez River Mouth). Still others remain as potential breeding sites although they have not been used by terns in several years (Aqua Hedionda, Los Penasquitos, Stony Point, South Shores, Cloverleaf, Naval Training Center). Crown Point has never been used by nesting terns and is expected to lose its status as a protected tern breeding area in the near future (E. Copper, pers. comm.).

Breeding Chronology - First-wave breeders began arriving at breeding areas from early to mid-April through mid-May; nesting began 1-2 weeks later (Table 2). Most sites had eggs in nests by mid-May, chicks by early June, and fledglings by the end of that month. Definitive second wave nesting was reported at only 16 sites; at three sites the second wave was minimal, and no second wave was evident at 19 sites. Terns began departing some breeding areas in early July, but remained at others until late August/early September.

First Wave - An estimated 1930 pairs nested in the first wave of breeding in 1992 (Table 3). Throughout the state there were small to moderate increases and decreases relative to 1991 at various sites, with the largest increases occurring at Huntington Beach and D Street Fill; the latter was likely the result of both an actual increase in the number of first wave breeders, and some shuffling by pairs of terns back and forth between D Street, Delta Beach, Saltworks, and Chula Vista Wildlife Reserve. Total first wave nests for Venice Beach includes 39 nests (the first 39) preyed on by crows prior to their completion (see Sources of Breeding Failure).

Season Totals - Approximately 2106 pairs of California Least Terns produced 1362-1448 fledglings statewide in 1992 (Table 4), resulting in mean fledgling production per pair = 0.65-0.69. Breeding success was strikingly localized rather than clustered geographically, although many southern sites experienced relatively pronounced breeding failure. Eight sites (NAS Alameda, McGrath Beach, Ormond Beach, Venice Beach, Seal Beach, Delta Beach South, Chula Vista Wildlife Reserve, Tijuana River Estuary North) had relatively high fledgling production/pair ($\geq$1); of these eight, four were particularly successful at producing large numbers of fledglings: NAS Alameda, Venice Beach, Seal Beach, and Santa Margarita River North Beach combined produced approximately 65% of the total fledglings produced statewide. The greatest increases in number of nesting pairs occurred at the following sites (with % of 1991 number in parentheses): Ormond Beach (all three sites: 150%), Point Mugu (266%), Huntington Beach (192%), San Elijo Lagoon (183%), FAA Island (126%), North Island NAS (175%), D Street Fill (294%), and Chula Vista Wildlife Reserve (2000%). Significant

declines occurred at Upper Newport Bay (51%), Batiquitos Lagoon Mouth (13%), Saltworks (26%), and Tijuana River Estuary South (62%). Some of the increases and decreases at particular locations probably reflects pair movement among sites, as has been noted in Annual Reports in the past (e.g., Johnston and Obst 1992).

Clutch Size - Clutch size at Type 1 sites ranged from 1 to 3, with one 4-egg clutch at Santa Margarita Saltflats (Table 5); statewide $\bar{X} = 1.87 \pm 0.47$ (n=1866 nests). Hatching success at Type 1 sites ranged from 16-100%, with a mean of approximately 72%.

Sources of Breeding Failure - Although predation on eggs, chicks, and adults contributed significantly to breeding failure for Least Terns in 1992 (Table 6), strikingly low fledgling production at many sites (Table 4) was attributed to food shortages associated with El Niño. At these sites, combinations of the following types of evidence pointed to food unavailability and the consequent abandonment of eggs and chicks, or the starvation of chicks, as important sources of breeding failure: (1) unusually large numbers of abandoned eggs and/or chicks with no obvious signs of predators present, (2) large numbers of large fish dropped at the site (brought back by adults but too large for chicks), (3) unusually large numbers of dead chicks found at site, (4) mean clutch size smaller than usual, and (5) high hatching success but low fledgling production in the absence of obvious predation pressure. Monitors at several of these sites reported observing chicks begging to adults other than their parents, adults returning with fish too large for chicks to swallow, and weakened chicks "using their last breath" to beg to parents returning with no food. Sites hit hardest by food unavailability were, for the most part, located in San Diego County, where fleglings/pair, compared with 1991 data, decreased by 44-89% at 7 sites, including all four at Camp Pendleton (White Beach, Santa Margarita River North Beach, Saltflats, and Saltflats Island), Mariner's Point at Mission Bay, North Island NAS, and D Street Fill. At Mariner's Point, 31 chicks were found dead, and 38 abandoned eggs were collected from 29 nests. At Camp Pendleton (all four sites combined), 203 dead chicks were found; 2 of 6 submitted to USFW for analysis were found to be emaciated, the remaining four were too decomposed for analysis. Low food availability was also thought to underlie the lack of second wave breeding at many sites (Table 2).

Predation was an important source of breeding failure in 1992 (Table 6); documented and suspected predators included by-now familiar species. Sites hit hardest by predation were the following, all in San Diego County: Buena Vista Lagoon, Batiquitos Lagoon, San Elijo Lagoon, San Diequito Lagoon, FAA Island, North Island NAS, Delta Beach North, D Street Fill, Saltworks, and Tijuana River North and South.

At several sites, predators were removed prior to or during/throughout the breeding season, in most cases by ADC.

