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CALIFORNIA LEAST TERN BREEDING SURVEY

1994 SEASON

by

Carolee Caffrey

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ABSTRACT

In 1994, a minimum of approximately 2,792 pairs of the endangered California least tern (Sterna antillarum browni) nested at 36 sites along the coast of California. This 20% increase over 1993 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 2,792 pairs is the highest number recorded since systematic monitoring began in 1973, and represents a four-and-a-half-fold increase over the estimated 600 pairs of that year. Unfortunately, in 1994, heavy predation pressure at many sites and an apparent food shortage at two large sites, combined with a variety of human-related constraints on tern reproductive success, resulted in poor fledgling production statewide. A minimum of approximately 1755-1871 fledglings were produced, 11% fewer than in 1993, resulting in a statewide fledgling per pair ratio of 0.62-0.67. Documented and suspected predator species across the State ran the usual gamut; however, kestrels, crows, ravens, rats, and a peregrine falcon were responsible for the loss of the majority of terns and tern eggs lost to predation in 1994.

As usual, successful and unsuccessful sites were distributed throughout the state. Terns themselves were more unevenly distributed: 48% of the statewide population bred at only four sites (Venice Beach, Huntington Beach, Santa Margarita River/North Beach, Mission Bay/FAA Island); inclusion of an additional five sites (NAS Alameda, Seal Beach, Bolsa Chica, Delta Beach/North, Tijuana River/South) accounted for 76% of all breeding pairs. And, again as usual, the bulk of fledglings produced statewide came from only a few sites; those produced at NAS Alameda, Venice Beach, Seal Beach, Santa Margarita River/North Beach, Mission Bay/FAA Island, and Delta Beach North comprised approximately 70% of the State total.

[1] Caffrey, C. 1995. California least tern breeding survey, 1994 season. Calif. Dep. Fish and Game, Wildl. Manage. Div., Bird and Mammal Conservation Program Rep. 94-3, Sacramento, CA. 49 pp.

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 negatively affect tern reproductive success. 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 almost four-fold increase in breeding population size from approximately 600 pairs in 1973 to approximately 2321 pairs in 1993. These efforts were continued in 1994, and the data are summarized herein.

METHODS

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. Separate sites within the same colony appear as indentations under colony location in Table 1, except those under "San Diego Bay"; terns in this cluster of colonies may share foraging areas, yet nesting areas are distinctly separate.

As part of the Batiquitos Lagoon Enhancement/Restoration Project, a brand new tern site was created on the north side of the lagoon mouth (north of the historical site Batiquitos Lagoon/Mouth) just east of U.S. 1. Construction took place in March 1994: iceplant was removed, a substrate was added, permanent fencing was erected on the north and west sides, chick fencing was placed around the entire perimeter, and signs were posted.

Statewide censuses of known California least tern breeding sites 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 least tern breeding sites in the State of California for which information was received for 1994. 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 1994a). Additionally, the actual final Site Reports used to prepare this survey are available through CDFG offices in Sacramento. These reports often contain many more details regarding site preparation, data collection, predation and disturbance problems and procedures than can be included here; readers interested in such additional information are encouraged to request copies.

For 1994, breeding data were collected at all known Californian sites (except possibly Pt. Mugu); requested data are reported here with the following exceptions: No reports or data were received from Pt. Mugu, although breeding terns were apparently present, thus data for this site are indicated as "not available." No reports were received for the four sites at Camp Pendleton (data included in Tables 1 and 4 were obtained via phone calls), thus many types of data (dates, clutch sizes, and information regarding site preparation, first-wave nesting, and sources of breeding failure) are lacking. A mid-season, but no final, Site Report was received for Naval Air Station (NAS) North Island, and only incomplete final reports were received from Naval Training Center and the three sites at Delta Beach; many types of data are therefore missing for these sites as well. (Official names for these military sites, and others throughout the State, can be found in the Appendix (page 22); throughout this report they are referred to as in Table 1.) Only an incomplete final Site Report was received for Lindbergh Field, and Unocal (who owns the land) placed restrictions on releasable data for Guadalupe Dunes; these sites, too, are lacking many types of information.

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 closely enough for monitors 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 (terns breeding or not), estimates of total number of breeding pairs present, and estimates of total number of fledglings produced. Fledgling counts are generally made at nocturnal roosting areas at three-week intervals, and

summed for the season (Massey 1989, Caffrey 1994a). Throughout the season, 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 numbered 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 and determine the presence of nests from the location of incubating adults; many types of data are therefore unavailable, e.g., clutch sizes and actual hatching dates. The "site" at Pismo Dunes is unusual enough to rate its own category (Type 3): the whole area is quite large and no "traditional" nesting site exists. Monitors search/observe throughout the season for least terns; if nesting terns are found outside of protected areas (Pismo Dunes is a State vehicular area; otherwise suitable nesting areas are subject to high levels of vehicular disturbance; Park officials cordon off particularly suitable areas prior to tern arrival in the hope that those will be chosen by nesting terns), short-term protection policies go into effect. Individual nests are then monitored regularly. As such, "number of visits" (Table 1) is somewhat meaningless.

Site preparation prior to the arrival of terns also varies from site to site. According to information included in mid-season and final Site Reports, vegetation was cleared by hand (Pacific Gas and Electric [PG&E] Pittsburg, NAS Alameda, Oakland Airport, Santa Clara River/Mouth, Venice Beach, Seal Beach, Mission Bay/FAA Island and Mariner's Point), mechanically (Terminal Island, Huntington Beach, Newport Slough, NAS North Island, D Street Fill, Chula Vista Wildlife Reserve), or with the use of herbicides (NAS Alameda). Accumulated litter or storm debris was removed (NAS Alameda, Venice Beach, NAS North Island), holes in concrete or tarmac substrate were filled/covered to prevent tern chicks from falling in (PG&E Pittsburg, NAS Alameda), and water level control was attempted at San Elijo Lagoon. Sand was cleared away from fencing to expose the chick fence at Venice Beach, added to the site as substrate at NAS North Island, and pushed into berms to restrict human access at Tijuana River South. Permanent fencing at sites was repaired (NAS Alameda, Vandenberg Air Force Base (VAFB) Purisima Point, Venice Beach, Seal Beach, NAS North Island), temporary site fencing was erected (Pismo Dunes, Mussel Rock Dunes, Santa Clara River/Mouth, Tijuana River North), and chick fencing was replaced (Terminal Island) or added to (Mission Bay/Mariner's Point). Signs were posted at Pismo Dunes, Mussel Rock Dunes, Santa Clara

River Mouth, San Elijo Lagoon, and Tijuana River North and South. Decoys were laid out to attract terns to particular areas at Pismo Dunes, VAFB Beach 2, VAFB Purisima Point, Terminal Island, Newport Slough, Batiquitos Lagoon/W-l, and NAS North Island. Crow carcasses were placed inside the perimeter fence at Venice Beach, and along with raven carcasses on site at D Street Fill, to deter crows (and ravens) from entering the site.

Site preparation also included predator removal at several sites. All military sites have permanent U.S. Department of Agriculture, Animal and Plant Health Inspection Services, 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. ADC was also on site at Batiquitos Lagoon/W-l prior to tern arrival. Pre-season predator removal occurred at Terminal Island as well.

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).

In this report, unless otherwise cited, data for the following years were taken from the indicated sources: 1987 and 1988 (Massey 1988), 1989 (Massey 1989), 1990 (Obst and Johnston 1992), 1991 (Johnston and Obst 1992), 1992 (Caffrey 1993), and 1993 (Caffrey 199433).

RESULTS

Distribution - In 1994, California least terns were reported to have nested at 36 sites from the San Francisco Bay area south to the Mexican border (Table 1). Terns returned to Lindbergh Field in San Diego after a hiatus of four years, and to Guadalupe Dunes (north of the Santa Maria River mouth) in San Luis Obispo County after several years, without the aid of decoys, site preparation, or any other type of human-related enticement. Two brand-new sites were added to our list in 1994: seventy-two pairs of terns nested at Batiquitos Lagoon/W-l, and a lone pair bred on the west side of Highway 75 on the Silver Strand, San Diego (on the Naval

Amphibious Base, Coronado: Delta Beach/Ocean), the latter presumably a case of natural expansion of/spillover from nearby Delta Beach North and South.

Of historical sites not used by breeding terns in 1994, many have been tern-less for several years ("unused1" in Table 1), due to a combination of an abundance of predators and/or humans in the area, vegetation overgrowth, and the lack of financial resources and effort on the part of agencies with the power to enhance, and enforce the protection of, these areas. Others ("unused2") were sites at which nesting had occurred in the last couple of years. For three of those (Oakland Airport, Newport Slough, and Batiquitos Lagoon/Northeast), courtship flights and fish exchanges (and even scrapes at Oakland Airport) were observed, yet terns chose to nest elsewhere, likely in response to an abundance of predators (especially red foxes) at Oakland Airport, and a combination of factors at Newport Slough, including the nearby residential trailer park (complete with dogs, kids, loud music, and lots of predator-friendly perch sites), lots of predators (Table 7), a lack of natural "dune" vegetation, and the lack of "a view" (a function of the "boxed-in" nature of the site). For three others, lack of nesting could be attributed to inundation of the Mouth site and Park and Ride site at Batiquitos Lagoon, and, for the heavily-disturbed-in-the-past site at Tijuana River North, the apparent enhancement of the site south of the river mouth. Extension of the border fence into the surf zone, fencing repair, construction of sand berms, increased Immigration and Naturalization Service presence, and improved communication between Border Patrol and USFWS all contributed to making Tijuana River South more attractive to terns, and apparently underlay their decision to abandon, at least temporarily, the site north of the river mouth.

