Inland-breeding Pelicans, Cormorants, Gulls, and Terns in California

A Catalogue, Digital Atlas, and Conservation Tool

W. David Shuford

Wildlife Branch
Nongame Wildlife Program Report 2010-01
California Department of Fish and Game, Sacramento

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Cover photo: Forster's Tern (*Sterna forsteri*) at its nest on an algae mat by tule (*Scirpus acutus*) clumps at Tule Lake National Wildlife Refuge Sump 1-A, Siskiyou County, California, 20 June 1997. This and all other photos by the author.

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Contents

Frequently Used Acronyms

AB = American Birds

AFN = Audubon Field Notes

BBS = Breeding Bird Survey

BCR = Bird Conservation Region

CAS = California Academy of Sciences

CBC = Christmas Bird Count

CDFG = California Department of Fish and Game

FN = Field Notes

GIS = Geographic Information System

LACM = Los Angeles County Museum of Natural History

MPCR = Middle Pacific coast region of North American Birds

MVZ = Museum of Vertebrate Zoology

NASFN = National Audubon Society Field Notes

NWR(s) = National Wildlife Refuge(s)

PRBO = PRBO Conservation Science (formerly Point Reyes Bird Observatory)

SBCM = San Bernardino County Museum

SBMNH = Santa Barbara Museum of Natural History

SDNHM = San Diego Natural History Museum

USFWS = U.S. Fish and Wildlife Service

WA = (State) Wildlife Area

WFVZ = Western Foundation of Vertebrate Zoology

WMA = Wildlife Management Area

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This project had its roots in California Gull research initiated at Mono Lake in 1983 by PRBO. That work led to statewide surveys of California and Ring-billed gull colonies in 1994, which inspired the statewide surveys of seven key species of inland-breeding waterbirds from 1997 to 1999 that provide the basis for this catalogue. The many collaborators on this project have been invaluable, inspiring, and a pleasure to work with, and I sincerely and deeply appreciate their help in all aspects of this work.

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CHAPTER I

Abundance, Distribution, Habitat Use, and Conservation Issues

Close-up of Ring-billed Gulls (*Larus delawarensis*) nesting on a low-lying island at Goose Lake, Modoc County, California, 18 May 1997.

Ring-billed Gull (*Larus delawarensis*) colony on a low-profile island in shallow waters near the southeastern shoreline of Goose Lake, Modoc County, California, 18 May 1997. At this location, the number of islands available and occupied by nesting gulls and terns varies considerably from year to year; no suitable nesting islands may be available when waters recede dramatically during extended dry periods.

EXECUTIVE SUMMARY

Despite the historic loss of over 90% of California's wetlands and strong anecdotal evidence of declines in numbers of colonial waterbirds in the interior of the state, a lack of knowledge of the current status and conservation needs of these birds has limited the remedial actions that can be taken on their behalf.

To inform effective conservation and management, from 1997 to 1999 PRBO Conservation Science and its collaborators conducted surveys throughout the interior of California for seven species of colonial waterbirds: the American White Pelican (*Pelecanus erythrorhynchos*), Double-crested Cormorant (*Phalacrocorax auritus*), Ring-billed Gull (*Larus delawarensis*), California Gull (*L. californicus*), Caspian Tern (*Hydroprogne caspia*), Black Tern (*Chlidonias niger*), and Forster's Tern (*Sterna forsteri*). The estimated number of breeding pairs of these species were: American White Pelican (2346–3039), Double-crested Cormorant (6865), Ring-billed Gull (12,660), California Gull (30,720), Caspian Tern (794–1762), Black Tern (4153), and Forster's Tern (2357).

Collectively these species bred widely, though locally, over much of the state's interior. The American White Pelican and Ring-billed Gull bred exclusively in northeastern California; the California Gull mainly in northeastern California, with an outlying colony at the Salton Sea. The Caspian Tern bred at many of the gull colonies in northeastern California but also in the Tulare Basin, at one site on the coastal slope of southern California, and at the Salton Sea. Likewise, the Forster's Tern bred mainly in northeastern California but also in the San Joaquin Valley and at one site on the coastal slope of southern California. The Black Tern bred widely in northeastern California and in the rice country of the Sacramento Valley and very locally in the San Joaquin Valley. The Double-crested Cormorant was the most widespread, as it bred in northeastern California, throughout the Central Valley, in the central Coast Ranges, on the coastal slope of southern California, and at the Salton Sea.

