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# BREEDING STATUS OF THE BLACK TERN IN CALIFORNIA

W. DAVID SHUFORD, JOAN M. HUMPHREY, and NADAV NUR, Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, California 94970

*The Black Tern is the familiar spirit of all fresh-water swamps in California north of the Tehachipe*—Dawson (1923)

ABSTRACT: We surveyed breeding Black Terns throughout California in 1997 and 1998, following winters of very high runoff. We estimated the state's nesting population at about 4150 pairs (±30%), of which 47% were in northeastern California and 53% in the Central Valley. The 1940 pairs in northeastern California were at 60 sites; 59% were at 10 sites and 70% were in Modoc County. State and federal wildlife refuges supported <4% of the regional population; the rest were mostly on U.S. Forest Service and private lands. Low emergents, primarily spikerush (*Eleocharis* spp.) and *Juncus* spp., dominated most nesting marshes in northeastern California. Percent cover of emergents (vs. open water) was >80% at 68% of breeding sites. About 90% of the Central Valley breeding population was in Sacramento Valley rice fields. The rest were in the San Joaquin Valley, primarily in flooded agricultural fields with residual crops or weeds and secondarily in rice fields. State, federal, or private refuges or reserves held <1% of Central Valley terns.

Currently the Black Tern is extirpated locally at Lake Tahoe and in the Sacramento–San Joaquin River Delta. In the San Joaquin Valley, formerly a center of abundance, terns typically now breed mainly in two small areas of rice fields in the San Joaquin Basin. The Black Tern is quasi-extirpated in the Tulare Basin, where it nests irregularly and locally in ephemeral habitats, mainly in extremely wet years. The 160,000 to 200,000 ha of rice currently planted annually in the Sacramento Valley may far exceed the average amount of natural shallow-water habitat available there before agriculture.

We recommend a statewide survey of the California breeding population about once every 10 years, during typical climatic and habitat conditions, and monitoring for population trends annually. Conservation should focus on restoring, enhancing, and providing long-term protection for suitable wetlands and on maintaining isolation of colonies from humans and ground predators. Given the scarcity of water in the Central Valley in most summers, efforts to enhance tern habitat may be most fruitful in years of exceptional runoff. Research is needed on nesting and foraging ecology, habitat suitability, demography, limiting factors, population response to changing water conditions, and the value of rice fields versus wetlands as breeding habitat.

Although the New World subspecies of the Black Tern (*Chlidonias niger surinamensis*) breeds widely across southern Canada and the northern United States, concern has been expressed because the population declined across the contintent (Dunn and Agro 1995, Peterjohn and Sauer 1997, Shuford 1999) during a period of rapid wetland loss (Dahl et al. 1997). Breeding Bird Survey data imply that the Black Tern declined across the range surveyed, though not significantly, at an average rate of –1.6% (95% confidence interval –4.4–1.1) annually (–41.3% overall) from 1966 to 1999 (Sauer et al. 2000). Although extirpated from only two states, the Black Tern has declined in at least 14 of the 34 states, provinces, and territories where it currently breeds (Shuford 1999). Consequently, the Black Tern is listed as threatened or endangered in six states and variously designated of conservation concern in 18 other states or provinces. For the United States overall, the Black Tern is listed as a "migratory nongame bird of management concern" (USFWS 1995), whereas in Canada it has no official status despite recommendations for listing as "threatened" by Gerson (1988) and "vulnerable" by Alvo and Dunn (1996). Knowledge of the Black Tern's status is poor in the western United States, including California, where anecdotal information led to its listing as a species of special concern (CDFG 1992).

To fill gaps in knowledge of breeding Black Terns in California, Point Reyes Bird Observatory surveyed populations statewide in 1997 and 1998 as the focus of a project to assess the status of seven species of "inland-breeding seabirds" (Shuford 1998, Shuford et al. 1999). Here we report current statewide population estimates, breeding distribution, breeding phenology, and habitat associations of the Black Tern and compare them with the historical record. We also make recommendations for conservation, management, and long-term monitoring of the Black Tern in California.

## STUDY AREA AND METHODS

Prior to field work, we searched the published and unpublished literature and contacted various field biologists to identify historic and potential breeding habitats of the Black Tern in California. We cite data from *Audubon Field Notes* (AFN) and *American Birds* (AB) by volume and page number and unpublished data from notebooks of the editors of the Middle Pacific Coast region of *North American Birds* as MPCR files.

In the field, we contacted additional biologists for further information on potential breeding habitat. We later obtained egg-set data on Black Terns from the California Academy of Sciences (CAS), Los Angeles County Museum of Natural History (LACM), Moore Laboratory of Zoology (MLZ), Museum of Vertebrate Zoology (MVZ), San Bernardino County Museum (SBCM), San Diego Natural History Museum (SDNHM), Santa Barbara Museum of Natural History (SBMNH), and Western Foundation of Vertebrate Zoology (WFVZ).

We varied field survey methods by region, to match local logistical constraints, and timed surveys to follow the passage of most migrants and begin with the initiation of nesting.

Northeastern California

The study area here included valleys of the Cascade Range, Klamath Mountains, and Sierra Nevada, the Modoc Plateau, and the Great Basin desert, that is, eastern Siskiyou, northeastern Trinity, eastern Shasta, Modoc, Lassen, Plumas, Sierra, and El Dorado counties. Potential Black Tern habitat in marshes, lakes, and reservoirs is scattered widely, primarily from 4000 to 6000 feet (1220–1830 m) elevation in intermountain valleys or in depressions in the Modoc Plateau. Precipitation, falling mostly from October through April as rain and snow, in the climate year (1 July–30 June) 1996–97 was 114.3 cm in the Sacramento Drainage Division and 79.8 cm in the Northeast Interior Basins Division (results from weather stations throughout the region averaged). Combined, these divisions encompass most of the study area. As these figures represent 119% and 147%, respectively, of the long-term ($n$ = 104) averages for these areas (Western Regional Climate Center; http://www.wrcc.dri.edu/divisional.html), wetlands in the study area were well supplied with water in summer 1997.

From 18 May to 19 July 1997, Shuford and colleagues surveyed most potential breeding habitat in northeastern California for Black Terns; all sites surveyed were listed by Shuford (1998). In addition, K. Laves and Shuford surveyed the south shore of Lake Tahoe, El Dorado County, on 14 June 1998, and M. McVey surveyed most potential breeding wetlands in the Shasta Valley, Siskiyou County, in spring and summer 1998 and 1999. Shuford and colleagues also opportunistically resurveyed various sites in the summers of 1998 to 2001, as indicated in the text or Table 1. We conducted surveys mostly on foot and occasionally by kayak or canoe. We were unable to survey only a few areas with high potential for nesting terns. We did not survey Picnic Grove and Lakeshore reservoirs in the Devil's Garden Ranger District of Modoc National Forest because of logistical difficulties, and we were denied access to a few private holdings, the largest being Steele Swamp, Modoc County, and Dixie Valley, Lassen County.

Early in the season it was possible at many sites to count both adult Black Terns using the wetland and all or most of their nests. We soon realized we would be unable to count all nests at all sites because of the time needed and our inability to count nests accurately once chicks began to leave their nests shortly after hatching. Thus, depending on circumstances, we obtained three types of counts and used three corresponding methods to estimate numbers of pairs of terns, presented here in order of their apparent reliability and annotated with respect to biases. When data are available to make more than one estimate, we present only the method of apparent highest reliability.

(1) Total nests: obtained by systematically walking all of a marsh and locating all or most nests by visually scanning areas where terns were agitated, flushing adults from nests, or following terns back to nests. At sites where a thorough search was impractical, we made partial nest counts, which served only to document breeding. We estimated the number of breeding pairs as the total number of nests at the time of the survey. This method may underestimate the total because of the difficulty of finding all

**Table 1** Numbers of Adult Black Terns, Nests, and Estimated Pairs from Surveys of Wetlands in Northeastern California in 1997

| Site | Survey date | Number of adults[a] | | Number of nests[b] | | Estimated pairs[c] |
|---|---|---|---|---|---|---|
| | | Disturbed | Undisturbed | Total | Partial | |
| *Siskiyou County* | | | | | | |
| Butte Valley WA | 14 July | 22 | — | — | 2 | 11[2] |
| Butte Valley National Grasslands | 14 July | 0 | 2 | — | 1 | 2[3] |
| Grass Lake[d] | 12 July | — | 28 | — | 2+ | 22[3] |
| Orr Lake | 30 May | — | 8 | — | — | 6[3] |
| | 24, 26 June | — | 6 | — | — | — |
| Dry Lake (T44N, R1W, sect. 30, 31) | 12 July | — | 4 | — | 2 | 3[3] |
| Lower Klamath NWR[e] | | | | | | |
| Unit 4E | 18 June | ~73 | 65 | — | 3 | 37[2] |
| Unit 4D | 18 June | — | 18 | 12+ | — | 12[1] |
| Barnum Flat Reservoir | 1 July | — | 68 | — | 2+ | 54[3] |
| Subtotal | | | | | | 147 |
| *Modoc County*[f] | | | | | | |
| Dry Lake (T44N, R6E, sect. 4, 5) | 20 June | — | 12 | — | — | 9[3] |
| Fourmile Valley | 27 May | 38 | 27 | 27 | — | 27[1] |
| Wild Horse Valley | 28 May | 6 | 8 | 3 | — | 3[1] |
| Buchanan Flat | 26–27 May | 36 | 29 | 21 | — | 21[1] |
| Weed Valley | 3 June | — | 203 | — | 6 | 160[3] |
| Baseball Reservoir | 26 May | 47 | 47 | 42 | — | 42[1] |
| Dry Valley Reservoir | 25 May | 58 | — | 30 | — | 30[1] |
| Hager Basin (North) | 24 May | 22 | 13 | 14 | — | 14[1] |
| Hager Basin (South) | 24 May | 51 | 21 | 18 | — | 18[1] |
| Telephone Flat Reservoir | 31 May | 23 | — | 7 | — | 7[1] |
| South Mountain Reservoir | 31 May–1 June | 6 | — | 2 | — | 2[1] |
| Pease Flat[g] | 21 May | — | 1 | 0 | — | — |
| | 17 July | — | ~60 | — | — | 47[3] |
| | 18 July | — | 19 | 2+ | — | — |
| Mud Lake (T46N, R12E, sect. 16) | 22 May | 26 | 8–10 | 16 | — | 16[1] |
| Crowder Mt. Reservoir | 1 June | — | 41+ | 40 | — | 40[1] |
| Whitney Reservoir | 20 June | 10 | — | — | — | 5[2] |
| Hackamore Reservoir | 20 June | 20 | — | — | 4 | 10[2] |
| Spaulding Reservoir | 21 June | 40 | — | — | 10 | 20[2] |
| Beeler Reservoir | 22 June | 26 | — | — | 10 | 13[2] |
| Pinky's Pond | 22 June | 14 | — | — | 3 | 7[2] |
| Widow Valley | 22 June | — | 82 | — | 1 | 64[3] |
| Bucher Swamp | 22 June | — | 122 | — | 5 | 96[3] |
| Six Shooter Tank | 23 June | 18 | 12 | — | 1 | 9[2] |