Breeding Chronology - First-wave breeders began arriving at breeding areas from mid to late April through mid May; nesting began l-3 weeks later (Table 2). Most sites had eggs in nests by mid to late May, chicks by early to mid June, and fledglings by late June to early July. Definitive second wave nesting was reported at 15 sites; at three sites the second wave was minor, and no second wave was evident at 12 sites. Two sites apparently had only second wave nesters (Pismo Dunes, Ormond Beach/Middle Site). Terns began departing some breeding areas in late June/early July, but remained at others until late August/early September.

In an attempt to discern the pattern of nesting across the State, monitors were asked to report the number of active nests ("active" defined as a scrape with eggs or chicks, attended by adult terns, Caffrey 1994a) at each site on each Saturday (+1 day) throughout the season. Data from only 19 of 36 sites were received (Figure 1); even so, emergent patterns were quite interesting. Nesting began in earnest earliest at sites in Los

Angeles and Orange counties. Venice Beach had the only nests in the State during the week ending April 30 (n=7), and 151 nests the following Saturday (60% of the State total) when nesting was just beginning at other Los Angeles/Orange County sites, but had not begun anywhere else. On that Saturday (May 7), nests at Venice Beach and Bolsa Chica combined comprised 85% of all nests in the State. Except for NAS Alameda (the furthest north) and Mariner's Point and FAA Island in Mission Bay, San Diego, nesting at all other sites for which data were received did not really begin until the week ending May 21. Second wave nesting is evident in the shape of the "North" curve; both Mussel Rock Dunes and VAFB Purisima Point had clear-cut second waves. Where second wave nesting occurred in central and southern California it was less pronounced, yet is reflected in the rightward skew of those curves.

First Wave - Because of the lack of data from Pt. Mugu and Camp Pendleton, the "total" of 2118-2123 first wave pairs (Table 3) likely underestimates the actual total by several hundred. Dramatic increases in the number of first wave pairs, relative to 1993, occurred at several sites (Table 3); at a few, this translated into a substantial number of birds (e.g., Venice Beach, Huntington Beach, FAA Island). Two of the large increases were associated with two noteworthy decreases: the large increase at FAA Island was at least in part due to many first wave pairs abandoning nearby Mariner's Point in response to intense egg predation by rats (75 nests lost), and the increase/decrease relationship between the two Tijuana River Mouth sites (discussed above).

Season Totals - Excluding data from Pt. Mugu, approximately 2777-2807 pairs of California least terns nested statewide in 1994 (Table 4). Relative to 1993, some sites experienced dramatic increases in the total number of nesting pairs present; at others, dramatic decreases (Table 4). Many of the increases likely reflect the 20% increase in statewide population size; Venice Beach stands out as accounting for 21% of the overall increase. At Terminal Island, removal of crows, ravens, and kestrels (sources of severe breeding failure in the past) prior to tern arrival likely played a part in the jump in numbers at that site (1991: 2, 1992: 0, 1993: 10, 1994: 31); factors contributing to the large increases at FAA Island in Mission Bay and Tijuana River/South, and the associated decreases at nearby Mariner's Point and Tijuana River/North, have been discussed above. The success in attracting 72 pairs to the new W-l site at Batiquitos Lagoon was likely facilitated by the lack of predation and people-related problems that have plagued the historic sites on the lagoon in the past, and the fact that two of them (Mouth, and Park and Ride) were essentially underwater. The decrease at D Street Fill may be noteworthy in that it appears terns may be (at least in the short-term) abandoning the site in response to intense predation pressure in the past (1992: 135 pairs (its highest number), F/P=0.10-0.18; 1993: 23 pairs (a 470% decrease), F/P=.04; 1994: 8 pairs).

In 1994, 48% of the statewide population bred at only four sites (Venice Beach, Huntington Beach, Santa Margarita River/North Beach, Mission Bay/ FAA Island); the addition of five more sites (NAS Alameda, Seal Beach, Bolsa Chica, Delta Beach/North, Tijuana River/South) accounts for 76% of the breeding population of California least terns.

Approximately 1755-1871 fledglings, again excluding those from Pt. Mugu, were produced in 1994, resulting in a statewide fledgling-to-pair ratio of 0.62-0.67. Successful sites (those with fledgling-to-pair ratios greater than or approximately equal to 0.7, an estimated "sustainable" F/P, see Fancher 1992), were distributed throughout the State. As usual, the bulk of fledglings produced statewide came from only a few sites; those produced at NAS Alameda, Venice Beach, Seal Beach, Santa Margarita River/North Beach, Mission Bay/FAA Island, and Delta Beach/North comprised 70% of the State total.

Clutch Size - Clutch size at Type 1 sites ranged from 1 to 3 (Table 5), with a statewide X = 1.87 (n=2333 nests). Hatching success at Type 1 sites ranged from 18-1008, with a mean of approximately 70.7%.

Sources of Breeding Failure - Predation was the major cause of breeding failure at most sites in 1994 (Table 6); documented and suspected predators included by-now familiar species, although kestrels, crows, ravens, rats, and a peregrine falcon were responsible for the loss of the majority of terns and tern eggs lost to predation in 1994. Prior to their removal, kestrels took 34-39 chicks/fledglings at NAS Alameda (a single female was observed to take 5 chicks in one day), and ravens took 12-13 chicks at the end of the season; 9-10 early nest abandonments were also suspected to be the result of predation. At Terminal Island, predation by kestrels, crows, and ravens resulted in the loss of 94-97% of potential fledged young, and the removal of all remaining eggs and chicks on July 3 by crows and ravens caused the early abandonment of the site. At Huntington Beach, a kestrel took at least 3 chicks/day for several weeks (>80 chicks) while avoiding capture, and was felt to be the reason underlying abandonment of a large number of eggs by terns at that site (n=188; 35% of all eggs laid). A peregrine falcon eluded capture at FAA Island, killed at least 3 adult terns, and was estimated to account for 88% of chick/fledgling losses. Egg predation by rats resulted in the loss of 75 nests and the subsequent abandonment of the site by many first-wave pairs at Mariner's Point. Crow and coyote predation was believed to underlie the low breeding success at VAFB Purisima Point (tracks of both were observed throughout the site); a coyote was also thought to have gotten the chicks produced in the single nest at nearby VAFB Beach 2. At least one unidentified canid (tracks of both red foxes and coyotes were found on site) took at least 90 eggs from

the first 56 nests at Bolsa Chica and then never returned. Predation was also felt to be the cause of the failure of the first two nests of the two pairs at P&&E Pittsburg, the complete failure of the 9 pairs at San Elijo Lagoon, and to contribute significantly to breeding failure at Tijuana River South. Delay in enacting predator control measures at Tijuana River South apparently exacerbated the situation.

An apparent shortage of food resulted in the lowest fledgling-to-pair ratio at Venice Beach in years, and contributed to the dismal success at Bolsa Chica as well. At Venice Beach, 46 eggs were abandoned and 160 dead chicks were picked up between May 31 and August5; at Bolsa Chica, 41 chick carcasses were picked up between May 31 and July 15. In both cases, there were no external signs regarding cause of death; of 60 chicks from Venice Beach submitted to the National Biological Survey National Wildlife Health Center for analysis, four were examined and found to be emaciated and in poor condition (two had microscopic evidence of terminal dehydration), with no evidence of infectious or toxic disease. "Is it possible that the chicks were not receiving sufficient food?" ends the report. At FAA Island in Mission Bay, although several chicks and fledglings were below normal weights, and 28 young chicks were found dead on site, delivery of food to chicks may have been limiting rather than an actual food shortage, due to the intense predation pressure by a peregrine falcon (documented to be preying on adults as well as chicks and fledglings).

The combination of lots of predators, people bicycling or walking with dogs on the dikes, and the lack of chick cover (2 chicks were found hiding under a gull carcass), at Saltworks resulted in the production of only 5-7 fledglings by 52 pairs of terns. At other sites, other species' nesting activities, problems with chick fencing, high tides and possibly high temperatures all contributed to the loss of terns and tern eggs, and humans continue to directly cause tern mortality (Table 6). Particularly noteworthy with regard to humans: illegal migrant foot-traffic destroyed at least 30 nests (52 eggs) and one chick at Tijuana River South; vehicles killed at least one other chick. At Ormond Beach/Edison, 14 of 18 nests "disappeared" after the July 4th weekend, likely the victims of Independence Day celebrants.