Despite on-going controversy regarding desirable/acceptable/appropriate/plausible predator management procedures, one example from 1992 makes clear the potential value of predator control: At Venice Beach, crows are often the predator species inflicting the most damage to tern reproductive success. In 1992, two crows (an adult male and a yearling) began patrolling the site prior to tern arrival. As terns arrived and nesting was initiated, these two crows were present daily. In addition, a different group of 5-6 nonbreeding crows visited the site occasionally. As terns began to nest, every single egg in the first 39 nests was preyed upon by crows. Permission was then granted to permanently remove one crow, and a California Fish and Game Warden shot the adult (of the two) in the presence of the yearling. The carcass was prominently displayed in the southeast corner of the enclosure, where crows usually entered. The following day, the group of nonbreeders was observed approaching the site as usual, and upon reaching the southeast corner, sharply turning 180° and leaving the area. Crow predation ceased thereafter until the very end of the season.

Humans apparently inadvertently trampled nests at Mussel Rock Dunes, San Elijo Lagoon, Mariner's Point, and Tijuana River Estuary, but intentionally entered the fenced colony at Seal Beach, resulting in the death of at least 38 chicks.

Other sources of breeding failure in 1992 included fencing problems, predation by ants, and probable hypothermia.

Sources of Disturbance - Sources of site disturbance (Table 7) are those that were believed to either underlie the abandonment of nests or whole breeding areas, or to contribute directly or indirectly to egg or chick mortality, although clear evidence of the connection was lacking. Disturbance resulting from human intrusion into nesting areas remains a problem on public lands. Beachgoers with or without pets cause disturbance, if not direct mortality, and ORV traffic continues to be a problem at several sites.

The presence of other avian species (nesting and/or roosting) was thought to cause terns to abandon sites and/or nests, or to refrain from nesting in particular areas, at NAS Alameda (particular areas: nesting gulls), Terminal Island (the whole site: crows), Buena Vista Lagoon (nests: roosting gulls), Batiquitos Lagoon Mouth (nests: nesting Forster's Terns), and FAA Island (nests: roosting gulls). Peregrine Falcon presence apparently caused nest abandonment at NAS Alameda and North Fiesta Island, and eventually whole site abandonment at FAA Island.

Overgrown vegetation was believed to prohibit nesting in certain areas at Batiquitos Lagoon Mouth.

DISCUSSION

The steep increase in the statewide number of California Least Tern breeding pairs over the last four years continued in 1992. From a recent low of 944 pairs in 1987, breeding population size had increased 94% by 1991, to 1830 pairs (Fancher 1992). The 1992 total of approximately 2106 pairs adds another 15% to 1991 population size, and brings the increase from 1987 through 1992 to 123%. This dramatic increase in breeding population size is directly attributable to the efforts of people working on behalf of terns to enhance and protect breeding areas; fencing repair, vegetation removal, and predator management all increase the reproductive potential of Least Terns. Unfortunately, predator control is not ubiquitous, and not much can be done to alleviate El Niño's effects on food availability and the consequent devastating effects on tern reproductive success. The increase in the number of breeding pairs in 1992, therefore, was somewhat eclipsed by the much reduced statewide production of fledglings. The 1362-1448 fledglings produced by 2,106 pairs in 1992 is even lower than the totals produced by 1830 pairs in 1991 (1729-1839) and 1706 pairs in 1990 (1487-1676).

As has been the case for at least the last several years (Fancher 1992), predation on Least Tern eggs and chicks was a major source of breeding failure in 1992, particularly at 12 sites in San Diego County (listed in Results: Sources of Breeding Failure). At those sites, mean hatching success was much lower then that for Type 1 sites statewide (45 vs 72%), as was mean fledgling production per pair (.42 vs .65-.67). The effects of such intense predation pressure on the recruitment of terns to potential breeder status was felt at sites of all sizes: smaller ones (3-7 pairs; Buena Vista Lagoon, Batiquitos Lagoon Mouth, San Diequito Lagoon) produced zero fledglings, medium-sized sites (22 and 49 pairs; San Elijo Lagoon and North Island NAS) produced only 2 and 5 fledglings, and two of the largest (158 and 135 pairs; FAA Island and D Street Fill) produced a combined total of only (approximately) 70-75 fledglings.

Breeding failure due to predation is often manifested simply as the disappearance of eggs/chicks without direct evidence as to the identity of the predator. However, in cases where monitoring is frequent and/or the evidence left behind is unequivocal, predators can be identified, and under certain circumstances, removed. The removal of offending predators invariably enhances tern breeding success, and may be especially important at struggling sites less able to withstand predation pressure than more robust ones. If accomplished early enough in the season, renesting by pairs whose first attempts were lost to predators can restore the "health" of the site and result in a successful season. For example, were it not for the removal of the crow at Venice Beach, not a single chick would have fledged; not a single egg would have hatched. As it was,

breeding success at Venice Beach was quite high, resulting in the production of 245 fledglings.

Because predators generally consume the prey they kill, large numbers of dead chicks suggest something else is at work. Although "starvation" is virtually impossible to determine unequivocally as the cause of mortality, many observations pointed to food unavailability as the reason underlying the pronounced breeding failure experienced at many sites, particularly in San Diego County. The patterns that emerged from the breeding season of 1992 were consistent with those of El Niño years in the past, relative to non-El Niño years: delayed breeding, reduced clutch size, a lack of second wave nesting, and low fledgling production per pair.