*(continued)*

**Table 1** *(continued)*

| Site | Survey date | Number of adults[a] | | Number of nests[b] | | Estimated pairs[c] |
|---|---|---|---|---|---|---|
| | | Disturbed | Undisturbed | Total | Partial | |
| Deadhorse Flat Reservoir | 23 June | — | 45 | — | 1 | 35[3] |
| Surveyors Valley | 23 June | — | 35 | — | 1 | 28[3] |
| Boles Meadow | 7 June | — | 211 | — | 15 | 166[3] |
| Fletcher Creek Reservoir | 16–17 June | — | 48 | 31 | — | 31[1] |
| Jack's Swamp | 5 June | — | 64 | 26 | — | 26[1] |
| Dead Horse Reservoir | 29 May | — | 7+ | 11 | — | 11[1] |
| Jesse Valley | 26 June | — | 13 | — | 4 | 10[3] |
| Whitehorse Flat Reservoir | 1 July | — | 37 | — | 4+ | 29[3] |
| Egg Lake | 30 June–1 July | — | 343 | — | 1+ | 270[3] |
| Taylor Cr. wetlands | 30 June | — | 128 | — | 2 | 101[3] |
| Subtotal | | | | | | 1367 |
| *Lassen County* | | | | | | |
| Muck Valley | 2 July | — | 53 | — | 5 | 42[3] |
| Hoover Flat Reservoir | 3 July | — | 7 | — | — | 6[3] |
| Moll Reservoir | 27 June | 34 | 20 | — | 3+ | 17[2] |
| | 16 July | 13 | — | — | — | — |
| Okendine's Spring | 27 June | 9 | 5 | — | — | 5[2] |
| | 16 July | — | 0 | — | — | — |
| Ash Valley (main) | 27 June | — | 66 | — | — | 52[3] |
| Ash Valley (SE) | 19 July | — | 9 | — | — | 7[3] |
| Red Rock Lakes complex | 26–27 June | — | 72 | — | 2+ | 57[3] |
| Boot Lake | 25–26 June | — | 15 | — | 8 | 12[3] |
| Poison Lake[h] | 5 July | 76 | 43 | — | 2 | 38[2] |
| Dry Lake (Grass Valley) | 10 June | — | 6 | — | — | 5[3] |
| | 5 July | — | 0 | — | — | — |
| Straylor Lake | 26 May | — | 11 | — | — | 9[3] |
| | 11 July | — | 1 | — | — | — |
| Long Lake (T34N, R8E, sect. 22) | 26 May | — | 6 | — | — | 5[3] |
| | 11 July | — | 0 | — | — | — |
| Ashurst Lake | 26 May | — | 7 | — | — | ? |
| | 13 June | — | 2 | — | — | 2[3] |
| | 10 July | — | 2 | — | — | — |
| Gordon Lake | 9 June | — | 12 | — | — | 9[3] |
| | 10 July | — | 10 | — | — | — |
| Pine Creek wetlands (T32N, R9E, sect. 28) | 10 June | — | 9 | — | — | 7[3] |
| | 10 July | — | 5 | — | — | — |
| McCoy waterpit | 9 June | — | 12 | — | — | 9[3] |
| | 10 July | — | 0 | — | — | — |

*(continued)*

**Table 1** *(continued)*

| Site | Survey date | Number of adults[a] | | Number of nests[b] | | Estimated pairs[c] |
|---|---|---|---|---|---|---|
| | | Disturbed | Undisturbed | Total | Partial | |
| Eagle Lake[i] | 8–9 July | — | 142 | — | 3+ | 112[3] |
| Willow Creek WA | 10 June | — | 13 | — | — | 10[3] |
| Horse Lake | 8 July | 15 | 15 | — | 1+ | 8[2] |
| Mountain Meadow Reservoir | 7 July | 22 | 20 | — | — | 11[2] |
| Honey Lake N (private) | 15 June | 5 | 5 | — | 1 | 3[2] |
| Subtotal | | | | | | 426 |
| Total | | | | | | 1940 |

[a]Numbers of adults from either disturbed or undisturbed counts (see Methods).

[b]Numbers of nests from either total or partial counts (see Methods).

[c]Numbers of pairs estimated by three methods, listed here in order of apparent reliability, on the basis of [1]numbers of total nests, [2]counts of total disturbed adults, and [3]counts of total undisturbed adults (see Methods). When data enable more than one type of estimate, the estimate presented is from the method of highest apparent reliability.

[d]A count of 13 undisturbed adults at Grass Lake on 24 June 1999 yields an estimate of 10 breeding pairs that year; no terns were seen there on 28 May during the drought year of 2001.

[e]Counts of undisturbed adults of 54 in Unit 6B, 220± in Unit 6C, 10 in Unit 10A, and 146 in Unit 12C on 21 June 2001 yield estimates of 42, 173, 8, and 115 breeding pairs in those units, respectively, that year.

[f]A count of 57 undisturbed adults on 21 June 1999 yields an estimate of 45 breeding pairs at Lost Valley, which was mostly dry and devoid of waterbirds on 22 June 1997.

[g]A count of 23 undisturbed adults at Pease Flat on 20 June 1999 yields an estimate of 18 breeding pairs that year.

[h]Five adults at Poison Lake on 23 June 1999 showed no signs of site attachment or other evidence of breeding.

[i]A count of 160 undisturbed adults at Eagle Lake on 23 June 1999 yields an estimate of 126 breeding pairs that year.

nests, particularly in large marshes, and, because of asynchronous egg laying among colonies or subcolonies, some birds may not have initiated or completed laying at the time of surveys.

(2) Total disturbed adults: taken from within the colony when the observer (or a predator) disturbed birds, and all or most terns, including adults attending nests, joined a mobbing flock around the intruder. We estimated the number of pairs as the best count of total disturbed adults rounded to the nearest even number and divided by two. This method does not account for adults foraging far from the colony, hence not attracted to mobbing flocks, adults not joining the mobbing flock, or failed breeders having left the colony. We did not use this method at large wetlands, where we were unable to obtain accurate counts because of many adults swirling rapidly around the observer and terns continuously joining or leaving the mobbing flock as they

flushed from, or returned to, nests as the intruder approached or left their "zone of concern."

(3) Total visible undisturbed adults: taken from the edge of the wetland or from a vantage point within where the observer did not attract mobbing adults. We estimated the number of breeding pairs as the best count divided by 1.27 (standard error 0.16), the mean ratio of undisturbed adults counted to nests at the 10 sites where we collected both types of data (317 total adults, 247 total nests) during the incubation period. The method's primary biases, adjusted by a correction factor, are that it underestimates total adults or pairs because of the difficulty of seeing many incubating and roosting terns obscured by vegetation or other visual obstructions and does not account for adults foraging away from the colony. Also, the number of visible adults may increase as nests hatch and adults spend more time foraging, or, conversely, may decrease as nests fail and adults disperse.

To characterize habitat at each breeding site, observers recorded the dominant species of emergent vegetation and visually estimated the percent cover of both emergent vegetation and open water. We estimated these variables for the entire wetland, except at managed refuges where we estimated them for just the diked wetland units in which terns were breeding rather than for the entire complex of units.

### Central Valley

The Central Valley, surrounded by mountains except at its western outlet into the San Francisco Bay estuary, averages about 644 km long and 64 km wide. It is divided into the Sacramento Valley, draining south, the San Joaquin Valley, draining north, and the Sacramento–San Joaquin River Delta where these rivers converge. The Sacramento Valley is further divided into the Colusa, Butte, Sutter, American, and Yolo drainage basins, the San Joaquin Valley into the San Joaquin Basin and the (usually closed) Tulare Basin.

Over 90% of the Central Valley's presettlement wetlands have been lost (Frayer et al. 1989, Kempka et al. 1991), and the dominant land use is agriculture. Hence, breeding habitat for waterbirds typically is scarce. Precipitation, falling mainly from October through April (as rain, or snow in adjacent mountains), is highly variable. Despite a massive reservoir storage and drainage system and high summer temperatures, in the wettest years extensive shallow water can persist through the breeding season. Precipitation in the climate year 1997–98, during El Niño, was 153.7 cm in the Sacramento Drainage Division and 86.9 cm in the San Joaquin Drainage Division, representing 161% and 169%, respectively, of the long-term ($n$ = 104) averages for these regions (Western Regional Climate Center; http://www.wrcc.dri.edu/divisional.html). Hence the breeding season of 1998 provided some of the best conditions for nesting waterbirds in the Central Valley since the 1950s. Shallow-water breeding habitat increased primarily in the Tulare Basin, where large areas of agricultural land were flooded, intentionally or unintentionally, and secondarily near Los Banos, Merced County, on refuges and in flood-control bypasses.