Sources of Disturbance - Sources of site disturbance (Table 7) were believed to either underlie the abandonment of nests or whole breeding areas, or to otherwise contribute directly or indirectly to egg or chick mortality, although unequivocal evidence of the connection was lacking. Because the presence of all tern predators causes disturbance and may cause abandonment, all potential predators observed by monitors in tern nesting areas should be listed here. However, for the sake of unclutteredness, species known or suspected to have preyed on terns (so listed in Table 6) are not included in Table 7.

Disturbance resulting from human intrusion continues to ill-affect terns. Pedestrians and/or their pets cause disturbance/ flushing, if not direct mortality. Off-road vehicles (ORV) and bicycle riders drive through nesting areas. Monitors reported many other types of human-generated problems, including low-flying helicopter disturbance (Terminal Island, Huntington Beach), kite-fliers and golfers apparently inadvertently crashing kites and smacking balls into tern nesting areas (Huntington Beach, Mariner's Point), boaters landing or people wading/swimming onto the site at Mariner's Point, and teenagers intentionally attempting to run down fledglings landing in the waters surrounding FAA Island.

Fourth of July festivities are likely a problem at several sites, although information of this type is not often reported. Yet the disturbance to nesting adults, chicks, and fledglings at Venice Beach each July 4th is so intense that it warrants description again this year (included first in 1993). A nearby city-run nighttime fireworks display brings hundreds of people to the beach, many of whom proceed to ignite their own displays. As it is a public beach, only my informative urging and pleading throughout the night, together with compassionate responses on the part of often inebriated revelers, brings about any lessening of disturbance to terns by increasing the distance between booming fireworks and the perimeter fence, or altering the target direction of bottle rockets. No matter how successful my efforts, however, terns repeatedly fly up in disturbance throughout the night. Although fireworks debris is always found within the fence the next morning, and tern eggs have been abandoned in the days following the Fourth, it is impossible to attribute any particular loss to fireworks disturbance (except in the case at Ormond Beach/Edison, discussed above).

Vandalism by humans was reported at two sites; people hopped the fences at Venice Beach and Mission Bay/North Fiesta Island and stole log books, maps, and other equipment. In addition, the cars of both the monitor and ADC personnel at Tijuana River South were broken into and equipment stolen.

DISCUSSION

The steep increase in the statewide number of California least tern breeding pairs over the last six years continued in 1994. The 2792 approximation (midpoint of range) for statewide Total Pairs may be viewed as a minimum because of the lack of data from Pt. Mugu (Pt. Mugu had 133 pairs in 1992, the last year for which data were received). Thus from a recent low of 949 pairs in 1987, breeding population size had increased by 80% in 1990, to 1706 pairs (Table 8), and by 145% in 1993; the current

estimate of 2792 represents a 194% increase in the number of pairs since 1987, or almost three times the size of the population only seven years ago. 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, monitor presence, education of the public, and predator management all increase the survivorship and reproductive potential of least terns. Unfortunately, heavy predation pressure at many sites, an apparent food shortage at two large sites, and a variety of human-related constraints on tern reproductive success across the State resulted in one of the lowest fledgling-to-pair ratios recorded over those same seven years (Table 8). Approximately 1813 fledglings (midpoint of range) were added to the population in 1994 (again, excluding data from Pt. Mugu); 11% lower than the number of fledglings produced in 1993, with 20% more breeding pairs.

Throughout the State, sites experienced increases in the number of breeding pairs present as a function of both some shuffling around among sites as some were deemed unsuitable by arriving/ breeding terns, and the general increase in statewide population size. The 20% increase in statewide population size from 1993 to 1994 contradicts the generalization put forth by Fancher (1992) regarding the relationship between the fledgling-to-pair ratio in one year and the change in population size two years later: that a statewide Fledgling/Pair of approximately 0.7 results in a population size two years later that is not greatly different from the preceding year, and that greater than 0.7 leads to an increase, and less than 0.7 to a decrease, two years later relative to the preceding year. Implicit in this putative relationship are two assumptions: that any increase in population size is a function of the addition of 2-year-olds breeding for their first time, and that (with a fledgling per **individual** ratio of 0.35) approximately 35% of the breeding population dies each year. It occurred to me that, particularly in recent years, increases in breeding population size might be a function of both the addition of new breeders **and** increased survivorship of experienced breeders resulting from the time and effort we all put into predator management (including site preparation, monitor and ADC presence, and predator removal). Fewer adults dying, relative to years past, would also contribute to an increase in population size (given some average range of recruitment percentages or numbers). Although reduced mortality of breeders seems logical, and would be particularly rewarding as well, this remains speculative due to lack of relevant data.

One of the longstanding tenets of least tern breeding biology is the existence of a "second wave" of nesting (occurring later in the season than the earlier "first wave"), composed primarily of 2-year-olds nesting for their first time. Although perpetuated as if the pattern of a first-wave (early) influx of

terns, followed by a lull (in days-weeks) in nest initiation and then a second influx of breeders was typical, at many sites in recent years, nest initiation after the initial peak in the number of new nests per day has trailed off over an extended period from late May through early July rather than adhering to the pattern described above ("not really" or "minor" second waves: Caffrey 1993, 1994b, this report). Due to the lack of published, or released, data involving marked individuals, we know little about the differences between late and early nesters, except for one attempt to address this question (Massey and Atwood 1981) involving primarily one site in one year and 15 banded individuals of known age. Massey and Atwood observed a clear-cut first versus second wave of nesting, with approximately two weeks of no new nests between the two (and thus reinforced the accepted dogma). One hundred percent of marked 2-year-olds nested in the second wave (n=12), accounting for 10 of 33 second wave nests. Three marked 3-year-olds, renesting after failed first attempts, were also part of the second wave (accounting for 2 nests). No banded 2-year-olds nested at that site in the first wave of that study year. Pooling observations of marked breeders across the State from 1976-1980, Massey and Atwood (1981) reported two 2-year-olds nesting in the first wave, accounting for only 5% of marked first-wave breeders (n=41), and 16, or 76% (n=21) of second-wave breeders. This suggested that 2-year-olds breeding for their first time tend to nest later enough in the season than older, more experienced individuals that they can be distinguished. One of my intended purposes for requesting the "number of active nests on Saturday" data (Figure 1) was to determine the extent to which the double-humped pattern of first and second waves existed; I now realize I should have requested "the number of new nests" each week. Oh well.

At any rate, curious about the 20% increase in the number of breeding pairs over 1993 following a relatively low fledgling-to-pair ratio in 1992, I began to play around with some numbers, and stumbled onto a couple of interesting questions and discoveries. Although largely unanswerable, or unconfirmable, given current knowledge (or rather, ignorance) of the system, I raise the following issues so that tern people across the State can enjoy thinking about them too, and with a hopeful eye toward stimulating future research. Please keep in mind the imprecision inherent in the pair and fledgling number data, and also that 3 years do not necessarily reflect "true" patterns, yet please also recall our efforts over these 3 years to standardize data collection and reporting methodology; the numbers are probably not too far off.

To determine the number of second-wave pairs, or an approximation of the "number of pairs breeding for the first time", I subtracted the number of first wave pairs (Table 3) from the total number of pairs (Table 4) for all sites for which I had the necessary data (Caffrey 1993, 1994b, this report: in all

cases where ranges were given, midpoints were used). For the sites at Camp Pendleton and Delta Beach in 1994, for which data were not made available, I conservatively estimated 80 second-wave pairs (Camp Pendleton had 466 pairs in 1993, of which 45 nested in the second wave; Delta Beach 102 pairs, 26 second-wavers). The data appear in Table 9; from them: **(1)** For both 1992 and 1994, second-wave pairs alone do not account for the increase in pair numbers over the previous year. Hence, either many first-time-breeding 2-year-olds are nesting in the first wave, or the increase in breeding population size is also a function of either greater adult survivorship than in the past, or recruitment into the California population of least terns from elsewhere (or the recruitment of older-than-2, Californian, for-some-reason previously non-breeding adults (if they exist) to breeding status). **(2)** Comparison of the number of first-wave pairs in 1992 and 1994 with the total number of breeding pairs in the previous year reveals that even if every single breeder in the previous year survived and returned to breed in the first wave of the subsequent year, that would not be enough to account for the number of first-wave pairs: either 2-year-olds **are** nesting in the first wave in relatively large numbers, or we are experiencing some other kind of recruitment (again, given that we can be reasonably confident in our numbers). **(3)** For the odd year with respect to the above, lower number of first-wave pairs in 1993 than the total in 1992 is what one would expect, all else being equal, if some of the individuals breeding in 1992 did not survive to breed in 1993. Maybe, if whatever was causing the increase in first-wave breeders in 1992 and 1994 over totals in 1991 and 1993, respectively, is closer to "the norm", the different pattern in 1993 reflected much higher mortality of post-breeding adults in 1992 related to the increased reproductive costs associated with migrating and attempting to breed under conditions of limited food availability (the 1992 El Niño). For 1993, the number of new pairs over 1992 **can** be accounted for by only those pairs nesting late in the season (presumably first-time breeders). **(4)** Although tempting to want to attribute any increase in numbers from one year to the next to the addition of new breeders to the population, even if it calls for a reassessment of who's breeding when, the 1992/1994 relationship begs some other explanation. For 1992, if all 276 more pairs over 1991 were composed of 2-year-olds breeding for their first time, then they comprised approximately 35% of the fledglings produced in 1990. Similarly, the 215 "new" pairs in 1993 comprised approximately 24% of the fledgling cohort of 1991. So far, so good, except for the fact that these data suggest that only a small fraction (less than a third?) of the fledglings produced in any given year return to breed in California two years later. But in 1994, if all 471 more pairs than in 1993 were 2-year-olds, then approximately 67% of the individuals fledged under El Niño conditions in 1992 returned to California, at 2, to breed. I find this hard to believe, from both a "face-value" and a comparison-with-other-years point of view. Clearly, if we are to ever understand any of the above and related

mysteries, we need to, at a minimum, resume banding terns on a large scale, and to incorporate censusing of marked individuals into our monitoring protocol.