Because the surveys were conducted during a period of above average precipitation, most species appear to have bred at more sites than they might have under a normal range of conditions. Still, not all sites were occupied annually. The American White Pelican bred at the fewest sites, with only two regular colonies in the Klamath Basin, and the Black Tern at the most, with 62 in northeastern California, 11 in the San Joaquin Valley, and an unknown number scattered in the extensive area of rice fields in the Sacramento Valley.

Species particularly concentrated at one or a few sites in California during the 1997 to 1999 survey period were: American White Pelican, 99% of state's breeders at Clear Lake National Wildlife Refuge in 1999; Double-crested Cormorant, 79% of interior breeders at the Salton Sea in 1999; Ring-billed Gull, 76% of state's breeders at three sites in 1997; California Gull, 81% of inland breeders at Mono Lake in 1997; and Caspian Tern, about 68% of interior breeders at the Salton Sea in 1997. Some species, such as the American White Pelican and California Gull, have concentrated at the same interior sites for many decades, whereas others, such as the Double-crested Cormorant and Caspian Tern, have shifted their colonies dramatically within a few years. The sizes or locations of individual colonies of all species can change rapidly in response to fluctuating conditions, mainly droughts and floods.

Particularly important breeding areas for the seven species of waterbirds were the Klamath Basin (freshwater wetlands, reservoirs); the Modoc Plateau, Great Basin Desert, and northern Sierra Nevada (freshwater wetlands, reservoirs, saline terminal lakes); the Central Valley (rice fields, remnant and artificial wetlands); and the Salton Sea (saline and freshwater wetlands). Although varying in extent and severity by region, habitat loss and degradation have diminished the value of wetlands to waterbirds. Less appreciated has been the profound effect on waterbirds of the nearly complete loss of revitalizing ecological processes in large areas of the state, such as flooding of ephemeral wetland habitat in the Central Valley.

Species accounts for the seven key species provide a summary of their general range and abundance in North America, conservation status at three scales, and seasonal status, historic and current range and abundance, ecological requirements, threats, management and research recommendations, and monitoring needs in California. Although historical data are sketchy, at least five of the seven species have shown declines in overall numbers or a retraction in the size of their breeding range in the interior of the state. Only one species, the California Gull, has clearly increased in numbers by exploiting human alterations of the landscape. The accounts for key species are complemented by a CD-ROM digital atlas with regional interactive maps that enable the user to zoom in on topo maps to locate individual colony (or subcolony) sites and to retrieve information about them.

Brief accounts also summarize the status of six related species—Brown Pelican (*Pelecanus occidentalis*), Laughing Gull (*Leucophaeus atricilla*), Franklin's Gull (*Leucophaeus pipixcan*), Least Tern (*Sternula antillarum*), Gull-billed Tern (*Gelochelidon nilotica*), and Black Skimmer (*Rynchops niger*)—that have bred very locally or irregularly inland in California.

Overarching conservation concerns for the seven key species are the availability of suitable nesting sites secure from ground predators and human disturbance and availability of high quality water to supply wetland foraging habitats that support abundant, uncontaminated prey. The concern for the availability of high quality water has been heightened in recent years by deformities of embryos of aquatic birds caused by high selenium levels in Central Valley wetlands, water shortages in the Klamath Basin, and projections that increasing salinity at the Salton Sea will soon cause a permanent crash in fish populations and the birds that depend on them. Solving or preventing such problems will require broad-based support, collaboration or negotiation among various stakeholders, and education of the general public and elected officials. Regardless, enhancing waterbird populations by restoring or mimicking lost ecological processes, even at a tiny scale, can be costly. It will be important to monitor the populations of these species and to conduct research that enables improvements in the implementation of management and conservation actions. If early warnings of decline are unavailable, and actions are not taken in response, further declines may progress to the point where recovery may be difficult, expensive, and contentious.

INTRODUCTION

Spurred in part by the success of the North American Waterfowl Management Plan (NAWMP 2004), initiated in 1986, conservation plans for other groups of birds (e.g., shorebirds, Brown et al. 2001; colonial waterbirds, Kushlan et al. 2002) have been developed. To be successful, these plans need effective strategies for implementation, which require a strong foundation of biological information that is relevant to the conservation and management of these birds.