Large areas of cultivated rice fields in the Sacramento Valley, and smaller areas in the delta and San Joaquin Basin, typically provide potential nesting

habitat for the Black Tern. In 1998, the intense and extended rainy season delayed rice planting in the Sacramento Valley by about three weeks, and only about 75% of the crop had been planted at the time of our surveys (60% by 31 May, 90% by 7 June; 9 June 1998 "Weekly Weather and Crop Bulletin," Natl. Agric. Statistics Serv., Agric. Statistics Board, U.S. Dept. Agric.). Other habitats in the Central Valley sometimes suitable for breeding terns include managed wetlands on refuges and duck clubs (limited summer water) and floodwater storage or recharge facilities (e.g., South Wilbur Flood Area, Kern Fan Element Water Bank). The average May to July temperatures of 62.5° F (16.9° C) and 66.5° F (19.2° C) for the Sacramento and San Joaquin drainage divisions, respectively, were the second lowest and lowest on record (Western Regional Climate Center, http://www.wrcc.dri.edu/divisional.html; $n = 105$). These were ideal conditions for both surveying in this typically very hot climate and delaying desiccation of the tern's breeding habitats.

Because of the 187,000 ha of rice planted in the Sacramento Valley in 1998, and limited access to private lands, we were unable to survey all potential breeding habitat. Instead, from 29 May to 10 June (also 18 June), seven observers conducted roadside transect surveys along most lightly traveled roads in the Sacramento Valley rice country (Glenn and Butte counties south to Yolo County) to estimate densities of Black Terns breeding there. Single observers covered routes by driving roads at 24 to 32 km/hr and counting terns seen within the primary census zone of 0.1 mile (160 m) on each side of the road. We surveyed without the aid of binoculars, except when needed to confirm identifications or estimate numbers accurately. We surveyed from 0600 to 1000 hours, later if temperatures were under 29° C; as temperatures often were below normal, this meant sometimes all day. We halted during strong winds (>24 km/hr) or persistent rain.

Observers recorded weather conditions, start and stop times, route covered, miles driven, distance surveyed (each side of the road tallied separately), number and age of terns, location(s) and habitat type where terns were observed, and any breeding evidence, including details of nest locations. Observers also recorded any terns seen beyond the primary census zone or off survey routes, but we did not use these data to calculate densities of breeding terns in rice fields. Observers recorded all observations of terns on maps in the field for later use in mapping patterns of breeding distribution. Observers were asked to try to confirm nesting by returning to make observations after finishing a survey or on a subsequent visit. We considered confirmed nesting all observations of nests with eggs, adults sitting in incubation posture on an apparent nest, adults feeding non-flying young, adults repeatedly carrying food to the same spot (presumably to an unseen chick), or nonflying or very weakly flying young. Because of delayed planting, at the time of our surveys little growing rice had emerged above water (15% emerged on 31 May, 35% on 7 June; 9 June 1998 "Weekly Weather and Crop Bulletin," Natl. Agric. Statistics Serv., Agric. Statistics Board, U.S. Dept. Agric.), and hence most terns sitting on nests were still visible.

We calculated densities of Black Terns in rice fields by first multiplying the distance surveyed on each route by 160 m, the width of the primary census zone, then converting this to hectares of habitat surveyed. We next deter-

mined the mean density of terns per 100 hectares for each county (or grouping of counties) by calculating the mean density for all of the county's routes weighted by distance surveyed. We estimated the total number of breeding terns in each county by multiplying tern density per county times the number of hectares of planted rice per county (M. Leighton, Calif. Agric. Statistics Serv. in litt.; National Agric. Statistics Serv., http://www.nass.usda.gov:100/ipedb/), adjusted by a correction factor of 0.75, the estimated proportion of rice planted at the time of our surveys. Field observations did not suggest any evidence of avoidance of, or attraction to, roads by nesting terns, which might have biased our estimates.

By contrast, in the delta, San Joaquin Valley, and in habitats in the Sacramento Valley other than rice fields, we surveyed from the ground or by boat all known potential breeding habitat for Black Terns. See Shuford et al. (1999) for a list of sites surveyed. In 1998, we surveyed the entire 807, 1817, 2220, and 1211 ha of planted rice in Stanislaus, San Joaquin, Merced, and Fresno counties, respectively, rather than sampling them as in the Sacramento Valley. We counted mainly visible undisturbed adults and, rarely, total nests via thorough nest searches. We did not count total disturbed adults or total nests at most sites because of the potential to damage crops by doing so. Partial nest counts at many sites served only to document breeding. Hence, depending on available data, we estimated numbers of pairs of Black Terns by either the "total nests" or "undisturbed adults" methods described above for northeastern California. In the latter case, the correction factor used for the Central Valley was that derived in northeastern California in 1997.

## RESULTS

### Population Size and Distribution

We estimated about 4153 pairs of Black Terns nested in the state in 1997 and 1998, 46.7% in northeastern California and 53.3% in the Central Valley.

*Northeastern California.* An estimated 1940 pairs nested at 60 widely scattered sites in this region (Table 1, Figure 1). About 70.5%, 22.0%, and 7.6% of that population was located in Modoc, Lassen, and Siskiyou counties, respectively. The 10 sites with >50 pairs of terns, which combined held 58.7% of the regional population, were Barnum Flat Reservoir, Siskiyou County; Weed Valley, Widow Valley, Bucher Swamp, Boles Meadow, Egg Lake, and Taylor Creek wetlands, Modoc County; and Ash Valley (main), Red Rock Lakes complex, and Eagle Lake, Lassen County.

*Central Valley.* Of the estimated 2213 pairs of Black Terns that bred in the Central Valley in 1998, 89.8% were in the Sacramento Valley and 10.2% in the San Joaquin Valley (Tables 2 and 3, Figures 2 and 3). From roadside surveys, we estimated that about 2523 ± 754 (1769–3277) adult terns, or about 1987 (1393-2581) pairs, bred in Sacramento Valley rice fields (Table 2). Although the birds were spread widely, the largest numbers were in the northern Colusa Basin (Table 2, Figure 2). In the San Joaquin Valley, about 75 pairs bred at five sites in the San Joaquin Basin and 151 pairs bred at six sites in the Tulare Basin (Table 3).

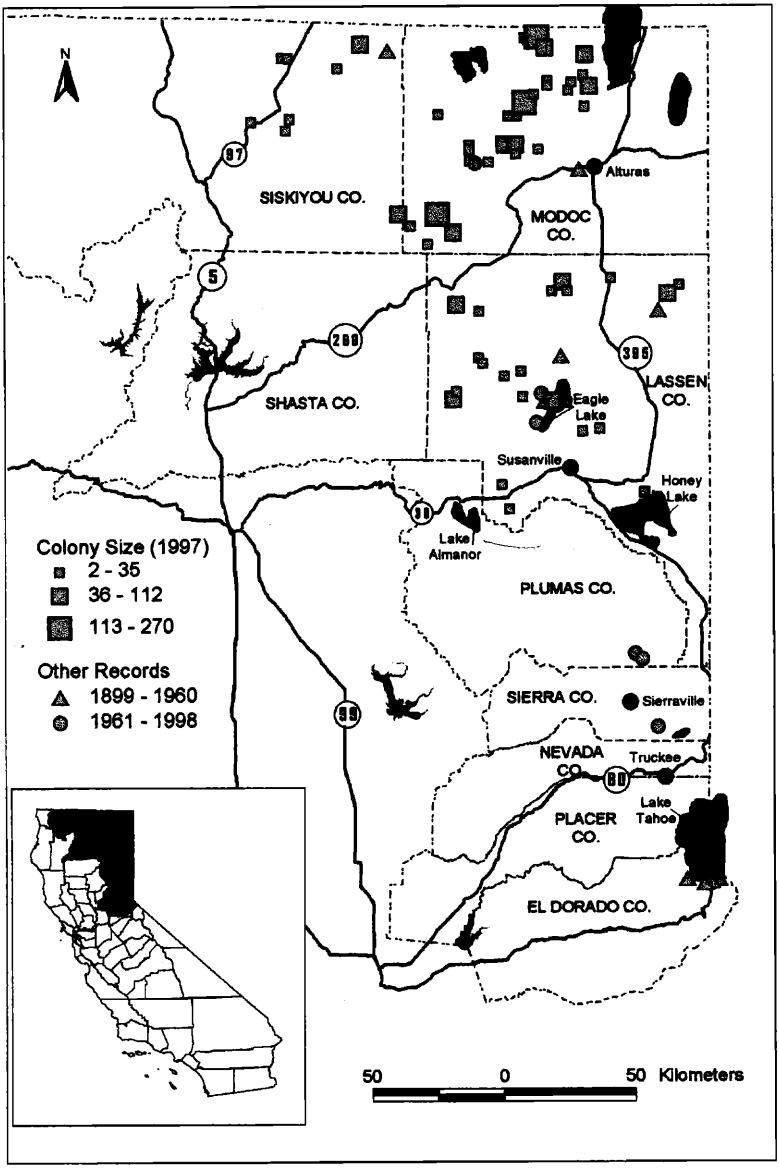


Figure 1. Distribution and size (number of pairs) of Black Tern colonies in northeastern California in 1997 (see Table 1), plotted with historical (1899–1960) and other recent (1961–1998) records of confirmed breeding (see Appendices 1 and 2).

**Table 2** Estimated Numbers of Black Terns Breeding in the Sacramento Valley from Roadside Surveys of Rice Fields, 29 May–10 June 1998

| County | Hectares planted rice[a] | Survey routes (*n*) | Distance surveyed (km)[b] | Terns per 100 ha (± SE)[c] | Terns estimated (± SE)[d] |
|---|---|---|---|---|---|
| Colusa | 36,637 | 38 | 370.2 | 2.67 ± 0.67 | 978 ± 245 |
| Sutter–Yolo–Sacramento[e] | 36,485[f] | 26 | 284.5 | 0.70 ± 0.23 | 255 ± 84 |
| Butte | 26,645 | 10 | 234.5 | 0.85 ± 0.31 | 226 ± 82 |
| Glenn | 25,131 | 44 | 352.8 | 3.68 ± 1.56 | 925 ± 392 |
| Yuba | 11,294 | 16 | 122.1 | 1.22 ± 0.44 | 138 ± 50 |
| Placer | 4239 | 4 | 47.0 | 0.00 ± 0.00 | 0 |
| Tehama[g] | 363 | 0 | 0 | — | 0 |
| Totals | 140,794 | 138 | 1411.11 | 1.80 ± 0.54[h] | 2523 ± 754 |

[a]Planted rice acreage adjusted to account for estimate that only 75% of the total for the year had been planted at the time of our surveys (see Methods).