The number of sites used by nesting terns throughout the State fluctuates from year to year, as potential nesting areas become, to arriving terns, either suitable, available, or more attractive (naturally or through site preparation efforts), or unsuitable or unavailable, as a function of human, predator, or other environmental disturbance. The increase to 36 active sites in 1994 from 35 in 1993 reflects the return of terns to previously used, but recently unoccupied sites (Guadalupe Dunes and Lindbergh Field), and the colonization of two new sites, one intentionally designed for use by nesting terns (Batiquitos Lagoon/W-l) and one not (Delta Beach/Ocean). Unavailability of nesting substrates at the Mouth site and Park and Ride site at Batiquitos Lagoon (they were mostly or completely underwater, respectively) precluded nesting; non-use of these sites should be only temporary because of the planned enhancement of both in time for the 1995 season (as part of the Batiquitos Lagoon Enhancement/Restoration Project). Nesting again at Tijuana North is likely given the site tenacity of terns and their propensity to "site shift" as local conditions change (amply demonstrated by our own records of temporarily-abandon-then-return events, including Lindbergh Field and Guadalupe Dunes this year). Hopefully, agencies with the power to do so will heed requests for predator management, improved fencing and signs, and better enforcement at Tijuana River North; given the long history of terns at that site, in spite of the never-relenting sources of disturbance and mortality, it clearly has the potential to be successful.

Although I would really like to be able to do so, interpreting the chronological data is simply beyond our capabilities. Why terns began nesting earlier at Venice than anywhere else, and why so many pairs were nesting at Venice Beach and Bolsa Chica when nesting was only getting underway elsewhere in the State, particularly in light of the apparent "food problem" at those two sites, is puzzling, to say the least. Of the all-time record for Venice of 345 nests, 186 were present by May 13; about the time nesting was just beginning at sites in San Diego County. I remember several "what-the-heck-is-up?" kinds of conversations with Liz Copper and Doreen Stadtlander back then, with no real clues as to the answer. I suppose this, too, must remain for now one of those delicious, and frustrating, little tern mysteries...

Mean clutch size for Type 1 sites throughout the State (1.87) was slightly lower than, but comparable to, the mean for the six previous years (X = 1.92, 1988-1993).

Predation continues to be the major factor constraining the fledging of terns across the State, although as usual, sites hardest hit by predation were generally located in the southern and central parts of the breeding range, or rather, sites that for some reason(s) escape the devastating effects of predation (even without the aid of ADC) all happen to be located in the northern part of the range. Virtually every site in San Diego County for which data were received was negatively impacted by predation; ADC personnel were able to keep predators in check at Batiquitos Lagoon/W-l, but were unable to stop the carnage at Mariner's Point and FAA Island in Mission Bay, and protocol-related delays in effecting predator control at Tijuana River South resulted in larger losses to predation than might otherwise have been the case. As usual, predation was felt to underlie the lack of fledgling production at San Elijo Lagoon (no ADC), and contributed to low fledgling production at D Street and Saltworks. Predation was also pretty much solely responsible for the almost complete failure at Terminal Island and VAFB Purisima Point. Lack of data from all military sites, and Lindbergh Field, in San Diego County preclude examination of the factors contributing to breeding failure at those sites; this is particularly unfortunate with regard to the large and important sites at Camp Pendleton, Delta Beach, and NAS North Island.

"Food shortage" is the other major statewide factor limiting tern reproductive success, yet the manifestation of limited food is generally only demonstrable in El Niño years, when the effects are large-scale. However, something was up, or not, in the waters off Venice and Bolsa Chica in 1994, because strong indirect evidence suggested large numbers of chicks were dying of starvation. The presence of large numbers of carcasses argues against predation as the cause of death, and the lack of injury, toxins and disease organisms, plus evidence of emaciation and terminal dehydration all point to a lack of food (and therefore water). At Venice, approximately 7% (n=46) of all eggs laid were abandoned, including 12 of 17 in the last 13 nests (initiated June 12-19). Similar data for Bolsa Chica are unavailable, but given the similarities in the timing and magnitude of the die-off, it is hard to imagine that events at Venice Beach and Bolsa Chica were independent. Yet if related, Terminal Island and Seal Beach (located between Venice and Bolsa Chica), and probably Huntington Beach (very close to Bolsa Chica) as well, should have been affected. The heavy predation at Terminal Island and Huntington Beach makes it impossible to tease out any effect of food unavailability on tern breeding failure at those sites. And although the final Site Report from Seal Beach did not indicate that any chick carcasses had been found, the lower-than-usual hatching success is suggestive. In 1994, 8.3% (n=27) of 324 eggs at Seal Beach were abandoned, compared with 3% in 1993 and 4.7% in 1992 (an El Niño year, but with only minor effects evident at sites north of Huntington Beach: Caffrey 1993). (Hatching success data are unavailable for years prior to 1992, precluding

calculation of a mean for comparative purposes.) At any rate, the egregious season at Venice Beach, a large site (in terms of pair numbers) with a mean F/P = 1.12 for the previous 6 years (1988-1993), had a measurable effect on the statewide fledgling-to-pair ratio. Had Venice had a "normal" year, an (approximately) additional 162 fledglings would have been produced, bringing the statewide F/P from 0.645 to 0.71 (using midpoints of ranges for calculation).

The combination of predation and a local lack of food resulted in one of the lowest fledgling-to-pair ratios for the State in years (Table 8). Intense predation and a shortage of food underlie the majority of breeding failure in all of the not-so-successful years since 1987: predation in 1987 and 1989 (Fancher 1992), and the combined effects of El Niño, apparently negatively affecting the prey base throughout the southern part of the breeding range of terns and causing major breeding failure, compounded by heavy predation at many sites, in 1992 (Caffrey 1993).

Humans, too, remain a major constraint on tern breeding success. Foot, vehicular, and pet traffic in and around nesting areas cause the loss of eggs and chicks directly through trampling or predation, and indirectly through disturbance, resulting in nest or site abandonment, or exacerbation of predation pressure. In addition, the lack of forethought and policy on the part of the parties responsible, resulting in the lack of site preparation, monitoring protocol, and predator management at Lindbergh Field and Chula Vista Wildlife Reserve, and the lack of tern breeding success as a consequence, is inexcusable. Military exercises and an accidental "death" associated with predator control notwithstanding, people and their pets, bicycles, ORVs, helicopters, fireworks, golf balls, kites, boats, jet skis, and their penchant for juvenile behavior, bureaucratic squabbling, and vandalism, continue to negatively impact the reproductive success of California least terns.

RECOMMENDATIONS

Funding Funding Funding - Underlying many of the limits on tern reproductive success is the lack of funds available for site preparation, site maintenance, site enhancement, monitoring, and predator control. Sites throughout the State need new fencing, fencing repair, vegetation control, lagoon water level control, educational signs, predator control, and above all, monitor presence, as it is monitors who are familiar with tern breeding requirements as well as the particulars and weaknesses of individual sites. Sources of funding must be found not only for site enhancement and the establishment of new sites, but also to simply maintain the status quo (e.g., the site at Venice Beach is

really deteriorating). Sources of funding for predator management would also help to alleviate some of the intense predation pressure at CDFG contract-monitored sites without access to ADC. And again, funding for adequate monitor presence must be secured. The lack of funds for monitors in 1994 not only caused hardship for dedicated and compassionate people who deserve adequate recompense, but was also partly responsible for the loss of the first 56 nests to predation at Bolsa Chica (we could only afford to have a monitor on site twice a week; had we been there more frequently, we might have been able to thwart some of the losses).

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, on a local level, of predation, human disturbance, and future El Niño events. Individual sites are often either successful or not regarding fledgling production, and a single predator can be enough to tip the balance toward the latter. In 1994, fledglings produced at only six sites comprised approximately 70% of the State total. This points to the vulnerability of the species' recovery to local threats, and begs the establishment of new sites.