For example, in response to threats to seabird breeding colonies (Carter et al. 1995a), one focus of efforts to manage for healthy seabird populations in California has been to establish baseline data on colony sizes and locations for evaluating population trends and threats over time. Such information can trigger management actions to help stem or reverse declines in these vulnerable species. To meet this need, comprehensive surveys of all species of seabirds that breed on the California coast have been conducted twice, from 1975 to 1980 (Sowls et al. 1980, Hunt et al. 1981) and 1989 to 1991 (Carter et al. 1992, 1995a). Annual surveys are now conducted of almost all coastal breeding colonies of threatened and endangered species as well as three abundant species, the Brandt's Cormorant (*Phalacrocorax penicillatus*), Double-crested Cormorant (*P. auritus*), and Common Murre (*Uria aalge*) (Carter et al. 1996).

By contrast, no comprehensive statewide surveys have been conducted for waterbirds breeding inland in California, despite the historic loss of over 90% of the state's wetlands (Dahl 1990) and strong, though poorly documented, indications of population declines in these species. To establish an accurate baseline, from 1997 to 1999 PRBO Conservation Science (PRBO) and collaborators conducted a study to document the status, distribution, and conservation needs of seven species of inland-breeding waterbirds in California. We focused survey efforts on particular regions of the state's interior in successive years and gathered supplemental information at some sites in 2000 and 2001. Species surveyed included the American White Pelican (*Pelecanus erythrorhynchos*), Double-crested Cormorant, Ring-billed Gull (*Larus delawarensis*), California Gull (*L. californicus*), Caspian Tern (*Hydroprogne caspia*), Black Tern (*Chlidonias niger*), and Forster's Tern (*Sterna forsteri*). This catalogue presents the results of these surveys, summarizes the historic and current patterns of distribution, abundance, and broad-scale habitat use of all species, and makes management recommendations for protection and enhancement of colony sites and foraging habitats.

STUDY AREA AND METHODS

Background and Overall Approach

To enable effective field work, I first searched the published and unpublished literature and contacted various field biologists to identify historic and potential breeding habitats in California for the seven key species of this study. In this report, data from *Audubon Field Notes* (AFN) and *American Birds* (AB) are cited 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, I contacted additional biologists for further information on potential breeding habitat. For all seven species, I later obtained egg-set data, or confirmed a lack thereof, from major California museums: 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).

The study area was virtually the entire interior of California. Along the coast, my collaborators and I did not survey colonies within coastal estuaries, in diked wetlands immediately adjacent to them, or other colonies within 10 km of estuarine shorelines. This assumed that waterbirds nesting in such proximity to estuaries were likely foraging in estuarine waters and hence their colonies were best classified as coastal rather than interior. Similarly, we did not survey colonies in Suisun Marsh because of its proximity to San Francisco Bay and because this area was included in prior surveys of coastal seabirds (Carter et al. 1992), some of which also breed in the interior.

I worked with various collaborators to survey almost all potential breeding habitat for the seven species. Because of California's large size and the scattering of colonies of the seven key species throughout much of its interior, we conducted surveys in three general regions over three consecutive years: northeastern California in 1997, the Central Valley in 1998, and the central and southern Coast Ranges and coastal slope, Sierra Nevada foothills, and Salton Sea area (Salton Sink) in 1999, as described below. We varied field survey methods by region to match local logistical constraints and timed surveys, as best as possible, to follow the passage of most migrants and begin with the initiation of nesting. With the large number of sites to cover and the substantial year-to-year variation in the timing of nest initiation for some species (e.g., Forster's Tern), survey timing was not always ideal.

We did not conduct surveys in the rugged Coast Ranges and Siskiyou and Klamath Mountains of northwestern California, in the Mojave Desert, or in most of the Colorado Desert of southeastern California. Habitat for waterbirds is very limited in these regions and there was no recent or prior evidence of any of the seven species breeding inland in these areas, except along the lower Colorado River or in the Salton Sink. The latter area was the only one we surveyed for waterbirds in the southern deserts. Although the Double-crested Cormorant has nested along the Colorado River (Rosenberg et al. 1991), we did not perform formal surveys along that river. Biologists conducting intensive surveys there for landbirds at the time of our waterbird surveys were confident that there were no colonies of this cormorant on the California side of the river (R. McKernan pers. comm.).