[b]Each side of road tallied separately.

[c]Density estimates for each county are means of survey routes, weighted by distance surveyed. SE, standard error.

[d]Tern numbers estimated by multiplying densities on roadside surveys times acreage of available rice fields. Standard errors represent variation in densities of terns on survey routes but do not account for possible error in the estimate of the amount of planted rice at the time of tern surveys.

[e]Data for these counties pooled because of small sample sizes for Yolo and Sacramento counties. Number of survey routes and distance surveyed, respectively, per county: Sutter, 15, 204.0; Yolo, 10, 69.4; Sacramento, 1, 11.1.

[f]Numbers of hectares planted rice per county at time of survey: Sutter, 27,553; Yolo, 6177; Sacramento, 2755.

[g]Although we surveyed no routes in Tehama Co. in 1998, coverage since the 1970s there has shown no evidence of terns there in the breeding season (S. Laymon in litt.). If terns breed there now the number would be small: 7 or 13 if densities were the same as for the entire Sacramento Valley or for Glenn County, respectively.

[h]Mean of county density estimates, weighted by hectares of rice.

## Nesting Phenology

In northeastern California in 1997, we observed the first nests with eggs at Mud Lake, Modoc County, on 22 May and the first hatched young at Fletcher Creek Reservoir on 17 June. On the basis of the species' 19–21 day incubation period (Dunn and Agro 1995), eggs at Mud Lake likely hatched by at least 12 June. Collection dates of egg sets for the region extend from 23 May to 30 June and reach a peak in early June (Figure 4). Observations in the Central Valley in 1998 were inadequate for assessing breeding phenology; dates of egg sets collected there extend from 3 May to 5 July and reach a peak from late May to early June (Figure 4).

## Habitat Associations

*Northeastern California.* Of 60 breeding sites in northeastern California, 52 (86.7%) were marshes dominated by low (<1 m) emergents, six

**Table 3** Numbers of Adult Black Terns, Nests, and Estimated Pairs in the San Joaquin Valley in 1998

| Site | Survey date | Number of Adults[a] | Number of nests[b] | | Estimated Pairs[c] |
|---|---|---|---|---|---|
| | | | Total | Partial | |
| *Merced County* | | | | | |
| Rice fields SW of Merced | | | | | |
| | 22 June | 30 | — | — | 24[2] |
| | 3 July | 25 | — | 2 | — |
| Raccoon Marsh, West Bear Creek Unit, San Luis NWR | | | | | |
| | 22 June | 4 | 2 | — | 2[1] |
| Cinnamon Slough, Merced NWR | | | | | |
| | 23 June | 4 | 2 | — | 2[1] |
| *Fresno County* | | | | | |
| Rice fields S of Dos Palos, Merced Co. | | | | | |
| | 22–23 June | 58 | — | 5 | 46[2] |
| James Bypass S of James Rd. | | | | | |
| | 1 July | 2 | 1 | — | 1[1] |
| *Kings County* | | | | | |
| S of Hacienda Ranch Flood Basin (T24S, R21E, sect. 31, 32) | | | | | |
| | 19 June | 69 | — | 7 | 54[2] |
| S of Hacienda Ranch Flood Basin (T24S, R21E, sect. 28, 33) | | | | | |
| | 19 June | 28+ | — | 3 | 22[2] |
| | 13 July | — | — | 3–4 | — |
| *Tulare County* | | | | | |
| Vicinity jct. Hwy. 43 and Virginia Ave. | | | | | |
| | 25 June | 35+ | — | 2 | 28[2] |
| 2 mi W of Rd. 40 about 3 mi S of Alpaugh | | | | | |
| | 23 June | 21 | — | 1 | 16[2] |
| Just W of Rd. 40 about 4 mi S of Alpaugh | | | | | |
| | 22 June | 32 | — | 3 | 25[2] |
| *Kern County* | | | | | |
| Kern Fan Element Water Bank (pond W-2), W of I-5 | | | | | |
| | 20 June | 7 | — | 1 | 6[2] |
| Total | | | | | 226 |

[a]Numbers of adults from counts of undisturbed birds (see Methods).

[b]Numbers of nests from either total or partial nest counts (see Methods).

[c]Numbers of pairs estimated by two methods, listed here in order of apparent reliability, on the basis of [1]counts of total nests or [2]counts of total undisturbed adults (see Methods). When data enable more than one type of estimate, the estimate presented is from the method of highest apparent reliability.

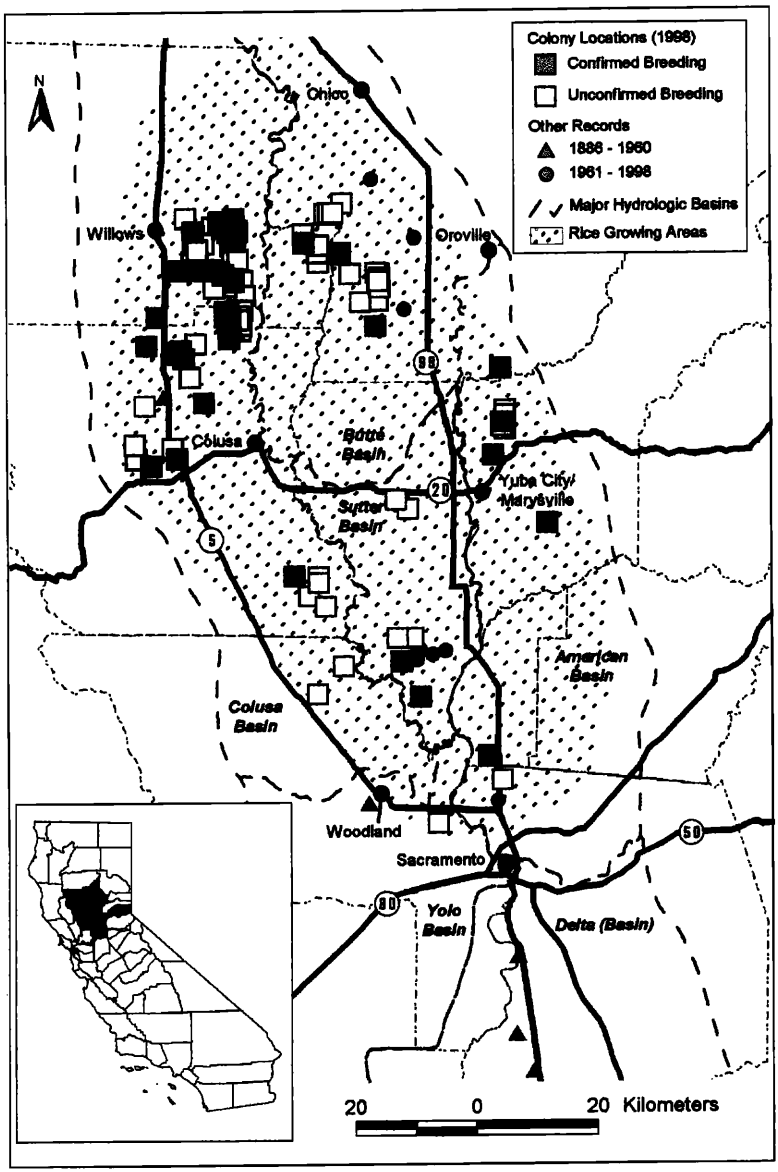


Figure 2. Distribution of breeding Black Terns in California's Sacramento Valley and Delta in 1998 (see Table 2), plotted with historical (1886–1960) and other recent (1961–1999) records of confirmed breeding (see Appendices 1 and 2). Stippling denotes areas where rice currently is grown.

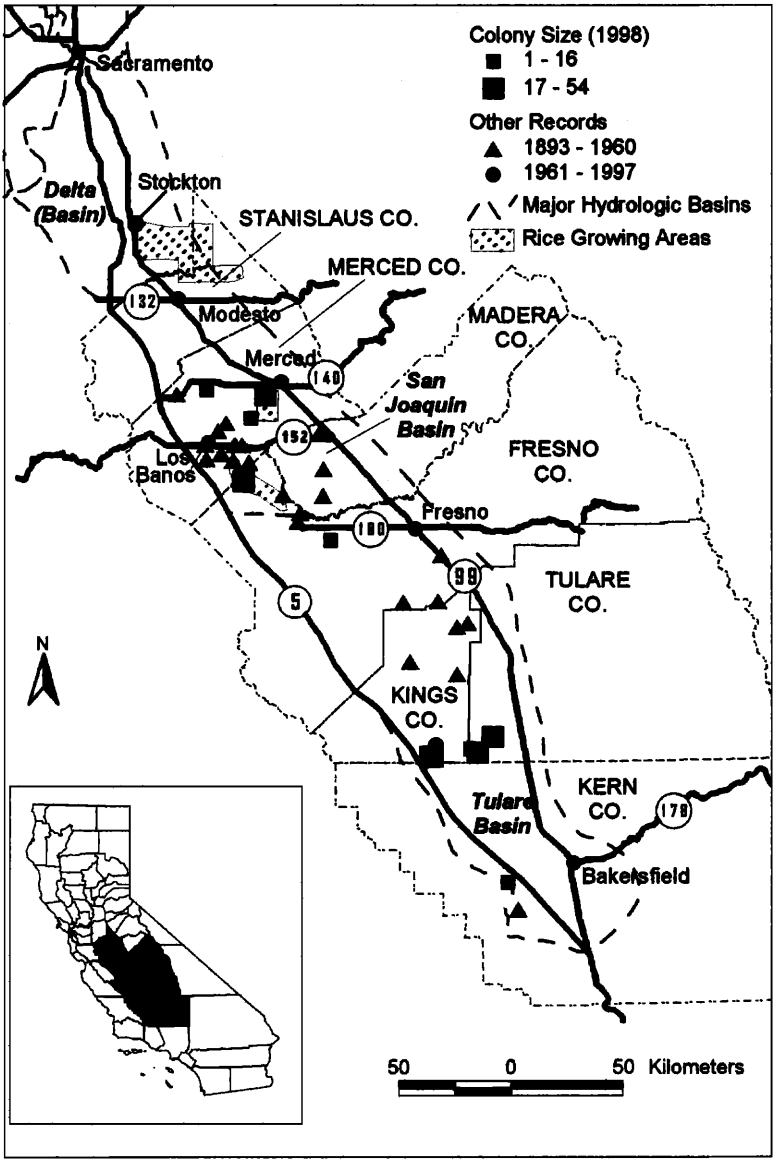


Figure 3. Distribution and size (number of pairs) of Black Tern colonies in California's San Joaquin Valley in 1998 (see Table 3) plotted with historical (1893–1960) and other recent (1961–1997) records of confirmed breeding (see Appendices 1 and 2). Stippling denotes areas where rice currently is grown.