Enhancement of well-established, incipient, and potential sites remains a priority. Human-related threats to terns are ostensibly mollifiable; educating the public is one solution. Efforts to educate the public at Mussel Rock Dunes, including signs depicting nesting terns along with educational information, in both English and Spanish, and information dispensed at the kiosk upon entering the preserve, **and** the exclusion of dogs during the tern breeding season, have all greatly reduced the number of nests lost to human-related disturbance. Enclosing nesting areas within fencing so as to exclude humans, in addition to educating them (the humans), might be the best we could do under current civilization-related conditions, yet is not always possible in practice. With an eye toward approaching that ideal, however, fencing repair or better fencing, better enforcement, and/or bilingual signs are badly needed at VAFB Purisima Point, Ormond Beach, Venice Beach, San Elijo Lagoon, Mission Bay/Mariner's Point (signs visible from the water are needed), and Tijuana River. Modifications to anti-predator fencing would also make life easier for terns at VAFB Purisima Point, mammal-proof fencing at Upper Newport Bay would be a welcome addition, and again, a fox-proof fence would go far to make the otherwise lovely site at Oakland Airport almost perfect.

On another anti-predation site-enhancing note, monitors at Huntington Beach reported that the terra cotta tiles placed out as shelters were used extensively by chicks seeking refuge from predators. In direct contrast, monitors at VAFB Purisima Point reported that the wooden pallets, ceramic tiles, and PVC pipe put out to serve as chick shelters, as required by Section 7 of the Endangered Species Act of 1973 (as amended relative to the Air

Force's launch program for nearby SLC-2), not only were not used at all by least tern chicks, but served as a focus point for predators: coyote and crow tracks were found leading to and away from these structures. Monitors desire to discuss the particulars of the site at VAFB Purisima Point with USFWS personnel to see if something can be worked out.

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. Both Venice Beach and Upper Newport Bay (CDFG contract-monitored sites) are becoming overgrown and could use some help clearing vegetation as part of site preparation. Clearing all vegetation in a buffer zone around nesting areas decreases the attractiveness to predators, and is strongly recommended in appropriate situations. In a similar vein, monitors at Huntington Beach and Newport Slough wonder if there's any way we could accomplish trimming/eradicating the nonnative trees in the vicinity of these sites, to decrease the area's attractiveness to kestrels, crows, and ravens. And we are losing control of beleaguered San Elijo Lagoon (only approximately 15 fledglings in 8 years, despite 103 nesting attempts, and zero fledglings for 17 attempts in the last two years): getting a handle on the lagoon water level, people-related problems, and especially predation is absolutely required in order to maintain this area as a California least tern nesting site.

In the past, terns have returned to breed in areas unused for variable periods of time (e.g., Mission Bay/North Fiesta Island in 1992, and Santa Clara River, Terminal Island, Batiquitos Lagoon/ Park and Ride, and Naval Training Center in 1993), and 1994 saw the return of terns to Guadalupe Dunes and Lindbergh Field; 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 the Naval Training Center, as well as to new sites, for example Mission Bay/Mariner's Point and Delta Beach South in the past, and Batiquitos Lagoon/W-l in 1994. Their use at sites used year after year can direct terns to particularly suitable areas.

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 least at current levels, and **recommended that those levels increase.** 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. Again, we need more money to do this.

A strong attempt was made in 1994 to standardize and improve monitoring and reporting methodology (Caffrey 1994a); this effort will continue in 1995.

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-contract monitored 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" or "species of special concern"), 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, and soon.

With an eye toward such a program, we have attempted to improve our base of information on predator behavior and effects, and site histories, by standardizing the reporting of actual or potential predation, and requesting the filling out of Predator Sighting Sheets (Caffrey 1994a) by all monitors, when appropriate. In the future, these will contribute to the establishment of 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 severely affected by predators in the past and at sites experiencing intense predation pressure during any particular breeding season is desperately needed. In addition, crow carcasses work so well at Venice Beach at keeping live crows out of the nesting area that I strongly recommend we pursue this means of non-lethal intervention at sites plagued by crows. Monitors at D Street Fill, where crow and raven carcasses were used in 1994, reported that crow and raven presence on site appeared much reduced compared to previous years. I repeat (from last year): Can we get some stuffed ones made, so we can determine whether or not **they** work, and if so, so that we can reuse them year after year? (Obtaining sufficient numbers of dead crows each year from wildlife rehabilitation places is not a trivial endeavor.)

Future Research and a Better Understanding of Demographic Mechanisms - Resumption of a large-scale basing program and the compilation of data on marked individuals would go a long way toward increasing our understanding of survivorship patterns, the mechanisms underlying population growth, the similarities among and the differences between sites with regard to nesting patterns, and maybe even breeding decisions made by individuals (e.g., choice of mate and/or breeding site). Dare I ask: Is there anyone willing to coordinate?

ACKNOWLEDGEMENTS

Much of this section is the same as that of the 1993 report; the people working on behalf of least terns in the State of California continue to be some of the nicest and most compassionate people I am privileged to know. I have added a couple of things, and changed some names, but refuse to remove much. I remain honored to acknowledge the contributions of the many people listed here. Each one truly gave a piece of themselves to this work; their generosity and dedication were 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, pilot boats, wade through water, trudge through mud, educate the public, and endure whitewashing as they watch and walk to keep data up to date; moreover, they are forced to become coroners of sorts, like it or not, and are our first step in predator crisis management. Through it all, they somehow manage to remain open-minded, 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: Laura Collins, Leora Feeney, Rob Burton, Walter Wehtje, Krista Fahy, Mary Perry, Jack Dougherty, Edla Enberg, Jim Watkins, Carrie Phillips, Dave Peretska, Don Davis, Bobbe Dorsey, Linda O'Neill, Jan Lewison, Art Marshall, Debra Pires, Annie Fang, Kathy Keane, Cheryl Ross, Kurt Campbell, Delia Garcia, Eliodora J. Chamberlain, Mark Burkholder, Gary Gillis, Megha Patel, Alice Gibb, Doreen Stadtlander, Mark Pavelka, Ray Vizgirdas, Heather Brashear, John Burridge, Jae Chung, Brenda Kutcher, Aya Nakamura, Carrie Payne, Jamie Schumm, Suzanne Stark, Joanne Woodall, Adam Whelchel, Rob Patton, Don Grime, Brian Foster, Susan Welker, Tricia Hobell, Ginger Johnson, Marit Evans-Lang, Elizabeth Copper, Al Sanchez, Gretchen Small, D. Leasure, Melissa Mailander, Linda Belluomini, Ken Andrecht, K. Sachiko Kohatsu, John Konecny, Susan Wynn, and Carol Roberts.

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Almost lastly: wise, calm, fair, supportive, and encouraging, none of this would be possible without Ron Jurek. His love of, and concern for, these littlest of terns permeates this work.

And finally, my own very special thanks to Alice Gibb and Gary Gillis, who went seriously underpaid in 1994, and continue to buck tradition by getting **all** of their reports in on time. I'd also like to thank Ron Jurek for his careful reading of a draft of this report. But mostly I want to thank my husband, Charlie Peterson, for his ear, his understanding, his site preparation assistance, his computer wizardry, his encouragement, his editorial comments, and his unqualified support of my role in this program.

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APPENDIX: MILITARY SITES

Naval Air Station, Alameda (NAS Alameda)
Vandenberg Air Force Base (VAFB Beach 2, and Purisima Point)
Marine Corps Base, Camp Pendelton (White Beach, and Santa Margarita River/North Beach, Saltflats, and Saltflats Island)
Naval Training Center, San Diego (Naval Training Center)
Naval Air Station, North Island (NAS North Island)
Naval Amphibious Base, Coronado (Delta Beach North, South, and Ocean

Table 1. Type, primary contact, and number of breeding season visits for each site in the state of California, 1994. Type 1 sites are monitored from inside; Type 2 from the outside. Pismo Dunes unusual enough to rate its own category (Type 3); see Methods for explanation. 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 site unoccupied by nesting terns in 1994 (1: site unused for several-many years, 2: site used in recent past). Primary contacts can be reached through CDF&G office in Sacramento.

Table 1.