We conducted surveys by foot, kayak or canoe, or airplane and supplemented data from our surveys with nests counts taken at other sites by cooperating biologists. I believe these surveys were nearly comprehensive and that any colonies missed likely were small or irregularly occupied. The detailed descriptions of survey methods, below, by three subregions and a complete list of sites surveyed (with or without nesting birds), included in Appendices 1–4 and various tables, will allow for a repeat of these surveys in future years and a direct comparison to the data collected from 1997 to 1999. Likewise, these data and prior historical records, summarized in Tables 1–19 and Appendices 5–10, will allow future researchers to assess long-term population trends and changes in distribution of these species.

Because five species had either relatively small populations, limited ranges, or few breeding sites in the interior of the state, I was able to estimate the size of inland breeding populations of the American White Pelican, Double-crested Cormorant, Ring-billed Gull, California Gull, and Caspian Tern from surveys conducted in a single breeding season (in some cases in more than one year). For the Double-crested Cormorant, however, this first required extensive preliminary surveys to locate colonies. We surveyed cormorants in northeastern California and the Central Valley in 1997 and 1998, respectively. In 1999, we conducted a statewide survey of cormorants in the interior by covering the remainder of the state for the first time and by also resurveying all colonies located in 1997 and 1998. By contrast, I estimated the size of inland breeding populations of the Black and Forster's terns from surveys over two years (1997 and 1998) because of their fairly extensive breeding ranges in the state, the large number of potential breeding sites, and the difficulty of surveying these species from an airplane.

Northeastern California

This region includes valleys of the Cascade, Klamath, and Sierra Nevada mountains, the Modoc Plateau, and the Great Basin Desert within eastern Siskiyou, northeastern Trinity, eastern Shasta, Modoc, Lassen, Plumas, Sierra, El Dorado, and Mono counties. Although much of the region is relatively arid, it has extensive potential nesting habitat for waterbirds in marshes, lakes, and reservoirs. These habitats are scattered widely, primarily from 4000 to 6000 feet (1220–1830 m) elevation, in plateaus, large valleys, or basins receiving drainage from nearby mountains. 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 (averaged results from weather stations throughout the region). Combined, these divisions encompass most of the northeastern study area. As these figures represent 119% and 147%, respectively, of the long-term averages for these areas (Western Regional Climate Center, www.wrcc.dri.edu/divisional.html; n = 104 yrs), wetlands in northeastern California were well supplied with water in summer 1997, when most surveys of this region were made.

American White Pelican and Double-crested Cormorant

Nesting habitat for the region's pelicans and cormorants consists of barren sandy and rocky islands and tule-mat islands in remote lakes and marshes; cormorants also nest in trees within lakes, marshes, and reservoirs.

On 12 and 13 May 1997 and 13 May 1999, I conducted aerial surveys in a Cessna 185 single-winged aircraft to photograph known colonies of the American White Pelican and Double-crested Cormorant and to search for additional colony sites for these and other species (Appendices 1 and 4). Aerial, rather than ground, surveys were conducted at most sites because of the extreme sensitivity of these species to disturbance at their nesting colonies. At each colony, I took multiple overlapping photographs with a single-lens reflex camera with a 300 mm lens while the plane circled at about 80 to 110 mph at about 120 to 150 m above the colony. This altitude was selected to obtain the best possible photographs while avoiding flushing birds from their nests. Pelican and cormorant colonies so photographed were at Meiss Lake, Butte Valley Wildlife Area (WA); Sheepy Lake at Lower Klamath National Wildlife Refuge (NWR), Siskiyou County; (lower) Sump 1-B at Tule Lake NWR, Siskiyou and Modoc counties; Clear Lake NWR, Modoc County; and Pelican Point at Eagle Lake, Lassen County. Agency personnel also conducted ground counts of cormorant nests at Meiss Lake during gull surveys on 14 to 15 May 1997 and 13 May 1999.

My colleagues and I used standardized methods developed for surveying coastal seabird colonies (G. J. McChesney and H. R. Carter in litt.) to count numbers of pelicans and cormorants. This involved first sorting to obtain a subset of overlapping reference photographs (slides) of the highest resolution and contrast, projecting these on a large sheet of white paper (69 x 86 cm easel), and marking nests and birds with a fine marker using identifiable landmarks as reference points to avoid double-counting. For most colonies or subcolonies, I estimated the number of pairs of pelicans and cormorants as the number of active nests (those with incubating or brooding adults, eggs, or chicks). Because of asynchronous nesting among subcolonies of pelicans, in some areas medium- to large-sized chicks (about 3–5 weeks old; Evans and Knopf 1993, P. Moreno pers. comm.) had gathered into crèches by the time of our surveys. I divided the counts of crèching chicks by 1.2 (the ratio of chicks per nest at Clear Lake; P. Moreno unpubl. data) to obtain an estimate of nests represented by these chicks.