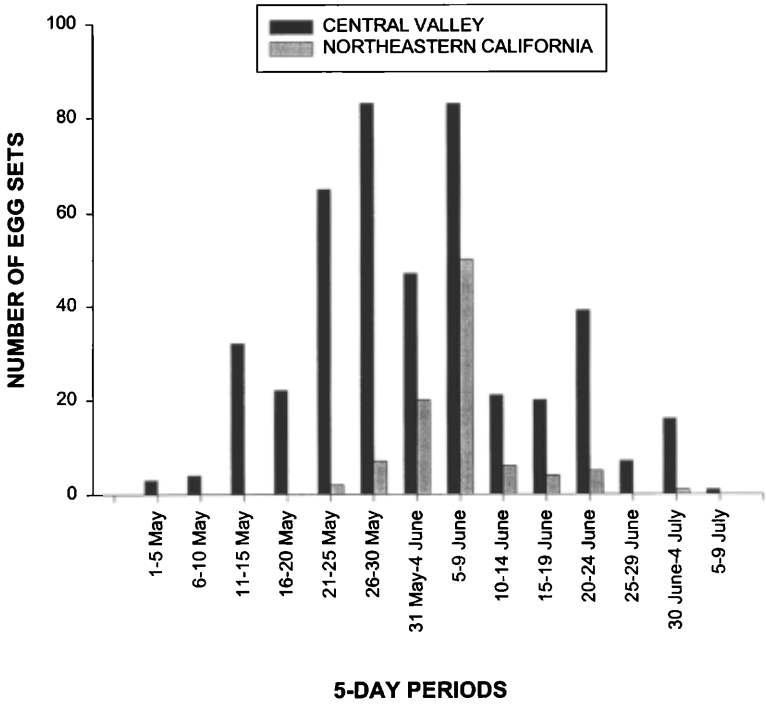


Figure 4. Temporal distribution of egg-set records of the Black Tern in California, 1886–1960. Data from major California museums (see Methods, Appendix 1).

(10%) by a mixture of tall (>1 m) and low emergents. At Lower Klamath National Wildlife Refuge (NWR), Black Terns nested in shallowly flooded basins dominated by residual barley stubble and algal mats and lacking much live emergent vegetation. At Boot Lake, Lassen County, in the Warner Mountains at 6560 feet (2000 m), the highest colony, breeding habitat was dominated by the floating yellow pond-lily (*Nuphar luteum* ssp. *polysepalum*). Of 58 sites with emergent vegetation, 50 (86.2%) were dominated or co-dominated by low emergent spikerush (*Eleocharis* spp.) or *Juncus* spp., seven by a mixture of tall emergents such as tules (*Scirpus* spp.) or cattails (*Typha* spp.) and low emergents, and one by a low emergent composite (*Arnica* sp.).

Percent cover of emergents was >80% at 41 sites (68.3%), between 60% and 80% at nine sites (15%), between 40% and 60% at three sites (5%), between 20% and 40% at no sites, and between 0% and 20% at seven sites (11.7%). All sites with <20% emergent cover, except Lower Klamath NWR, were lakes or reservoirs with mostly open water fringed by marsh vegetation. If we had limited estimates of vegetative cover to actual breeding sites, rather

than the entire wetland, the proportion of total sites with >80% cover would have been higher.

*Central Valley.* Of the valleywide total, about 2057 pairs (93.0%) bred in cultivated rice fields, 151 (6.8%) in agricultural fields with residual crops and weeds and shallow water remaining from winter floods, and 5 (0.2%) in emergent wetlands of low stature. Of the four pairs that bred in protected areas, two each were at Merced and San Luis NWRs in the San Joaquin Basin. All breeding evidence in the Sacramento Valley was from rice fields, though one colony in Glenn County was in sedges in the corner of a field rather than in the rice itself (Shuford pers. obs.). Of the 226 pairs in the San Joaquin Valley, 66.8% were in flooded agricultural fields with residual crops or weeds, 31.0% in rice fields, and 2.2% in emergent wetlands of low stature.

## DISCUSSION

### Accuracy of 1997–1998 Surveys

Although unable to estimate the precision of all methods used to survey terns in 1997–1998, we suspect our overall population estimate for the state was within 30% of the actual number. The 95% confidence interval was ±60% for surveys in rice fields of the Sacramento Valley (Table 2) versus ±25% for the "undisturbed adults" method used in northeastern California and the San Joaquin Valley (Tables 1 and 3). The precision estimate for the latter method, though, is applicable only for the incubation period, when it was derived, even though this method was used for data collected throughout the breeding season. Although the "total nests" and "disturbed adults" methods, also used widely in northeastern California and the San Joaquin Valley (Tables 1 and 3), lack estimates of precision both underestimated numbers of nesting pairs (see Methods). Another source of underestimation was our inability to cover some potential tern nesting habitat in northeastern California. Hence our overall estimate is more likely an under- than an overestimate of the statewide nesting population during the survey period.

To have conducted the statewide survey in one rather than two years would have been desirable also. We suspect, though, that numbers from the 1997–98 survey were representative of those statewide in 1998, when we surveyed the entire Central Valley and water conditions in northeastern California were similar to those in 1997.

### Historical Patterns of Distribution and Abundance

Past data on the distribution and abundance of breeding Black Terns in California are mostly anecdotal (Grinnell and Miller 1944, Cogswell 1977, Shuford 1999). Breeding populations were restricted to two distinct areas: (1) the Modoc Plateau and mountain valleys of northeastern California and (2) the lowlands of the Central Valley. Today the outlines of the breeding range remain much the same (Figures 1–3). In northeastern California, however, the species is extirpated at Lake Tahoe. In the Central Valley it is extirpated in the delta, and in much of the San Joaquin Valley it is either extirpated or breeds irregularly, only in exceptionally wet years. Grinnell and

Miller (1944) considered the Black Tern a "locally common" breeder in California. Evaluating subsequent population trends is very difficult given the anecdotal nature of early accounts and the lack of recent Breeding Bird Survey data for California sufficient for trend analysis (Peterjohn and Sauer 1997, Sauer et al. 2000).

*Northeastern California.* Historic locations of confirmed breeding for this region include Tule Lake and Alturas Meadow, Modoc County; Grasshopper Meadows/Lake and Eagle Lake, Lassen County; and Lake Tahoe, El Dorado County (Grinnell and Miller 1944; Appendix 1). Assessing population trends is problematic given the few known historic breeding areas, the large number of recent breeding sites (Table 1), few of which have a long record of occupancy, and the species' propensity to shift from site to site with fluctuating environmental conditions. Extensive wetland loss, particularly in the Klamath Basin, may have been partially offset on the Modoc Plateau by the creation of shallow reservoirs for livestock grazing and recent enhancement for waterfowl (T. Ratcliff, G. Studinski pers. comm.).

Black Terns have bred at Eagle Lake since at least 1918 (Appendix 1). Using a combination of nest counts in habitat visited, the behavior and number of terns in suitable habitat not well surveyed for nests, and the extent of suitable habitat not visited, Gould (1974, in litt.) estimated 300 breeding adults at Eagle Lake in 1970 and 150 in 1971. From nest counts, Lederer (1976) estimated 46 breeding adults in 1974; Shaw (1998) estimated 78 in 1996 and 64 in 1997. Our independent estimate in 1997, based on counts of undisturbed adults, was 224 breeding adults (112 pairs; Table 1). A count of 160 undisturbed adults on 23 June 1999 yielded an estimate of 252 breeding adults (126 pairs; Table 1, footnote). Together these numbers may reflect year-to-year variation in nesting population size, perhaps mirroring changing patterns of emergent vegetation in response to lake levels (G. Gould pers. comm.) rather than a population decline followed by recovery, or, in part, the variation in survey techniques among observers.

Black Terns formerly reached their southeastern breeding limit in the region at Lake Tahoe, where they nested mainly at Rowlands Marsh near the mouth of the Upper Truckee River, El Dorado County (Orr and Moffitt 1971). That colony once held over 100 pairs, and, prior to 1920, colonies of four or five pairs bred near the mouth of Emerald Bay, at Meeks Bay, and near Tahoe Vista; "a few pairs" also formerly nested annually west of Tallac (Orr and Moffitt 1971; Appendix 1). Habitat loss and degradation from development and lowering of water levels eliminated breeding Black Terns at Lake Tahoe (Orr and Moffitt 1971, Cogswell 1977, K. Laves pers. comm., Shuford pers. obs. in 1998). Today the species reaches its southern limit in the Sierra Nevada at Sierra Valley, Plumas and Sierra counties, and at Kyburz Flat, Sierra County, where breeding is irregular, particularly at Kyburz (Appendix 2).

Black Terns have been reported breeding in the extensive marshes of Sierra Valley since at least the early 1970s (Appendix 2), primarily by birders looking off Marble Hot Springs Road (Dyson Lane), Plumas County. Numbers there fluctuate annually (up to 50 on 27 May 1989, J. McCormick in litt.), and terns are absent in some drought years, such as 2001 (Shuford

pers. obs., 12–16 June) The species also occurs in the Sierra County portion of the marsh (e.g., up to nine adults ~4 miles north of Sierraville 15–20 June 1999; J. McCormick, Shuford pers. obs.), but this area gets little coverage.