	Type	Primary Contact	# Visits
San Francisco Bay Area			
PGE, Pittsburg	1&2	Laura Collins	16
Port Chicago (Allied)	unused1	Laura Collins	
NAS Alameda	1&2	Laura Collins	120
Oakland Airport	unused2	Leora Feeney	90
San Luis Obispo/Santa Barbara Counties			
Pismo Dunes	3	Rob Burton	na
Santa Maria River Mouth:			
Guadalupe Dunes*	2	Walter Wehtje	39
Mussel Rock Dunes	1	Morgan Boucke	41
San Antonio Creek	unused1	Jim Watkins	
Vandenberg AFB, Beach 2	2	Jim Watkins	21
VAFB Purisima Point	2	Jim Watkins	55
Santa Ynez River Mouth	unused1	Jim Watkins	
Ventura County			
Santa Clara River: Mouth	1	Morgan Boucke	57
McGrath Beach	unused2	Morgan Boucke	
McGrath Lake	unused2	Morgan Boucke	
Ormond Beach: Perkins Rd	2	Morgan Boucke	29
Middle Site	2	Morgan Boucke	29
Edison	2	Morgan Boucke	29
Point Mugu	na	Ron Dow	na
Los Angeles/Orange Counties			
Venice Beach	1	Carolee Caffrey	61
Terminal Island	1	Kathy Keane	45
Seal Beach	1	Delia Garcia	30
Bolsa Chica	1	Carolee Caffrey	30
Huntington Beach	1	Mark Pavelka	46
Newport Slough	unused2	Delia Garcia	16
Upper Newport Bay	2	Carolee Caffrey	20
San Diego County			
MCB Camp Pendleton:			
White Beach	1	L Belluomini	66

Santa Margarita River:			
North Beach	1	L Belluomini	67
Saltflats	1	L Belluomini	61
Saltflats Isl	1	L Belluomini	61
Buena Vista Lagoon	unused2	Elizabeth Copper	
Aqua Hedionda	unused1	Elizabeth Copper	
Batiquitos Lagoon:			
W-1*	1	Adam Whelchel	85
Northeast	unused2	Adam Whelchel	
Park and Ride	unused2	Adam Whelchel	
Mouth	unused2	Adam Whelchel	
San Elijo Lagoon	1	Robert Patton	23
San Diequito Lagoon	unused2	John Konecny	
Los Penasquitos	unused1	Elizabeth Copper	
Mission Bay:			
Mariner's Point	1	Ginger Johnson	49
Crown Point	unused1	Elizabeth Copper	
FAA Island	1	Brian Foster	35
North Fiesta Isl	1	Brian Foster	38
Stony Point	unused1	Elizabeth Copper	
South Shores	unused1	Elizabeth Copper	
Cloverleaf	unused1	Elizabeth Copper	
San Diego Bay:			
Lindbergh Field*	2	Ken Andrecht	na
Naval Training Center	1	Elizabeth Copper	70
NAS North Island	1	Elizabeth Copper	na
Delta Beach: North	1	Elizabeth Copper	128
South	1	Elizabeth Copper	65
Ocean*	1	Brian Foster	12
Grand Caribe Island	unused1	Elizabeth Copper	
D Street Fill	1	Delia Garcia	32
Chula Vista Wldlf Res.	1	Elizabeth Copper	6
Saltworks	1	John Konecny	44
Tijuana River: North	unused2	Delia Garcia	19
South	1	Robert Patton	41

Table 2. Chronology of California least tern reproductive activities, 1994. For date of arrival, "earlier than or equal to" indicates terns present on that day, but may have arrived earlier. "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; "minor" reflects a tough-to-distinguish situation (the number of new nests per day trails off over an extended period; no clear-cut demarcation between waves existed). "Probably" for second wave at Pismo Dunes is author's interpretation regarding the date the two nests were found. First Egg, Chick, and Fledgling dates indicate actual date, if known, or the first date observed ("earlier than or equal to"). Blank spaces indicate no eggs, chicks, or fledglings produced.

Table 2.

	Activity Period			Date of First		
	Arrive	**Depart**	**Second Wave?**	**Egg**	**Chick**	**Fledgling**
PGE, Pittsburg	≤5/2	8/4	yes,6/1	≤5/16	≤7/1	≤7/22
NAS Alameda	≤4/16	≥8/11	minor,6/15	≤5/9	6/1	≤6/18
Oakland Airport	5/4					
Pismo Dunes	na	na	probably			
Guadalupe Dunes	5/18	na	no,8/25	5/25	na	8/8
Mussel Rock Dunes	≤4/28	≥8/22	yes,6/27	5/19	6/2	7/4
VAFB Beach 2	5/9	6/24	no,6/24	≤6/3	≤6/15	
VAFB Purisima Point	5/4	≥8/31	yes,6/10	≤5/20	na	≤8/15
Santa Clara Rv: Mouth	5/5	na	no,8/25	≤5/31	6/19	7/22
Ormond Beach: Perkins	4/29	9/8	no,9/15	6/2	na	7/11
Middle Site	6/15	8/24	na	≤6/30	na	
Edison	5/12	7/22	yes,≤7/17	5/31	6/18	7/7
Point Mugu	na	na	na	na	na	na
Venice Beach	≤4/16	≥8/8	no,8/10	≤4/30	5/17	≤6/19
Terminal Island	4/8	7/5	yes,6/6	5/8	5/29	6/20
Seal Beach	4/15	8/11	yes,6/16	5/6	5/28	6/18
Bolsa Chica	4/23	8/6	minor,6/20	≤5/3	≤5/25	≤7/12
Huntington Beach	4/25	8/10	minor,6/15	≤5/4	≤5/27	≤6/17
Upper Newport Bay	5/5	7/11	yes,6/6	na	≤5/31	≤7/15

White Beach	na	na	na	na	na	na
SM River: North Beach	na	na	na	na	na	na
Saltflats	na	na	na	na	na	na
Saltflats Isl	na	na	na	na	na	na
Batiquitos Lagoon: W-1	4/26	na	no,9/1	≤5/13	≤6/2	≤6/22
San Elijo Lagoon	4/25	7/20	yes,7/12	5/15	6/29	
Mission Bay: FAA Isl	4/19	8/9	yes,6/20	5/11	6/1	6/25
Mariner's Point	4/12	8/15	no,8/16	5/10	6/3	6/28
N Fiesta Isl	4/27	7/30	no,7/30	na	na	na
Naval Training Center	4/16	7/30	no,7/30	5/12	6/7	6/23
Lindbergh Field	≤5/9	na	no	≤5/9	na	6/22
NAS North Island	4/18	na	yes,6/11	5/11	6/7	na
Delta Beach: North	4/16	8/26	yes,6/2	5/13	6/4	6/24
South	4/12	8/20	yes,6/23	5/16	6/8	6/29
Ocean	5/20	7/1	no,7/1	5/20	6/17	na
D Street Fill	5/2	8/12	yes,7/1	5/18	≤6/15	6/28
Chula Vista Wldlf Res	na	na	no	na	na	na
Saltworks	4/21	8/18	yes,6/20	5/16	≤6/13	6/28
Tijuana River: South	5/3	8/16	yes,6/14	≤5/17	≤6/10	6/28

Table 3. First wave totals for 1994 California Least Tern breeding season; included are all sites with nesting terns in either 1994 or 1993. Total Nests includes known renests of first wave pairs. Total Pairs are followed by numbers of first wave pairs at each site in 1993 (in parentheses). Percent Change 1993 indicates increase or decrease in 1994 first wave pairs relative to 1993 numbers (midpoints of ranges used in calculation, and Chula Vista Wildlife Reserve omitted due to lack of accurate data). Total Eggs generally not available at Type 2 colonies. Pismo Dunes included only in Season Totals (Table 4) because both nests found in July; too late to unambiguously include in "first wave."

	Total Pairs	**% 1993**	**Total Nests**	**Total Eggs**
PGE, Pittsburg	2 (2)	0	2	5
NAS Alameda	129 (115)	+12	144	≥275
Pismo Dunes	0 (0)		na	na
Guadalupe Dunes	1		na	na
Mussel Rock Dunes	36 (45)	-20	36	72
VAFB Beach 2	1 (10)	-90	1	2
VAFB Purisima Point	31 (9)	+244	31	na
Santa Clara River Mouth	26 (14)	+86	26	53
Ormond Beach: Perkins	7 (0)		na	na
Middle Site	5 (0)		na	na
Edison	18 (9)	+100	na	na
Point Mugu	na (na)		na	na
Venice Beach	345 (219)	+58	345	635
Terminal Island	25 (5)	+400	25	49
Seal Beach	157 (198)	-21	198	391
Bolsa Chica	176 (142)	+24	224	381
Huntington Beach	274 (144)	+90	274	498
Upper Newport Bay	41 (50)	-18	41	na

White Beach	na (27)		na	na
Santa Margarita River:				
North Beach	na (308)		na	na
Saltflats	na (59)		na	na
Saltflats Island	na (27)		na	na
Batiquitos Lagoon: W-1	72		79	144
Park and Ride	0 (4)			
Mouth	0 (18)			
San Elijo Lagoon	9-11 (7)	+43	11	21
Mission Bay: FAA Island	330 (112)	+195	330	599
Mariner's Point	62 (205)	-70	107	165
N. Fiesta Island	8 (6)	+33	na	na
Naval Training Center	13 (1)	+1200	13	26
Lindbergh Field	10 (0)		na	na
NAS North Island	40-43 (43)	-2	43	81
Delta Beach: North	94 (69)	+36	94	169
South	15 (7)	+114	15	28
Ocean	1		1	2
D Street Fill	8 (20)	-60	8	14
Chula Vista Wldlf Res.	$\geq$1 (48)		na	na
Saltworks	52 (38)	+37	52	96
Tijuana River: North	0 (19)			
South	129 (73)	+77	129	239
Total	>>2118-2123 (>2052)			>>3945 (>>3982)

Table 4. Totals for 1994 California least tern breeding season; only those sites with nesting pairs included. Total Pairs and Fledglings/Pair numbers are followed by mean 1993 data (in parentheses). Percent Change 1993 indicates increase or decrease in 1994 total pairs relative to 1993 number (midpoints of ranges used in calculation, and Chula Vista Wildlife Reserve omitted due to lack of accurate data). Any discrepancy between 1994 Total Pairs and Total Nests reflects renesting attempts by pairs. Total Fledglings for Ormond Beach/Perkins (27*) probably an overestimate for that site (suspected dispersers from Pt. Mugu), therefore Fledgling/Pair for Ormond Beach sites not calculated or included in State mean. Seal Beach 1993 Fledgling/Pair not included (number of fledglings overestimated; see Caffrey 1994b).