Nesting in 1992 began significantly later than in the previous two years at sites in San Diego County. I compared first egg dates for 1992 with those of 1990 and 1991 at the same sites, where the data were available (Obst and Johnston 1992, Johnston and Obst 1992). Compared with 1990, nesting at eight of nine San Diego County sites began later in 1992 ($p=.04$, Sign test), whereas for sites north of San Diego County, six were earlier, three were later (including Mussel Rock Dunes, an El Niño site), and three were essentially the same (within 2 days; including Huntington Beach, an El Niño site) ($p=.508$). Compared with 1991, nesting began later at 12 of 14 San Diego County sites in 1992 ($p=.012$), while for those north of San Diego County, seven were earlier, four were later (including Mussel Rock Dunes), and one was the same ($p=.548$). Date of first egg was not available for Huntington Beach in 1991.

Mean clutch size for the state in 1992 was smaller, albeit only slightly (and not significantly), than that for 1990 and 1991 ($1.87\pm.47$ vs $1.99\pm.44$ and $2.0\pm.45$, respectively), and the lack of second wave nesting was clear: half of all sites in San Diego County, as well as throughout the state, reported no second wave. Low fledgling production in the face of high hatching success, and in most cases, the absence of intense predation pressure, was perhaps the most striking manifestation of El Niño's effects on food availability. At the 11 sites where the criteria were met for listing Food Shortage as a source of breeding failure (Table 6), a total of 1370 eggs hatched, yet only approximately 372 tern chicks fledged. Fledglings per pair for these sites averaged approximately .41; much lower than the already-low .65-.69 for the state as a whole, and similar to the statewide mean of .45 in 1982, the last El Niño year.

Fancher (1992) notes that a statewide fledgling to pair ratio of less than 0.7 results in a decline in the size of the breeding population two years later; not only will El Niño's deleterious effects on the reproductive success of California Least Terns in 1992 be felt in 1994, they will likely affect the population dynamics of this endangered species for several years to come (Massey et al. 1992). Because the effects of the lowered fledgling

production in 1992 on breeding population size will reverberate for years, efforts to enhance Least Tern breeding success must continue if the species is to recover. Enrichment and protection of established and incipient sites, as well as attempts to acquire and attract terns to new sites, are critical to this end.

RECOMMENDATIONS

Nesting Sites - Acquiring shore-front property is as difficult as it sounds, yet the creation of new sites must proceed to buffer the potentially devastating effects of predation, human disturbance, and future El Niño events, on a local level. Individual sites are often either successful or not regarding fledgling production, and a single predator can be enough to tip the balance in favor of the latter. In 1992, fledglings produced at only four sites comprised 65% of the state total. This points to the vulnerability of the species' recovery to local threats, and begs the establishment of new sites. Attempts to surmount bureaucratic obstacles to develop a new site at Dockweiler Beach need to continue; this site will be an important annex to the ever-successful-but-getting-pretty-crowded site at neighboring Venice Beach.

Enhancement of well-established, incipient, and potential sites remains a priority. Human foot, vehicular, and pet traffic reduces the breeding success of terns either directly through the trampling of eggs or chicks, or indirectly through disturbance, resulting in abandonment of entire sites or individual nesting attempts. Enclosing nesting areas and educating the public as to the contents is clearly the ideal solution, yet is not always possible in practice. With an eye toward approaching that ideal, however, better fencing, better enforcement, and/or bilingual signs are badly needed at PG&E Pittsburg, Mussel Rock Dunes, Pismo Dunes, Ormond Beach, Batiquitos Lagoon NE, San Elijo Lagoon, San Diequito Lagoon, and Tijuana River Estuary.

Because terns seek flat, open, sandy areas with little vegetation as nesting sites, overgrown vegetation can constrain, or even prohibit, breeding at otherwise suitable sites. The latter was apparently the case at Batiquitos Lagoon Mouth this year, and monitors at several other sites (Seal Beach, FAA Island, Crown Point and Chula Vista Wildlife Reserve) felt that more aggressive vegetation clearing would enhance the breeding success of terns. Laura Collins notes that clearing all vegetation in a buffer zone around the nesting area at NAS Alameda decreases its attractiveness to predators.

In the past, terns have returned to breed in areas unused for variable periods of time (e.g., Delta Beach North), and 1992 saw the return of terns to Buena Vista Lagoon, San Diequito Lagoon, and North Fiesta Island; this underscores the importance of continued

protection and enrichment of such sites. The use of decoys has been successful in efforts to attract terns back to previously used areas, such as North Fiesta Island (and the Naval Training Center in 1993, E. Copper pers. comm.), as well as to new sites (e.g., Mariner's Point in the past, and Delta Beach South and Dockweiler Beach in 1992). Their use at sites used year after year can direct terns to particularly suitable areas (e.g., D Street Fill).

Monitoring - Because monitors not only collect data but serve as the direct link between recovery efforts and tern life during the breeding season, it is crucial that monitoring continue at at least current levels. It is a given that the more closely a site is monitored, the better the troubleshooting and problem intervention/ solving. As often as possible, and for as long as possible, monitors should visit sites, assess the impact of all things that impinge on breeding success and, when possible, respond to negative influences in ways that promote tern survival and reproduction.

A strong attempt was made in 1992 to refine and standardize monitoring and reporting methodology (Caffrey 1992); this effort will continue in 1993.