Small's (1994) report of "the largest regular [breeding] concentration (1000+) in northern California" in the Klamath Basin is unsubstantiated. Although Zeiner et al. (1990) mapped the summer range as including the Shasta Valley, Siskiyou County, and Small (1994) cited Cedar Lakes, Shasta Valley, as a recent breeding area, we know of no documented breeding records for that valley (Appendices 1 and 2, R. Ekstrom in litt.). M. McVey (in litt.) did not find evidence of Black Terns breeding at any of numerous wetlands in the Shasta Valley he surveyed in 1998 and 1999.

*Central Valley.* Grinnell and Miller (1944) reported Black Terns nesting in the Central Valley along the Sacramento and San Joaquin rivers (latter near Merced) and at Los Banos, Merced County, Laton and Firebaugh, Fresno County, and Buena Vista Lake, Kern County. They also noted the species had colonized rice fields. Egg-set data provide a minimum of two nesting records for the Sacramento Valley, 39 for the delta (none reported by Grinnell and Miller), and 399 for the San Joaquin Valley (Appendix 1). Although terns were widely scattered in the latter valley, many egg sets were collected from the Los Banos area of the San Joaquin Basin, perhaps reflecting local abundance, ease of observer access, or collector bias. In the early 20th century the San Joaquin Valley was of great importance to breeding Black Terns; Ray (1906), Chapman (1908), Tyler (1913), and van Rossem (1933) described the species as very numerous there. Among the few early quantitative estimates were over 100 nests near Los Banos and South Dos Palos from 19 to 22 May 1919 (J. G. Tyler et al., Appendix 2), "many hundreds in sight in all directions" in overflow lands of the San Joaquin River near Los Banos on 29 May 1941 (W. B. Minturn field notes), and a colony of "about 200 pairs" at Buena Vista Lake on 21 June 1921 (A. J. van Rossem egg data slip, WFVZ 2470). Sacramento Valley and delta records being so few may in part reflect limited egg collecting there.

From the cessation of most egg collecting in the mid-1940s until our 1997–1998 surveys, the limited information on the Black Tern's status in the Central Valley was primarily anecdotal. Although Grinnell and Miller (1944) noted the at least partial shift in breeding from reclaimed marshes to cultivated rice, it is unclear how widespread or numerous terns were in rice fields, which in 1943 totaled 96,000 ha in California (National Agric. Statistics Serv.; http://www.nass.usda.gov:100/ipedb/). The estimate of 1000+ migrant Black Terns at the Woodland Sugar Ponds, Yolo County, 8–21 May 1955, though notable at the time (AFN 9:355), far exceeds any such recent estimate for the Sacramento Valley. Black Terns bred at Sacramento NWR in 1958 (Appendix 2), when rice was regularly grown on the refuge, but no terns are known to have bred on any federal refuge in the Sacramento Valley since at least the early 1980s (J. Silveira pers. comm.). Greenberg (1972) reported up to 48 Black Terns in mid-June on two 6-mile (9.6-km) road transects in Sutter and Sacramento counties from 1969 to 1971, but data are too few for trend analysis. Cogswell (1977) concluded that Black Tern numbers declined in the Central Valley with loss of marshes,

increased with expansion of rice growing, and declined again "recently," perhaps from pesticide accumulation. The anecdotal nature of his and others' claims of declines (AFN 24:638, AB 32:1205, AB 39:98) or upswings (AB 31:1185) in tern numbers in the Sacramento Valley in the 1970s and 1980s make them hard to evaluate. Lee (1984) found six colonies (one in Sacramento Co., five in Sutter Co.) while studying Black Tern nesting biology in rice fields in 1976 and 1977 but made no population estimates for the area.

Numbers of Black Terns recorded during surveys of pheasant broods in Butte County in late June and early July, 1976–1992 (J. Snowden in litt.), did not show any significant temporal trend but appeared to track the county's rice acreage (Figure 5). Similarly, the only Breeding Bird Survey route in California (no. 148) with moderate numbers of Black Terns (median 9, range 0–54), in Glenn and Colusa counties in the Sacramento Valley, showed substantial variability in numbers and no clear trend from 1971 to 1999 (USGS Patuxent Wildlife Research Center 2000; http://www.mp2-pwrc.usgs.gov/bbs/retrieval/).

W. B. Minturn (field notes) was still observing up to 500+ at various sites in the San Joaquin Valley in May through at least 1950. In the Tulare Basin, Black Terns probably bred regularly at Tulare and Buena Vista lakes until the 1940s and 1950s (Appendix 1), when dams constructed on the rivers feeding them cut off most runoff. Since then breeding in that basin has been irregular,

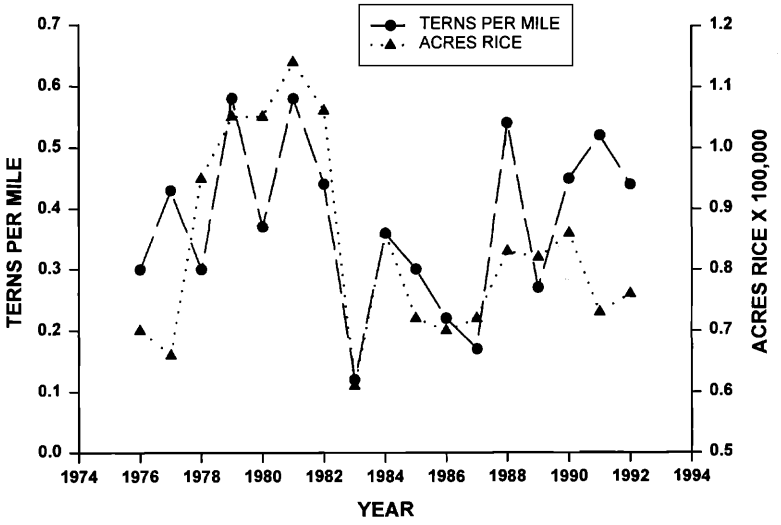


Figure 5. Numbers of Black Terns on California Department of Fish and Game survey routes for pheasant broods in Butte County, 1976 to 1992 (see Methods), relative to yearly totals of rice acreage for that county (National Agricultural Statistics Service 1999; http://www.nass.usda.gov:100/ipedb/).

mainly in extremely wet years. On 22 July 1983, following an El Niño winter, R. Hansen (MPCR files) found "many" nests and up to 70 Black Terns, mostly fledged young, at the Hacienda Ranch Flood Basin and South Wilbur Flood Area, Kings County. Also in the early 1980s, Black Terns nested in thick ditch-grass (*Ruppia maritima*) at J & W Farms agricultural evaporation ponds, 18 km southwest of Corcoran, Kings County (G. Gerstenberg pers. comm.). These ponds are no longer active, though, and other evaporation ponds in the basin currently do not support much emergent growth or any breeding Black Terns (R. Hansen, J. Seay pers. comm.).

Similar local extirpations have also occurred in the San Joaquin Basin. In the early to mid-1950s, Black Terns nested where a slough flooded areas of spiny saltbush (*Atriplex spinifera*) interspersed with vernal-pool–like habitat at Volta Wildlife Area (WA) near Los Banos (R. Wilbur pers. comm.). Black Terns appear to have been still widespread around Los Banos at that time, as R. D. Ross (MPCR files) estimated 200–250 terns on a drive across Highway 152 on 15 June 1956. Subsequently, P. J. Metropulos (in litt.) found the species "common" in the Los Banos area on 20 June 1970, V. Remsen and P. Myers (AB 27:914) counted 43 south of Los Banos on 16 June 1973, and R. J. Bacon (MPCR files) sighted two or three nesting pairs at Merced NWR in summer 1983. Black Terns apparently were nesting in the Traction Ranch section of Mendota WA, Fresno County, when ponds were first developed there about 1990 (S. Bruggemann pers. comm.). Today terns do not nest regularly at any of the state or federal refuges in the San Joaquin Valley (J. Allen, S. Bruggemann, R. Wilbur, D. Woolington pers. comm.). They likely breed regularly, though, in the limited rice acreage near Merced and South Dos Palos, though this remains to be documented. The current tenuous status of breeding Black Terns in the San Joaquin Valley documents a major population decline there over the last 100 years and an apparent shift of abundance to the Sacramento Valley. It is possible, though, that the Sacramento Valley has always been an important, though poorly documented, breeding area.

*Extralimital breeding.* Apparent nesting at Merritt Lake, near Castroville, Monterey County (Silliman 1915), likely represents an extralimital attempt, as the species has not bred elsewhere along the coast of California.

### Historical Habitat Shifts

In the past, Black Terns nested in the Central Valley in ephemeral early successional wetlands created by natural overflow of rivers and lakes (Mailliard 1904, Tyler 1913, van Rossem 1933) or by flood irrigation of pasturelands (Chapman 1908). It is hard to estimate the extent of tern breeding habitat, particularly ephemeral overflow lands, available prior to the massive alteration of the Central Valley's natural hydrology. Hall (1880) estimated 324,000 ha of the Sacramento Valley were subject to inundation from annual overflow and an additional 117,000 ha by "occasional temporary overflow." In the San Joaquin Valley, he estimated 253,000 ha of swamp land were subject to periodic inundation. In the Tulare Basin alone the fluctuating margins of Tulare Lake could engulf many thousands of additional hectares after a series of wet winters.

Although it is unclear how much ephemeral habitat remained through the terns' breeding season, the vast flood plains and natural flood basins delayed transmission of flood flows, reduced peak flows and velocities, and increased summer river flows, as the floodwaters slowly drained back into the rivers, sometimes through July, or evaporated (Bay Institute 1998). The buffering effect of the flood basins shifted high upstream flows of January to May to a period of high river outflow from March to June. Rainfall-induced floods (December–March) predominated in the Sacramento Valley, whereas prolonged snowmelt floods (April–June) were the norm in the San Joaquin Valley, particularly in the Tulare Basin (Bay Institute 1998). Hence, the latter region likely had the most ephemeral habitat for breeding terns.