Table 4.

	Total Pairs	% 1993	Total Nests	Total Fledglings	Fledglings/ Pair
PGE, Pittsburg	2 (2)	0	4	3	1.5 (2)
NAS Alameda	138 (127)	+8	162	186-206	1.35-1.49 (1.63)
Pismo Dunes	2 (0)		2	0	0
Guadalupe Dunes	4-6 (0)		5-6	2	.33-.5
Mussel Rock Dunes	56 (61)	+2	na	45-50	.8-.89 (.62)
VAFB Beach 2	1 (10)	-90	1	0	0 (.70)
VAFB Purisima Point	38 (9)	+322	46	3	.08 (.78)
Santa Clara Rv: Mouth	26 (15)	+73	26	34	1.31 (.94)
Ormond Beach: Perkins	7-15		na	27*	
Middle Site	6 (17)	+129	na	0	na* (.64)
Edison	22		na	4	
Pt. Mugu	na		na	na	na
Venice Beach	345 (246)	+40	345	224	.65 (1.14)
Terminal Island	31 (10)	+210	37	2-4	.07-.13 (.74)
Seal Beach	179 (198)	-10	185	200-250	1.12-1.4
Bolsa Chica	185 (142)	+30	242	30	.16 (.26)
Huntington Beach	279-284 (234)	+21	298	48-60	.17-.22 (.67)
Upper Newport Bay	41-56 (50)	-13	56	25	.45-.61 (.32)

White Beach	42 (31)	+36	45	18	.43 (.48)
SM River: North Beach	371 (338)	+10	409	375	1.01 (1.17)
Saltflats	47 (67)	-30	51	44	.94 (.31)
Saltflats Isl	28 (30)	-7	33	36	1.29 (1.10)
Batiquitos Lagoon: W-1	72		80	68	.94
San Elijo Lagoon	9 (8)	+13	12	0	0 (0)
Mission Bay: FAA Isl	330 (133)	+148	352	130-150	.39-.46 (.36)
Mariner's Point	62 (205)	-70	107	25	.4 (.68)
N Fiesta Isl	10 (6)	+67	12	≥6	≥.6 (.33)
Naval Training Center	13 (3)	+333	13	12	.92 (1.75)
Lindbergh Field	10 (0)		na	2-4	.2-.4
North Island NAS	43 (43)	0	51	32	.74 (.33)
Delta Beach: North	150 (95)	+58	210	≥100	≥.66 (1.37)
South	15 (7)	+114	18	7-10	.47-.67 (.43)
Ocean	1		1	1	1.0
D Street Fill	8 (23)	-65	9	3	.38 (.04)
Chula Vista Wldlf Res.	≥1 (52)		na	na	na (.1)
Saltworks	52 (38)	+37	65	5-7	.10-.14 (.21)
Tijuana River: North	0 (19)				(2.1)
South	151 (73)	+107	180	58	.38 (.03)
Total	>2777-2807 (2321)	+20		≥1755-1871 (2028)	.62-.67 (.87)

Table 5. Clutch sizes and hatching success at Type 1 sites, 1994. "Unsure" denotes either the number of nests abandoned or preyed upon prior to completion at Type 1 sites (thus actual clutch size unknown), the total number of nests at Type 2 sites (thus Total Number of Eggs not available), or some combination of the above (for sites where both Type 1 and Type 2 methods are used to monitor, e.g., PGE Pittsburg and NAS Alameda). Mean clutch size provided for known clutch sizes only. Total Eggs for PGE and NAS Alameda includes those of "unsure" clutch sizes, and thus represents the minimum at those sites.

Table 5.

Clutch Size

	1	2	3	Unsure	Mean	Total Eggs	% Hatch
PGE, Pittsburg		1	1	2	2.50	8	na
NAS Alameda	4	74	3	81	1.99	318	84
Pismo Dunes	na	na	na			na	na
Guadalupe Dunes	na	na	na			na	na
Mussel Rock Dunes	8	48	3		1.92	113	na
VAFB Beach 2		1			2.00	2	100
VAFB Purisima Point				46		na	na
Santa Clara Rv: Mouth	1	23	2		2.04	53	na
Ormond Beach: Perkins	na	na	na			na	na
Middle Site	na	na	na			na	na
Edison	na	na	na			na	na
Point Mugu	na	na	na			na	na
Venice Beach	60	280	5		1.84	635	93
Terminal Island	7	29	1		1.84	69	72
Seal Beach	52	127	18		1.83	324	92
Bolsa Chica	79	161	2		1.68	407	na
Huntington Beach	66	229	3		1.79	533	58
Upper Newport Bay				56		na	na

White Beach	na	na	na			na	na
SM River: North Beach	na	na	na			na	na
Saltflats	na	na	na			na	na
Saltflats Isl	na	na	na			na	na
Batiquitos Lagoon: W-1	17	59	4		1.84	147	88
San Elijo Lagoon	4	6	2		1.83	22	18
Mission Bay: FAA Isl	72	277	1		1.80	633	87
Mariner's Point	49	58			1.54	165	27
N Fiesta Isl	na	na	na			na	na
Naval Training Center	1	11	1		2.00	26	92
Lindbergh Field	na	na	na			na	na
NAS North Island	na	na	na			na	na
Delta Beach: North	37	171	2		1.83	385	87
South	2	16			1.89	34	74
Ocean		1			2.00	2	50
D Street Fill	3	6			1.67	15	53
Chula Vista Wldlf Res.	na	na	na			na	na
Saltworks	12	53			1.82	118	74
Tijuana River: South	37	141	2		1.81	325	54

Table 6. Causes of California least tern breeding failure, as reported, 1994. 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 (the predator was removed), most often by ADC. Birds: BCNH - Black-Crowned Night Heron, BnO - Barn Owl, BSK - Black-Shouldered Kite, BwO - Burrowing Owl, Cr - American Crow, Gl - gull species, GBH - Great Blue Heron, GBT - Gull-Billed Tern, GHO - Great Horned Owl, Ks - American Kestrel, LS - Loggerhead Shrike, NH - Northern Harrier, Os - Osprey, Ow - owl species, PF - Peregrine Falcon, Rv - Raven, RTH - Red-Tailed Hawk, SE - Snowy Egret, TV - Turkey Vulture, WG - Western Gull, WM - Western Meadowlark. Mammals: Bc - Bobcat, Ct - Domestic Cat, Cy - Coyote, Dg - Domestic Dog, FC - Feral Cat, FD - Feral Dog, GF - Gray Fox, LTW - Long-Tailed Weasel, Op - Opossum, Rc - Raccoon, RF - Red Fox, RSp - rodent species, Rt - Rat, Spk - Spotted Skunk, Stk - Striped Skunk. Other: An - Ant, Fl - Flooding (nests innundated as the result of high tides), FP - Fencing Problems (decaying chick fence entrapped and caused the death of 17 chicks), FS - Food Shortage, Hu - Human-related mortality (1: pedestrians caused egg or chick mortality, 2: aircraft killed two fledglings, 3: adult tern injured in process of shooting kestrel (rehabilitated and now in retirement at the Monterey Bay Aquarium), 4: jet-ski hit and fatally injured fledgling, 5: human neglect seems appropriate moniker for low tern reproductive success associated with lack of policy for monitoring, management, and predator control, 6: bicyclist crushed 1 chick), Hpr - Hyperthermia (record-breaking temperatures, and 2 chicks found dead for no obvious reasons), OSpp - other species' (Caspian terns and Skimmers) nesting activities destroyed at least 3 nests, V - Human-driven vehicles.

Table 6.

	Predation				
	Documented		Suspected		Other
	Bird	**Mammal**	**Bird**	**Mammal**	
PGE, Pittsburg					
NAS Alameda			Ks*,Rv		Hu2,Hu3
Pismo Dunes					
Guadalupe Dunes					
Mussel Rock Dunes			LS,Gl	Cy	Hu1
VAFB Beach 2				Cy	
VAFB Purisima Point			LS,Cr	Cy*	
Santa Clara River					Hu1
Ormond Beach: Perkins					
Middle Site					
Edison					
Venice Beach					FS
Terminal Island			Ks*,Cr*,Rv		
Seal Beach	LS*				
Bolsa Chica				Cy,RF	FS,OSpp
Huntington Beach	Ks		Cr,LS		
Upper Newport Bay					

White Beach					
SM River: North Beach					
Saltflats					
Saltflats Isl					
Batiquitos Lagoon: W-1	Ks,GHO	FC	BnO		
San Elijo Lagoon	Rv		Ks	Rc,Cy,LTW	
Mission Bay: FAA Isl	PF		Ks,BwO		Hu4,FP,FS?
Mariner's Point	Ks	Rt*			An
N Fiesta Isl					
Naval Training Center					
Lindbergh Field					Hu5
North Island NAS		GF*			
Delta Beach: North					
South					
Ocean					
D Street Fill					
Chula Vista Wldlf Res					Hu5
Saltworks		Ct*	PF,Gl	Dg,Stk*	Hu6
Tijuana River: South	Rv*,Ks*,WG	RSp	NH*,LS	FD	Hu1,V,Fl,Hpr?