Predator Control - Predation on Least Tern eggs, chicks, fledglings, and adults has been, and will continue to be, a major problem at most sites. Wiping out all potential predators prior to the onset of nesting would clearly benefit terns, but is unnatural, unacceptable, and not possible anyway. Presently, at CDFG tern breeding sites, predator management consists mostly of "crisis control", where predators are removed only after damage is done and the predator(s) can be identified. Sometimes, even after predators have been identified, predator removal is not attempted. The decision as to the fate of the offender(s) is based on several criteria, including the status of the predator (e.g., "endangered"), the estimate of its potential effects on tern breeding success, the site history, and financial and local residential considerations. All of these are important variables, and in most cases, the ultimate decision is neither easy nor straightforward. Yet the time, and additional terns, lost in the decision-making process (as well as the paperwork quagmire), and the frustration and helplessness felt by monitors with no control over the situation are issues that can be addressed directly. Thus, some sort of ecologically- and ethically- sound predator management program must be worked out.

With an eye toward such a program, we have made the first real attempt at establishing an objective base of information on predator behavior and effects, and site histories, by standardizing the reporting of potential or actual predation, and requesting the filling out of Predator Sighting Sheets (Caffrey 1992) by all monitors, when appropriate. In the future we hope to establish a predator management program where site histories and documented predator effects dictate a more standardized approach to predator

control than exists now.

In the meantime, increased ADC assistance at sites plagued by predators in the past and at sites experiencing intense predation pressure during any particular breeding season is desperately needed. Permanent funding for such services should be sought. In 1992, monitors at several sites requested predator-control assistance in their Final Reports (Oakland Airport, Batiquitos Lagoon NE, San Elijo Lagoon, San Dieguito Lagoon, FAA Island). Additionally, although how is not clear, discouraging gulls from roosting in Least Tern nesting areas prior to tern arrival would alleviate some abandonment problems.

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ACKNOWLEDGEMENTS

So many people have contributed to this project in so many important ways, it is an honor to acknowledge their efforts. Each one of the more than 60 individuals listed here truly gave a piece of themselves to this work; their generosity and dedication was overwhelming. I am proud to be associated with all of you.

Field monitors remain the vital link between us and the terns, and the terns and their survival as a species. Monitors pull vegetation, erect fencing, shovel sand, and endure whitewashing as they watch and walk to keep data up to date; moreover, they are forced to become forensic pathologists, like it or not, and are our first step in predator crisis management. Through it all, they somehow manage to remain openminded, levelheaded, and upbeat in the face of predation, human recklessness, and that sometimes nightmarish phenomenon we like to call bureaucracy. Thanks to all of you: Leora Feeney, Mary S. Perry, Tina Fabula, Jack Dougherty, Matt Fischer, Bob Perry, Chuck Warner, Nancy Warner, Rob Burton, Don Davis, Kris Mashburn, Bobbe Dorsey, Terry O'Neill, Linda O'Neill, Mary J. Davis, Dale Schafer, Grace Smith, Alan Naydol, Debra Pires, Fritz Hertel, Kathy Keane, Mari Hoffmann-Nelson, Margaret Rubega, Alice Gibb, Gary Gillis, Michelle Faulhaber, John Konecny, Rob Patton, Brian Foster, Trisha Hobell, Susan Welker, Tim Dillingham, Jennifer Price, Ginger Johnson, Mary Grishover, Melissa Mailander, Ken Andrecht, Shauna Deasley, and Jack Fancher.

Special thanks to Regional Coordinators Laura Collins, Morgan Boucke, and Elizabeth Copper, not only for their efforts in the field, but also for their support and guidance of monitors, deft handling of paperwork, and their gracious return of all of my phone calls (well, ok, almost all of them). It has been a pleasure working with you guys. CDFG Wildlife Biologists Morgan Boucke, Chanelle Davis and Tim Dillingham somehow always came through when needed, as did ADC personnel, who do incredible work at an unenviable job; thanks to John Turman, Scott Little, Bob Parker, Maynard Small, Craig Knight, Joe Albee, and David Moreno.

Information for the following California Least Tern breeding sites was provided by the US Navy from work funded by the Naval Surface Forces, Pacific, Command on behalf of Assault Craft Unit - Five and the Landing Craft Air Cushion (LCAC) program, the Commander in Chief, Pacific Fleet under a Memorandum of Understanding with the US Fish and Wildlife Service, and base operating funds from Naval Air Station, Alameda and Naval Air Weapons Station, Point Mugu: NAS Alameda, Point Mugu (Naval Air Weapons Station, Point Mugu), White Beach (Marine Corps Base, Camp Pendleton), Santa Margarita (Marine Corps Base, Camp Pendleton), Naval Training Center, North Island NAS (NAS, North Island), Delta

Beach (Naval Amphibious Base, Coronado). Site Preparation at White Beach and Santa Margarita was accomplished by the Marine Corps Base, Camp Pendleton. The cooperation of the Department of the Navy in providing information from the above sites is greatly appreciated. We are extremely grateful to Linda Belluomini, Doreen Stadtlander, Mark Pavelka, Carol Roberts, Pat Baird, Barbara Massey, Lisa Kares, Marit Evans-Layng, Ron Dow, and Tom Keeney for their efforts at those sites, as well as Sherri Withrow, Clark Winchell, and Doug Pomeroy for lots of inside help. Thanks to Tim Burr and especially Dave Boyer, not only for their work in the field, but also for how easy and enjoyable they make it to access their minds, as well as their data.

We gratefully acknowledge the US Air Force for allowing access to the site at Vandenberg Air Force Base, and also the Nature Conservancy for access to their land. We cannot thank Pat Baird enough for her unwavering committment to the Dockweiler Beach site and seemingly endless supply of energy on its behalf. Finally, Ron Jurek remains a perpetual source of wisdom, calm, encouragement and understanding, and a master of all-sides-of-the-story compromise. None of this would be possible without him.