Today's water-management infrastructure keeps rivers within their banks, except during extreme floods, after which water usually rapidly drains or is pumped back into river and bypass channels, leaving few areas of shallow water where Black Terns could breed. The exception is the closed Tulare Basin where in extreme winters flood waters are diverted into shallow storage basins or run unchecked into fields. Flood frequency has decreased such that floods in the Sacramento Valley that formerly occurred about every 2 years now occur once every 7 to 13 years, 10-year floods every 100 years (Bay Institute 1998). Valleywide, the volumes of large floods remain largely unchanged, but only in years of a very heavy snowpack in the Sierra Nevada do flood flows in the San Joaquin Valley approach historic levels.

The great loss of wetlands was mitigated in the Sacramento Valley by the expansion of rice to the current annual level of 160,000 to 200,000 ha (Figure 6), which may far exceed the average extent of shallow-water habitat available there previously in summer. By contrast, wetlands lost in the San Joaquin Valley have been replaced to only a tiny degree by rice, which has declined there since the mid-1950s (Figure 6). Terns formerly bred in rice fields as far south as Kern County (Appendix 1) but no longer do so.

### Migratory Stopovers

From 1949 to 1977, estimated peak counts of Black Terns at Tule Lake NWR, Siskiyou and Modoc counties, from July to early September ranged from 2000 to 19,000 ($n$ = 17 years, median 5000, Klamath Basin NWR files), documenting it as an important postbreeding or migratory stopover for the species. Estimates of tern numbers at Tule Lake, 15 July–4 August 1997, ranged from 1000 to 6000 (J. Beckstrand, R. Ryno, R. Ekstrom in Shuford 1998). In five years from 1958 to 1972, peak counts at Lower Klamath NWR in August exceeded 1000 (maximum 9000, Klamath Basin NWR files); large numbers have not been reported there in recent years. The only other key stopover site known in the state is the Salton Sea, Riverside and Imperial counties, outside the breeding range. Up to 15,000 have been estimated there in early August (Patten et al. in press), but the only census, 13–16 August 1999, tallied 4011 individuals (Shuford et al. in press). Small (1994) implied that numbers at the Salton Sea have declined since 1987, but M. A. Patten (in litt.) has no evidence of this. Numbers of migrants on the southern California coast have declined greatly since the early 20th century (Garrett and Dunn 1981).

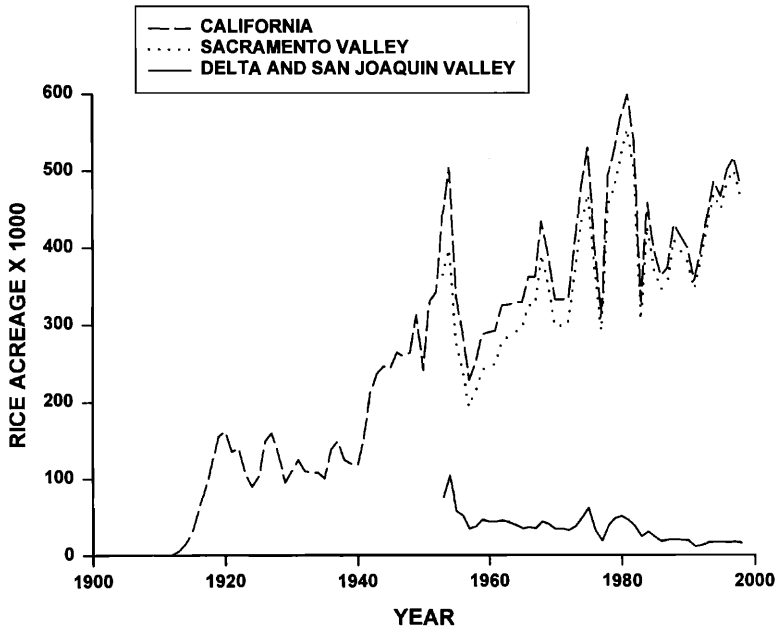


Figure 6. Historic changes in acreage of planted rice in California, 1912 to 1998, and in the Sacramento Valley and Delta and San Joaquin Valley, 1953 to 1998. Data from National Agricultural Statistics Service (1999; http://www.nass.usda.gov:100/ipedb/); county and district breakdowns available only since 1953.

## Current Threats

*Central Valley.* Agricultural practices that rapidly draw down water levels in rice fields have exposed tern nests to rat predation only to destroy renesting attempts later when fields were reflooded above original levels (Lee 1984). In 1998, Shuford saw terns sitting on nests in muddy fields from which the water had been temporarily drained, and later some of these nests were abandoned. The rapid increase in rice cultivation coincided with the post-World War II boom in chemical use in agriculture. Three egg yolks collected from a Black Tern colony in rice fields in the Sacramento Valley in 1969 had 8.0, 9.1, and 11.8 ppm DDE (Greenberg 1972), but there is no evidence of deleterious effects of pesticides or other agricultural chemicals on terns breeding in rice fields. Dunn and Agro (1995) and Weseloh et al. (1997) reviewed the literature on contaminants in Black Tern eggs but found no evidence of reproductive effects. They concluded that direct chemical toxicity is generally not a problem with these terns, but pesticides may reduce favored insect foods. Loss of insect diversity or biomass could lead to chick starvation.

## Conservation Priorities

Black Tern conservation should focus on protecting and enhancing high-quality nesting habitat. Because of the variable and generally arid climate in much of the California breeding range, the value of management efforts in years of short versus abundant water supply should be assessed carefully. Water levels should be regulated to protect important nesting and foraging habitats from ground predators and human disturbance, and management for terns should be coordinated with activities to conserve other species groups via other multi-partner conservation efforts (e.g., Central Valley Habitat Joint Venture, U.S. Shorebird Conservation Plan). Protection of key migratory stopovers, such as Tule Lake and the Salton Sea, is also vital.

*Northeastern California.* Because few Black Terns currently nest on refuges, it would be valuable to see if spikerush-dominated marshes, the species' main breeding habitat in the region, could be established or expanded in these areas.

*Central Valley.* Because summer water typically is scarce in the Central Valley, and because seabirds' productivity often runs in cycles of boom and bust, efforts to enhance tern habitat may be most fruitful in years of exceptional runoff. Recent evidence of extensive, irregular nesting in flooded fields with residual vegetation or crop stubble in the Tulare Basin indicates the species would benefit from more of this habitat. Perhaps fields with marginal crop yields could be retired from production and put in a conservation bank to be flooded when excess water is available. Such flooding should be weighed against possible waterbird mortality from botulism outbreaks, which might be reduced by rotating the fields to be flooded and choosing areas with no prior evidence of disease. Scant breeding on newly restored wetlands on refuges near Los Banos perhaps could be increased in the future, particularly in years of high runoff. In such years, infrastructure improvements likely could spread water over larger areas within or adjacent to bypasses, such as the Eastside Bypass near Los Banos and the James Bypass/Fresno Slough south of Mendota WA. Study also is needed of whether suitable habitat on refuges adjoining bypasses could be increased during years of high flow by drawing upstream water, circulating it through refuge ponds, and draining it back into the bypass downstream. Maintaining a slow, steady flow likely would reduce the chances of botulism.

## Monitoring and Research Needs

Shuford (1999) summarized monitoring and research needs for the Black Tern across North America. Efforts should be made to coordinate California surveys and research with those in other states and provinces to establish a broad perspective on population trends and ecology. Research is particularly needed on the foraging and nesting ecology of Black Terns in California. Studies of habitat suitability at both the local and landscape level are needed to guide wetland protection and acquisition efforts (Naugle et al. 2000). Banding studies are needed to reveal how terns shift with changing water conditions, as are demographic studies to identify which breeding habitats are sources or sinks for the overall population. Researchers should focus on variation in aspects of reproduction most likely to influence population

trends and on understanding factors limiting nest success (Servello 2000), using methods that minimize disturbance to nesting terns (Shealer and Haverland 2000).

We recommend a statewide survey approximately every 10 years, during typical climatic and habitat conditions, to document potential range shifts and calibrate long-term monitoring data. We recommend annual monitoring by trained observers using sampling protocols incorporating precision estimates; methods should be suitable for local conditions and responsive to the shifting of breeding locations.

*Northeastern California.* Monitoring should be conducted in mid-June by counting undisturbed adults from points where observers do not attract mobbing terns. Surveys should be based on a random or stratified sampling of a subset of potential breeding sites, accounting for the difficulty of reaching some.

*Central Valley.* Monitoring should be conducted via standardized roadside transects in rice fields in the Sacramento Valley. Concern about the potential effects of agricultural pesticides and cultivation practices on Black Terns (Lee 1984) begs for expansion of research on these topics. Studies are needed to assess whether the value of rice fields to Black Terns equals that of ephemeral overflow lands or natural marshes.

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## Appendix 1. Numbers of egg sets of the Black Tern in California, 1886–1960, from major California museums.

Northeastern California

Modoc County: Alturas Meadow, 9 June 1918 (2); 3.7 mi W of Alturas, 9 June 1918 (4).

Lassen County: Grasshopper Meadows/Lake, 2–22 June 1918 (20); Spaulding's, Eagle Lake, 3 June 1918 (7); Eagle Lake, 3–6 June 1918 (5), 22 June 1928 (1); nr. Truxell's, east shore of Eagle Lake, 23 May 1923 (1); Upper Ragar Meadow, 1 June 1935 (1).

El Dorado County: nr. Bijou, Lake Tahoe, 19 June 1899 (1), 9 June 1911 (5), 10 June 1912 (2), 6 June 1918 (9); Lake Tahoe, 6 June 1910 (1); Rowland's Marsh (i.e., Al-Tahoe), Lake Tahoe, 22 June 1902 (1), 10 June 1909 (3), 23 May–15 June 1910 (7), 30 May–9 June 1914 (18), 30 June 1918 (1), 5 June 1919 (1), 30 May 1920 (1), 14 June 1928 (1), 21 June 1930 (1), 15 June 1939 (2); nr. Tallac, Lake Tahoe, 22 June 1911 (1).

Central Valley: Sacramento Valley

Colusa County: Maxwell, 23 June 1939 (1).
Yolo County: Woodland, 11 May 1886 (1).