Table 7. Sources of nesting site disturbance: there was no direct evidence of actual predation or mortality caused by indicated sources, however, sources were believed to underlie lack of nesting, or nest or site abandonment, or exacerbate sources of mortality. Sources of breeding failure (Table 6) biologically relevant here, but are not included because of space considerations. Predators listed here were either (1) present at site prior to or during season and removed (*), or (2) obvious to monitors and suspected to be the cause of nest or site abandonment. Human disturbance was military or recreational in nature, or associated with recovery efforts: Mlt - base personnel involved in military or recreational exercises approached or entered nesting area, RE - monitor and ADC presence may have been disturbing enough to result in observed abandonment (47% of eggs), Rec1 1 pedestrians (beachgoers, surfers, joggers) with or without pets in and/or around nesting area, Rec2 - bicycles and/or ORVs in and/or around nesting area, Rec3 - helicopter "practice landings" over site (a) or low flights (b), Rec4 - kite fliers crashed kites onto site, Rec5 - pleasure boat containing several teenagers attempted to run down fledglings landing in surrounding water, Rec6 - boaters and/or swimmers entered onto site from water on several occasions, Rec7 - golf balls smacked onto site, and dog present on 1 occasion but caused no obvious damage. Other: J4 - July 4th activities, Vnd - humans intentionally entered and vandalized site, Vg - vegetation overgrowth prohibited or limited nesting, WL - water level in lagoon high until mid-April; this plus heavy rain in late April kept substrate moist and may have delayed nesting. All other abbreviations as in Table 6.

Table 7.

	Human	Animal	Other
PGE, Pittsburg			
NAS Alameda		PF	
Oakland Airport		RTH,Ks,Cr,Rv,NH, RF,Op,Stk,Ct	
Pismo Dunes			
Guadalupe Dunes			
Mussel Rock Dunes			
VAFB Beach 2			
VAFB Purisima Point	Rec1 or Mlt	NH,RTH,Ks,LS,TV, PF,GHO,Gl,Bc	
Santa Clara Rv: Mouth	Rec1		
Ormond Beach: Perkins	Rec1,Rec2		
Middle Site	Rec2	Gl	
Edison	Rec2	RF	J4
Pt. Mugu			
Venice Beach			J4,Vnd
Terminal Island	Rec3a		
Seal Beach			Vg
Bolsa Chica			
Huntington Beach	Rec3b,Rec4	PF	
Newport Slough		Cr,GBH,Gl,Rv,Ct	
Upper Newport Bay			

White Beach			
SM River: North Beach			
Saltflats			
Saltflats Isl			
Batiquitos Lagoon: W-1			
San Elijo Lagoon	Rec1	GBH,NH,LS,Rv,BCNH, RTH,Ow,PF,Gl,WM, BSK,Dg,FC,Stk	WL
Mission Bay: FAA Isl	Rec5		
Mariner's Point	Rec6,Rec7		
N Fiesta Isl		LS,Ks,RTH,Rv,WM	Vnd
Naval Training Center			
Lindbergh Field			
NAS North Island		Ks*,Rv*,PF,GBH, Gl,Op*,FC*	
Delta Beach: North			
South			
Ocean			
D Street Fill	RE	Cr*,Rv*,NH,GBH, PF,Dg*	
Chula Vista Wldlf Res		Gl,Rv,PF,GBT,Ks,RF	
Saltworks	Rec1,Rec2		
Tijuana River: N and S	Rec1	Os	

Table 8. California least tern population demographic data, 1987-1994. Data from CDFG Annual Breeding Surveys; number of sites for 1987-1990 different from those reported so as to reflect current definition of "site" (see Methods). Midpoints of ranges of pair numbers used in calculation of Percent Change from the previous year.

Year	Sites	Breeding Pairs	% Change	Fledglings	Fledglings/Pair
1987	28	935-963		593-672	.62-.72
1988	30	1228-1278	+32	1078-1182	.84-.96
1989	32	1234-1245	-1	739-789	.59-.64
1990	30	1706	+38	1487-1676	.87-.98
1991	34	1825-1834	+7	1729-1839	.94-1.01
1992	38	2101-2111	+15	1362-1448	.65-.69
1993	35	2305-2337	+10	1998-2059	.85-.89
1994	36	2777-2807	+20	1755-1871	.62-.67

Table 9. Number of breeding pairs of California least terns in the indicated categories, in the indicated years. First and second wave numbers for 1994 are estimates (see text).

Year	1st Wave	2nd Wave	Total	Increase
1991			1830	
1992	1930	176	2106	+276
1993	2053	268	2321	+215
1994	(2529)	(263)	2792	+471

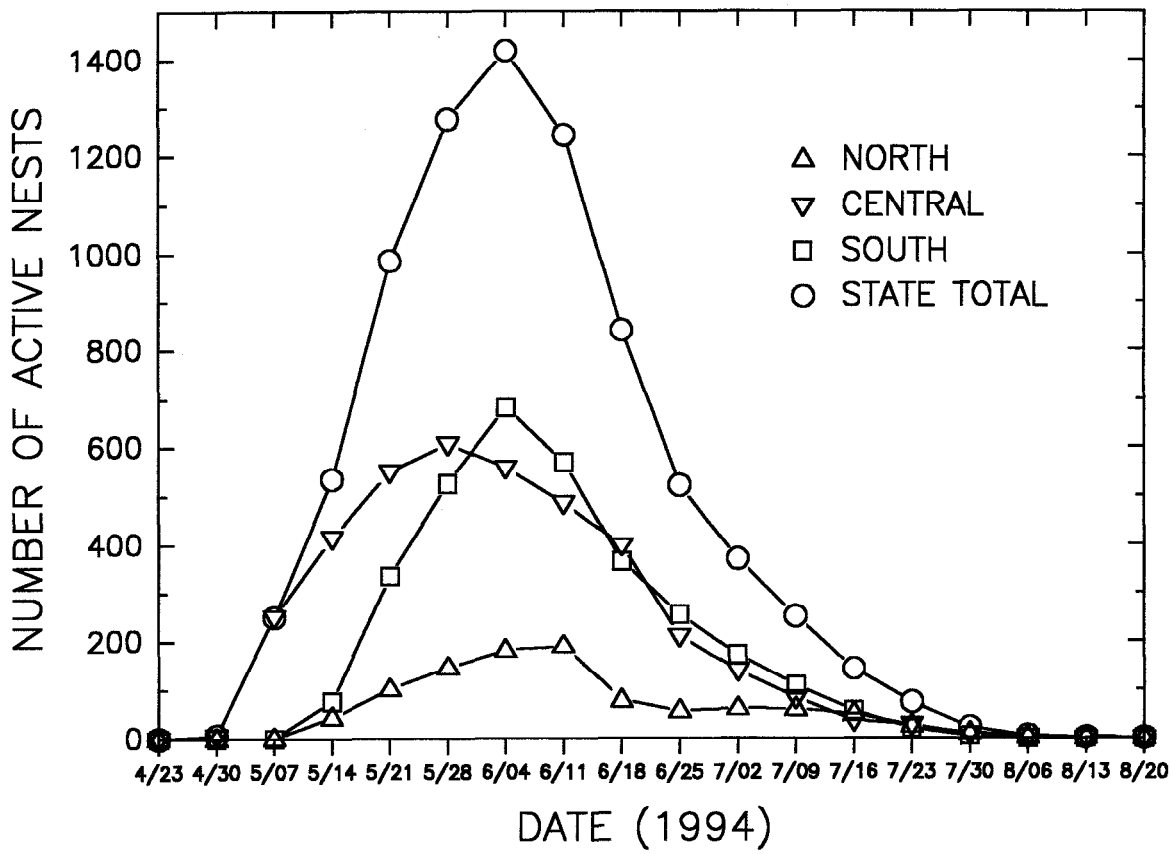

Figure 1. Number of active least tern nests for each Saturday (± 1 day) of the breeding season, 1994. Data from the following sites: North: PGE Pittsburg, NAS Alameda, Mussel Rock Dunes, VAFB Purisima Point, Santa Clara River Mouth. Central: Venice Beach, Terminal Island, Seal Beach, Bolsa Chica, Huntington Beach, Upper Newport Bay. South: Batiquitos Lagoon/W-1, San Elijo Lagoon, Mission Bay/FAA Island, Mission Bay/Mariner's Point, Delta Beach/North, D Street Fill, Saltworks, Tijuana River/South.