My own very special thanks to Elizabeth Copper for all of her help and kind words throughout the year. I'd also like to thank Charlie Peterson, Fritz Hertel and Ron Jurek for their careful reading of, and helpful comments on, a draft of this manuscript.

And Bryan, you continue to live on in this work, especially for me.

Table 1. Type, primary contact, and number of breeding season visits for each site. Type 1 sites are monitored from inside; Type 2 from the outside. An asterisk next to site name indicates it is either a new site this year, or one used for the first time in several years; unused indicates historically used sites unoccupied in 1992.

	Type	Primary Contact	# Visits
San Francisco Bay Area			
PGE, Pittsburg	2	Laura Collins	12
Port Chicago (Allied)	unused	Laura Collins	
NAS Alameda	1 & 2	Laura Collins	118
Oakland Airport	2	Leora Feeney	na
San Luis Obispo/Santa Barbara Counties			
Mussel Rock Dunes	1	Morgan Boucke	31
Pismo Dunes	1	Rob Burton	64
San Antonio Creek	unused	Morgan Boucke	
Vandenberg AFB, S-5*	1	Alan Naydol	12
Purisma Point (VAFB)	1	Alan Naydol	21
Santa Ynez River Mouth	unused	Morgan Boucke	
Ventura County			
Santa Clara River	unused		
McGrath Beach: 3 sites	1	Morgan Boucke	6
Ormond Beach: Edison	2	Morgan Boucke	13
Middle Site*	2	Morgan Boucke	13
Perkins Rd	2	Morgan Boucke	23
Point Mugu	2	Ron Dow	na
Los Angeles/Orange Counties			
Venice Beach	1	Carolee Caffrey	52
Terminal Island	unused	Kathy Keane	
Seal Beach	1	Mari Hoffmann-Nelson	24
Bolsa Chica	1	Margaret Rubega	23
Huntington Beach	1	Jack Fancher	23
Newport Slough*	1	Jack Fancher	23
Upper Newport Bay	2	Margaret Rubega	20

San Diego County			
White Beach	1	L Belluomini	61
Santa Margarita River:			
North Beach	1	L Belluomini	68
Saltflats	1	L Belluomini	67
Saltflats Isl	1	L Belluomini	67
Buena Vista Lagoon*	2	John Konecny	9
Aqua Hedionda	unused	John Konecny	
Batiquitos Lagoon: NE	1	John Konecny	20
Park and Ride	unused	Elizabeth Copper	
Mouth	1	John Konecny	20
San Elijo Lagoon	1	Robert Patton	46
San Diequito Lagoon*	1	John Konecny	20
Los Penasquitos	unused	John Konecny	
Mission Bay: FAA Isl	1	Jennifer Price	27
Mariner's Point	1	Ginger Johnson	49
N Fiesta Isl*	1	Brian Foster	21
Crown Point	unused	Elizabeth Copper	
Stony Point	unused	Elizabeth Copper	
South Shores	unused	Elizabeth Copper	
Cloverleaf	unused	Elizabeth Copper	
Lindbergh Field	unused	Elizabeth Copper	
Naval Training Center	unused	Elizabeth Copper	
NAS North Island	1	Elizabeth Copper	88
Delta Beach: North	1	Elizabeth Copper	125
South*	1	Elizabeth Copper	55
Grand Caribe Island	unused	Elizabeth Copper	
D Street Fill	1	Brian Foster	47
Chula Vista Wldlf Res	1	Brian Foster	45
Salt Works	1	Jennifer Price	21
Tijuana River: North	1	Robert Patton	27
South	1	Robert Patton	27

Table 2. Chronology of California Least Tern reproductive activities, 1992. For date of arrival, "earlier than or equal to" indicates terns were already present on the first day of monitoring. "Later than or equal to" for departure indicates last day terns observed, although actual departure date could be later. Second wave occurrence was determined for each colony: if yes, beginning date is provided; if no, date provided is that through which "lack of" determination was made; nr reflects a "not really" sentiment on mid-season or final Site Report (no clear-cut demarcation between waves existed). First Egg, Chick, and Fledgling dates indicate actual date, if known, or the first date observed ("earlier than or equal to").

Table 2.

	Activity Period			Date of First		
	Arrive	Depart	Second Wave?	Egg	Chick	Fledgling
PGE, Pittsburg	≤5/1	na	no,7/28	5/10-15	≤6/2	≤6/23
NAS Alameda	4/25-29	na	yes,6/13	≤5/5	5/28	6/17
Oakland Airport	4/29	8/27	no,8/27	5/19		
Mussel Rock Dunes	4/26-30	7/31-8/4	nr,6/25	5/25-28	≤6/17	≤7/16
Pismo Dunes	5/10	8/8	no,9/5	5/20	6/7-10	7/1
Vandenberg AFB, S-5	≤6/4	8/17	yes,7/12	≤6/4	na	≤7/12
Purisma Point (VAFB)	5/1-6	8/12	no,8/17	≤5/28	6/16	7/4
McGrath Beach: 3 sites	4/20	na	nr,7/1	5/9-16	6/6	≤7/1
Ormond Beach: Edison	≤5/25	≥7/6	no,7/2	5/27	6/25	na
Middle Site	≤5/25	≥7/6	no,7/2	≤6/9	≤7/4	na
Perkins Rd	5/7	8/13	no,7/2	≤5/16	≤6/20	≤6/25
Point Mugu	≤4/24	8/3	yes,6/13	≤5/15	≤6/12	≤6/22
Venice Beach	4/20	≥8/3	yes,6/9	4/28	5/27	≤6/21
Seal Beach	4/3	7/31	yes,6/4	4/29	5/12	5/29
Bolsa Chica	≤4/28	7/13	yes,6/7	≤4/28	5/11	≤6/22
Huntington Beach	≤4/24	7/10	yes,6/15	≤5/8	≤5/25	≤6/12
Newport Slough	≤4/24	7/10	no,7/10	≤5/22		
Upper Newport Bay	4/28	≥7/6	no,7/1	≤5/10	≤6/2	≤6/26