Central Valley: Sacramento–San Joaquin River Delta

Sacramento County: 0.5 mi S of Freeport, 15 June 1899 (2); Bear Lake, 27 May 1923 (5); vic. Sacramento (?county, ?delta), 7 June 1902 (1), 13 May 1906 (2); Stone Lake, 15–29 May 1921 (23), 4 June 1922 (1), 13–30 May 1923 (4).

San Joaquin County: White Ranch, 9 mi N of Stockton, 3 June 1921 (1); Kettleman Swamp, 9.5 mi NW of Stockton, 1 June 1947 (3).

Central Valley: San Joaquin Valley

Madera County: Chowchilla (egg record says "Merced Co."), 23 June 1900 (5); 15 mi W of Madera, 30 June 1923 (1); "Madera Co.," nr. Firebaugh, Fresno Co., 16–17 May 1927 (8); "Madera Co.," 10 mi E of Firebaugh, Fresno Co., 26 May 1927 (4); 10 mi from Firebaugh (?county), 5 June 1927 (1); "Madera Co.," 28 May 1928 (1), 9 June 1930 (3).

Merced County: nr. Brito, 21 May 1919 (1); Dos Palos, 17–22 May 1912 (5), 8 June 1927 (1); Gadwall, 16 May 1914 (1), 1–2 July 1917 (6), 12 May–4 June 1918 (14); Gustine, 14 May 1931 (1), 5 June 1932 (1), 12 June 1934 (1), 7 June 1937 (5);

Los Banos, 17 May 1898 (1), 8 June 1901 (1), 5 June 1905 (3), 2 June 1908 (2), 26 May 1910 (3), 2 July 1913 (1), 7 June 1914 (2), 29 May–25 June 1916 (12), 3–4 June 1918 (4), 26 June 1919 (1), 30 May 1920 (1), 28 May 1921 (1), 3–4 June 1922 (3), 1–18 June 1923 (15), 21 May–21 June 1925 (9), 23 May–20 June 1926 (8), 3 June 1928 (1), 30 May–1 July 1930 (23), 14 June 1931 (1), 13 May–5 June 1932 (10), 12 May–12 June 1934 (4), 11–13 May 1935 (5), 25 May 1936 (4), 14 May–1 June 1937 (11), 4 June 1938 (1), 10 May–7 June 1939 (8), 19 May 1940 (4), 9 June 1941 (1), 9 June 1942 (2); 4–6 mi S of Los Banos, 21–23 May 1919 (2), 30 May 1920 (1), 12–21 June 1931 (5); 8–10 mi E of Los Banos, 7 May 1927 (1), 13 May–1 June 1935 (5); 5–10 mi NE of Los Banos, 9 May 1936 (1), 14 May 1937 (3), 31 May 1939 (1); "Merced Co.," 20 May 1899 (1), 25 May–1 July 1908 (16), 26 May 1909 (9), 15–28 May 1926 (2), 28 May 1928 (1), 9 June 1930 (2), 25 June 1931 (1), 12–19 May 1935 (4), 3 May–9 June 1936 (20), 10 May 1939 (1), 5 June 1946 (1), 22–23 June 1948 (4), 22–23 May 1949 (6); San Joaquin R. at Los Banos Crossing, 15 May 1897 (2).

Fresno County: Columbia Ranch, 24–25 June 1919 (4), 8–9 June 1920 (8), 22–23 June 1921 (5); Firebaugh, 28 May 1916 (2); "Fresno Co.," nr. South Dos Palos, Merced Co., 20 May 1919 (3); nr. Laton, 21 June 1919 (2), 3 June 1922 (1); McNeil's Ranch SW of Fresno, 7 June 1920 (1); Mendota, 26 May 1915 (1), 7–21 June 1930 (5); Riverdale, 25 May 1917 (1), 24 May 1919 (1).

Kings County: 12 mi from Corcoran (egg record says "Kern Co."), 24 May 1940 (1); Gernsey Slough, 3 June 1946 (2); 3 mi E of Hanford, 24 May 1922 (1); nr. Stratford, 23–24 May 1936 (10); border of Tulare Lake, 4 mi W of Waukena, Tulare Co., 6 June 1893 (3); Tulare Lake, 8 June 1941 (11); Tulare Lake (Kings Co.), 24 May–8 June 1941 (18); 14 mi NW of Tulare, 6 June 1893 (1).

Kern County: Buena Vista Lake, 10 June 1907 (1), 19–20 June 1914 (2), 18 June 1916 (1), 19–21 June 1921 (3), 11 June–5 July 1922 (8), 4 July 1937 (1), 5 June 1938 (4), 6 June 1948 (1), 20 June 1954 (2), 24 June 1956 (1); rice field between Wheeler Ridge and Buena Vista Lake, 12 June 1960 (2); Kern River, 5 June 1938 (2).

## Appendix 2. Sight records of confirmed breeding of Black Terns in California, 1899 to 1999, other than those listed or summarized in the text.

Northeastern California

Siskiyou County: Lower Klamath NWR, Unit 13A, mid-July 1995 (22 nests, Klamath Basin NWRs files).

Siskiyou/Modoc County: Tule Lake, early July 1899 ("nests," Bailey 1902).

Modoc County: Beeler Reservoir, 19 June 1976 (nest, B. E. Deuel).

Lassen County: Eagle Lake, 22 June 1921 (15–20 nests, Grinnell et al. 1930), summer 1974 (23 nests, Lederer 1976); Delta Bay, Eagle Lake, late May–mid July 1971 (1 nest, Gould 1974); North Basin, Eagle Lake, late May–late June 1996 (29 nests, Shaw 1998), early June–mid July 1997 (21 nests, Shaw 1998); southwest shore, Eagle Lake, late May–mid July 1971 (6 nests, Gould 1974); nr. Spaulding's, Eagle Lake, 9 June 1925 ("many nests," Grinnell et al. 1930), late May–mid July 1970 (30 nests, Gould 1974), late May–mid July 1971 (33 nests, Gould 1974), early June–mid July 1997 (11 nests, Shaw 1998); eastside bays (Troxel and Duck Island bays), Eagle Lake, late May-mid July 1971 (11 nests, Gould 1974), late May–late June 1996 (10 nests, Shaw 1998).

Plumas County: Sierra Valley, 23 July 1973 (nest, G. Zamzow), 14 June 1989 (nest, D. Shuford et al.), 13 June 1998 (nest, D. Shuford, J. McCormick).

Sierra County: Kyburz Flat, 28 June 1973 (nest, G. Zamzow), 19 July 1973 (nest, G. Zamzow).

El Dorado County: Emerald Bay, Lake Tahoe, 10 August 1918 ("parents feeding

young," J. W. Mailliard in Orr and Moffitt 1971); Rowland's Marsh (i.e., Al-Tahoe), Lake Tahoe, 1 June 1909 ("scores of nests," Ray 1913).

Central Valley: Sacramento Valley

Butte County: W of Biggs, 6 July 1987 (2 nests, J. Snowden in litt.); 3 mi S of Durham, 1 June 1985 (2 nests, J. Hornstein); 2 mi NE of Richvale, 3 July 1984 (7 nests, J. Snowden in litt.).

Glenn County: Sacramento NWR, 9 June 1958 (2 chicks banded; refuge files).

Colusa County: S side of White Rd. 0.7 mi W of Browning Rd., 26 June 1999 (2+ nests, B. Williams in litt.).

Sutter County: S of Kirkville Rd. adjacent to Sutter Bypass, June–July 1976 (3 nests, Lee 1984); jct. Hwy. 113 and Varney Rd., June–July 1976 (10 nests, Lee 1984); E of Armour Rd. between Kirkville and Varney roads, May–July 1977 (2 nests, Lee 1984); jct. Hwy. 113 and Kirkville Rd., June–July 1977 (8 nests, Lee 1984); N of Kirkville Rd. adjacent to Sutter Bypass, June–July 1977 (11 nests, Lee 1984); N of Robbins, June 1969 ("colony of 12 terns [with] nests," Greenberg 1972).

Sacramento County: jct. Hwy. 99 and Elkhorn Blvd., 24 May–22 June 1976 (13 nests, Lee 1984).

Central Valley: San Joaquin Valley

Merced County: nr. Los Banos, 16 June 1903 (young of year just beginning to fly, Chapman 1908), prior to 1923 (photo of chicks, Dawson 1923); San Joaquin River nr. Merced, prior to 1904 ("number of nests recorded," Mailliard 1904).

Merced/Fresno County: vic. Los Banos and South Dos Palos, 19–22 May 1919 (>100 nests examined, J. G. Tyler et al.).

Fresno County: nr. Laton, 31 May 1910 ("set of 3 eggs," C. Lamb in Tyler 1913), 27 May 1917 (colony of about 30 pairs, 8 egg sets, N. K. Carpenter, A. M. Ingersoll *fide* J. G. Tyler); Firebaugh, 30 May 1912 (several birds "sitting on nests," Tyler 1913); Riverdale, 25 May 1917 (colony of 20–25 pairs, 13 egg sets, J. G. Tyler, N. Carpenter); pond S of Fowler, 30 May 1918 (nest, J. G. Tyler); Mendota, 30 May 1928 (3 nests, W. B. Minturn, J. G. Tyler); White's Bridge Rd., Mendota, 17 May 1930 (nest, W. B. Minturn), 7 June 1930 (about 20 nests, W. B. Minturn, J. G. Tyler), 1 May 1937 (7 nests being built, W. B. Minturn), 22 May 1937 (8 nests, W. B. Minturn, C. Chandler), 14 May 1941 (partly completed nest, W. B. Minturn), 7 June 1941 (nest, W. B. Minturn).

Fresno/Madera County: Mendota Dam (i.e., Mendota Pool), 3 June 1933 (8 nests, W. B. Minturn, J. G. Tyler), 23–24 June 1933 (7 nests, W. B. Minturn, J. G. Tyler).

Madera County: 12 mi W of Madera, 9 June 1934 (2 nests, J. G. Tyler).

Kings County: Hacienda Ranch Flood Basin and South Wilbur Flood Area, 22 July 1983 ("many nests", one photographed, R. Hansen); East Hacienda Ranch Flood Basin, 29 June 1997 (5 nests, R. Hansen in litt.)