White Beach	4/30	7/19	no,7/19	5/12	6/4	6/27
SM River: North Beach	4/19	8/15	no,8/15	5/7	5/28	6/23
Saltflats	4/19	8/15	no,8/15	5/11	6/2	6/23
Saltflats Isl	4/19	8/17	no,8/15	5/9	6/2	6/23
Buena Vista Lagoon	5/10	8/16	no,8/16	≤6/14		
Batiquitos Lagoon: NE	5/10	8/16	yes,6/20	≤6/24	≤7/24	≤8/2
Mouth	5/3	8/16	no,8/16	6/14		
San Elijo Lagoon	4/12	9/1	nr/6/14	5/11	6/3	6/29
San Diequito Lagoon	5/31	7/24	no,8/30	≤5/29	≤6/7	na
Mission Bay: FAA Isl	4/18	na	yes,6/9	5/11	6/2	6/27
Mariner's Point	4/22	7/30	no,7/30	5/9	5/26	6/20
N Fiesta Isl	≤5/14	7/22	yes,6/24	5/14	6/7	7/8
North Island NAS	4/10	7/18	yes,6/8	5/8	6/2	6/27
Delta Beach: North	4/12	9/10	yes,6/12	5/16	6/6	6/26
South	4/26	7/4	no,9/17	5/22	6/12	7/3
D Street Fill	4/10	7/11	no,8/15	5/2	5/24	6/20
Chula Vista Wldlf Res	4/30	8/8	yes,6/2	6/2	6/23	7/4
Saltworks	4/28	na	yes,6/25	6/5	6/25	>7/17
Tijuana River: North	≤4/21	9/1	yes,7/3	6/4	6/27	7/16
South	≤4/21	9/1	yes,na	5/16	6/4	7/2

Table 3. First wave totals for 1992 California Least Tern breeding season. Type 1 colonies are monitored from the inside; Type 2 from the outside. Total Nests includes known renests of first wave pairs. Total Pairs includes 3 at Mussel Rock Dunes that had not yet begun breeding, and are followed by numbers of first wave pairs at each colony in 1991, where available (in parentheses). Total Eggs not available at Type 2 colonies.

	Colony Type	Total Nests	Total Pairs	Total Eggs
PGE, Pittsburg	2	2	2 (2)	≥5
Port Chicago (Allied)	2	0	0 (0)	0
NAS Alameda	1 & 2	115	111 (97)	≥240
Oakland Airport	2	2	2 (0)	na
Mussel Rock Dunes	1	19	22 (30)	35
Pismo Dunes	1	3	4	5
VAFB S-5	1	2	2	4
Purisma Point (Vandenberg)	1	18	15 (10)	37
Santa Ynez River		0	0 (0)	0
Santa Clara River		0	0 (2)	0
McGrath Beach, n and s	1	24	24 (23)	46
Ormond Beach: Edison	2	4	4 (3)	na
Perkins Rd	2	9	9 (9)	na
Middle Site	2	5	5	na
Point Mugu	2	na	107	na
Venice Beach	1	247	193 (180)	346
Terminal Island		0	0	0
Seal Beach	1	182	189	368
Bolsa Chica, South Island	1	122	122	243
Huntington Beach	1	130	130 (31)	259
Newport Slough	1	1	1	na
Upper Newport Bay	2	46	46	na
White Beach	1	31	31 (25)	66
Santa Margarita River:				
North Beach	1	270	269 (219)	532
Saltflats	1	36	36 (24)	69
Saltflats Island	1	29	29 (25)	56
Buena Vista Lagoon		3	3 (0)	7

Aqua Hedionda Lagoon		0	0 (0)	0
Batiquitos Lagoon: mouth	1	3	3 (24)	5
Park and Ride		0	0 (11)	0
East		0	0 (0)	0
San Elijo Lagoon	1	22	22 (13)	45
San Dieguito Lagoon	1	7	7 (0)	14
Los Penasquitos Lagoon		0	0 (0)	0
Mission Bay: FAA Island	1	158	158 (120)	276
Mariner's Point	1	126	120 (125)	235
N. Fiesta Island	1	5	5 (0)	10
Crown Point	1	0	0	0
Stony Point		0	0 (0)	0
South Shores		0	0 (0)	0
Cloverleaf		0	0 (0)	0
North Island NAS	1	49	49 (28)	96
Delta Beach: north	1	23	23 (32)	42
south	1	1	1	2
Grand Caribe Island		0	0 (0)	0
D Street Fill	1	135	135 (44)	244
Chula Vista Wildlife Res.	1	0	0	0
Saltworks	1	8	8 (40)	14
Tijuana River Estuary: nth	1	4	4 (1)	6
sth	1	39	39 (54)	79
TOTAL			1930	≥3386

Table 4. Totals for 1992 California Least Tern breeding season. Total Pairs and Fledglings/Pair numbers are followed by mean 1991 data (in parentheses). McGrath Beach 1991 comparison data include Santa Clara River site. Ormond Beach 1991 data are pooled for the 3 sites, as are 1992 Total Fledglings and Fledglings/Pair. Venice Beach Total Nests includes first 39 preyed on by crows prior to their completion. Any discrepancy between 1992 Total Pairs and Total Nests reflects renesting attempts by pairs.

Table 4.

	Total Pairs	Total Nests	Total Fledglings	Fledglings/ Pair
PGE, Pittsburg	2 (2)	2	1	.50 (1.5)
NAS Alameda	121-130 (110)	138	215-221	1.65-1.83(1.25)
Oakland Airport	2 (0)	2	0	0
Mussel Rock Dunes	28-29 (35)	29	8-10	.28-.36 (.77)
Pismo Dunes	4 (6)	4	1-2	.25-.50 (.67)
Vandenberg AFB, S-5	6	6	3	.50
Purisma Point (VAFB)	12 (10)	20	1	.08
McGrath Beach: 3 sites	26 (26)	26	35	1.35
Ormond Beach: Edison	4	4		
Middle Site	5 (12)	5	17	.94 (1.08)
Perkins Rd	9	9		
Point Mugu	133 (50)	na	72	.54 (1.14)
Venice Beach	229 (198)	275	245	1.07 (1.01)
Seal Beach	219 (189)	219	250-300	1.14-1.37(1.5)
Bolsa Chica	131 (159)	131	32	.24 (.6)
Huntington Beach	138 (72)	150	31	.23 (.71)
Newport Slough	1 (0)	1	0	0
Upper Newport Bay	46 (90)	46	11	.24 (.34)

White Beach	31 (33)	31	11	.36 (1.58)
SM River: North Beach	269 (259)	270	166	.62 (1.14)
Saltflats	36 (36)	36	19	.53 (1.22)
Saltflats Isl	29 (33)	29	16	.55 (1.18)
Buena Vista Lagoon	3 (0)	3	0	0
Batiquitos Lagoon: NE	8 (0)	8	3-5	.38-.63
Mouth	3 (24)	3	0	0 (1.29)
San Elijo Lagoon	22 (12)	35	2	.09 (.42)
San Diequito Lagoon	7 (0)	7	0	0
Mission Bay: FAA Isl	158 (125)	182	≥52	≥.33 (.99)
Mariner's Point	120 (125)	128	70	.58 (1.04)
N Fiesta Isl	5 (0)	7	2	.40
North Island NAS	49 (28)	52	5	.10 (.89)
Delta Beach: North	38 (35)	40	20-30	.53-.79 (.57)
South	1 (0)	1	1	1
D Street Fill	135 (46)	135	14-24	.10-.18 (.87)
Chula Vista Wldlf Res	20 (1)	20	16-21	.80-1.05 (0)
Saltworks	8 (31)	16	≥5	≥.63 (.32)
Tijuana River: North	4 (1)	5	7	1.75 (0)
South	39 (63)	65	31	.80 (.44)
Total	2101-2111 (1830)		≥1362-1448 (1784)	.65-.69 (.98)

Table 5. Clutch sizes and hatching success for nests in Type 1 colonies. Venice Beach data do not include first 39 nests preyed on by crows prior to their completion. The Saltflats site at the Santa Margarita colony had one nest with a clutch size of 4 (not shown). "Unsure" denotes either the number of nests abandoned or preyed upon prior to completion at Type 1 colonies (thus actual clutch size unknown), or the total number of nests at Type 2 colonies (thus Total Number of Eggs not available). Mean clutch size ± Standard Deviation provided for known clutch sizes only.

Table 5.

Clutch Size

	1	2	3	Unsure	X ± SD	Total Eggs	% Hatch
PGE, Pittsburg		1	1		2.5±.71	5	100
NAS Alameda	19	94	11		2.01±.54	276	88
Oakland Airport				2		na	0
Mussel Rock Dunes	9	20			1.69±.47	49	63.3
Pismo Dunes	1	3			1.75±.5	7	na
Vandenberg AFB, S-5		6			2	12	50
Purisma Point (VAFB)	2	17	1		1.95±.39	29	na
McGrath Beach: 3 sites		26			2	52	na
Ormond Beach: Edison				4		na	
Middle Site				5		na	
Perkins Rd				9		na	
Point Mugu				na		na	
Venice Beach	58	159	6	17	1.77±.48	394	91
Seal Beach	44	161	14		1.86±.5	408	95.3
Bolsa Chica	17	104	9	1	1.94±.45	252	74-85
Huntington Beach	22	120	8		1.91	286	84.6
Newport Slough				1		na	
Upper Newport Bay				46		na	

White Beach		27	4		2.13±.34	66	95.5
SM River: North Beach	26	226	18		1.97±.4	532	89.3
Saltflats	5	30			1.92±.5	69	79.7
Saltflats Isl	4	23	2		1.93±.46	56	83.9
Buena Vista Lagoon		2	1		2.33±.58	7	0
Batiquitos Lagoon: NE	1	7			1.88±.35	15	40
Mouth	1	2			1.67±.58	5	0
San Elijo Lagoon	5	25	5		2.0±.54	70	15.7
San Diequito Lagoon	1	5	1		2.0±.58	14	21.4
Mission Bay: FAA Isl	55	121	4	2	1.72±.5	309	59.9
Mariner's Point	20	106	2		1.86±.39	238	70-82
N Fiesta Isl	2	5			1.71±.49	12	83.3
North Island NAS	6	44	2		1.92±.39	100	73
Delta Beach: North	11	29			1.73±.45	69	60.9
South		1			2	2	100
D Street Fill	30	101	4		1.81±.47	244	62
Chula Vista Wldlf Res	7	13			1.65±.49	33	76
Saltworks	6	10			1.63±.5	26	80.7
Tijuana River: North	2	3			1.6±.55	8	87.5
South	11	51	3		1.88±.45	122	41

Table 6. Causes of California Least Tern breeding failure. Documented and suspected avian and mammalian predators are indicated, as well as other sources of mortality. An asterisk next to predator species indicates that predator-control measures were taken, most often by ADC. Birds: CT - Caspian Tern, Cr - American Crow, G - gull species, GBT - Gull-Billed Tern, H -Harrier, K - American Kestrel, L - Loggerhead Shrike, M - Meadowlark, PF - Peregrine Falcon, R - Raven. Mammals: C - Domestic Cat, Cy - Coyote, D - Domestic Dog, F - Red Fox, FC - Feral Cat, FD - Feral Dog, Op - Opossum, Rc - Raccoon, Sk - Striped Skunk, W - Weasel. Yni: predation definitely occurred; regarding predator species, you name it, it was on suspected predator list. Other: A - Ant, FP - Fencing Problems (1: mesh too big and chicks escaped, 2: chicks killed by hot fence), Hu - Human foot traffic caused egg or chick mortality, Hy - Hypothermia, FS - Food Shortage associated with El Niño, V - Vehicles.

Table 6.

	Predation				
	Documented		Suspected		Other
	Bird	Mammal	Bird	Mammal	
PGE, Pittsburg			yni	yni	
NAS Alameda			G		Hy
Oakland Airport		F*			
Mussel Rock Dunes				Cy	Hu,FS
Pismo Dunes					
Vandenberg AFB, S-5				Cy	
Purisma Point (VAFB)		Cy	K		
McGrath Beach: 3 sites					
Ormond Beach: Edison					
Middle Site					
Perkins Rd					
Point Mugu	PF		K		
Venice Beach	Cr*,G				
Seal Beach			G		Hu,FP1,FP2
Bolsa Chica			M		
Huntington Beach			K		FS
Newport Slough			Cr		
Upper Newport Bay					

White Beach	G				FS
SM River: North Beach	G				FS
Saltflats					FS
Saltflats Isl					A,FS
Buena Vista Lagoon				Rc	
Batiquitos Lagoon: NE			K,L	Rc	
Mouth					
San Elijo Lagoon	R	Rc,Cy	yni	yni	Hu
San Diequito Lagoon				D,C	Hu
Mission Bay: FAA Isl	G*,PF				A*
Mariner's Point	G				Hu,A,FS
N Fiesta Isl			K*,L*		FS
North Island NAS	G		yni	Sk*,FC*,Op*	FS
Delta Beach: North			yni	FC,Sk	FS
South					
D Street Fill	L*,K*,H,PF,GBT*			FD*,FC*,Sk*	FS
Chula Vista Wldlf Res	R				
Saltworks			R,PF,GBT,CT	FC	
Tijuana River: N and S	G		yni	FD,W,yni	Hu,V

Table 7. Sources of nesting site disturbance: there was no direct evidence of actual predation or mortality caused by indicated sources, however, sources were either (1) known predators present at site prior to or during season and removed (*), (2) obvious to monitors, and/or (3) present and suspected to be the cause of abandonment. Human disturbance was pedestrian or vehicular in nature. Unsp: unspecified in mid-season or final report. Vg: vegetation overgrowth interfered with nesting. Unkn: source unknown, but something caused abandonment by several pairs early in the season. All other abbreviations as in Table 6.

	Human	Animal	Other
PGE, Pittsburg		FD*	
NAS Alameda		PF,FC*,H*	
Oakland Airport		Sk*	
Mussel Rock Dunes			
Pismo Dunes	Veh		
Vandenberg AFB, S-5			
Purisma Point (VAFB)	Veh		
McGrath Beach: 3 sites	Veh		
Ormond Beach: Edison	Veh		
Middle Site	Ped,Veh	D	
Perkins Rd	Ped		
Point Mugu			
Venice Beach			
Terminal Island		Cr	
Seal Beach			
Bolsa Chica			
Huntington Beach		K	
Newport Slough			
Upper Newport Bay			
White Beach	Ped,Veh	Unsp*	

SM River: North Beach	Ped,Veh	Unsp*	
Saltflats	Ped,Veh	Unsp*	
Saltflats Isl	Ped,Veh	Unsp*	
Buena Vista Lagoon		G,yni	
Batiquitos Lagoon: NE	Ped,Veh	D	
Mouth			Vg
San Elijo Lagoon	Ped		
San Diequito Lagoon	Ped, Veh	D,C,G,Rc,H	
Mission Bay: FAA Isl		PF	
Mariner's Point			
N Fiesta Isl		PF	
North Island NAS		A*,PF	
Delta Beach: North		A*,Unsp*	
South		Unsp*	
D Street Fill		FD*,PF,H	
Chula Vista Wldlf Res			
Saltworks		Unsp*	Unkn
Tijuana River: N and S	Ped		