At a couple of sites where cormorants nested in trees, aerial photographs were not suitable for estimating numbers of nests. Hence, from 14 to 15 May 1997, agency personnel counted cormorant nests at Lake Shastina, Siskiyou County, and at Butt Valley Reservoir, Plumas County. It was possible to count cormorant nests in trees from a distance at Lake Shastina (by boat) and at Butt Valley Reservoir (from the shoreline), thus avoiding disturbance to the colonies. Personnel also conducted a helicopter survey of cormorant nests at Butt Valley Reservoir on 10 May 1999. Observers also took supplemental counts at a number of cormorant colonies in 1998.

Ring-billed Gull and California Gull

The counts at colonies of these gulls in 1997 were the culmination of surveys of the two species in the interior of the state from 1994 to 1997, which focused on the Modoc Plateau and Great Basin Desert in northeastern California where most historic colonies have been located (Shuford and Ryan 2000). See the cited paper for a description of climatic conditions prior to and during the 1994–1997 surveys. Beyond obtaining data on historic, current, or potential breeding sites, as described above, I also scouted for additional gull colonies during other surveys. These included shorebird surveys (by airplane, airboat, and on foot) in northeastern California in late April to early May in 1994 and 1995 and surveys of the state's interior for various inland-breeding waterbirds from mid-May to mid-July, 1997 to 1999, as described elsewhere in the Methods. As part of ongoing studies, biologists censused California Gull colonies at Mono Lake in the Great Basin of northeastern California (PRBO unpubl. data, J. R. Jehl Jr. in litt.) and at a recently formed colony at the Salton Sea in the Colorado Desert of southern California (Molina 2000; see for methods). Because there also have been ongoing censuses of the only coastal colonies of the California Gull in San Francisco Bay (Shuford and Ryan 2000, Strong et al. 2004; see for methods), these data were combined with those for the interior to provide a comprehensive perspective of the species' status for the whole state.

I also supplemented the statewide gull surveys with data from opportunistic surveys or ongoing studies from 1998 to 2000. For numbers from other sources, I report dates of surveys, methods used, and the numbers of nests or pairs when these are available. Otherwise, I report numbers of nesting adults as I knew of no reliable way, lacking knowledge of survey methods, to convert raw counts or estimates of adults to nesting pairs.

To capture peak nesting numbers, I selected a primary survey period of mid- to late May in northeastern California, which reflected the late incubation to very early hatching period of both species (PRBO unpubl. data). My colleagues and I counted all gull nests or breeding adults at various colonies in northeastern California primarily from 11 to 29 May, 1994 to 2000. A few early-season surveys (27 Apr–3 May) served mainly to confirm the lack of nesting at a few sites occupied irregularly. I also counted nesting gulls at Goose Lake in mid-June 1999 and 2000; gull nesting at Goose Lake in these years appeared greatly delayed compared to other sites in the region. Dates of nest counts at Mono Lake in all other years, 1983 to 1993, ranged from 18 May to 2 June, except in 1983 when they spanned 29 May to 16 June (PRBO unpubl. data, J. R. Jehl Jr. in litt.). My colleagues and I conducted aerial photographic surveys of nesting gulls at the otherwise inaccessible Sheepy Lake pelican and cormorant colony at Lower Klamath NWR on 23 May 1994, 12 May 1997, and 13 May 1999. Gulls may have nested at this site in other years of our surveys, but a lack of counts at this small colony has little effect on statewide totals. Similarly, we were unaware until 1995 that in 1994 a few gulls bred at Steamboat Lake on Shasta Valley WA, Siskiyou County; no gulls bred at this location in subsequent years (M. McVey pers. comm.).

In northeastern California, including Mono Lake, observers made most counts by walking through colonies and marking each nest individually (on the rim or on an adjacent rock or weed) with a dab of spray paint to avoid over- or undercounting. For those colonies, I estimated the number of nesting pairs equaled the number of nests counted. At Clear Lake, most years we used the spray-paint method to count one to two gull colonies not inhabited by other colonial waterbirds. Otherwise, observers minimized disturbance to multispecies colonies by counting all adults gulls from a small motorboat cruising slowing by the colonies about 60 m offshore. I estimated the number of nests on these islands as 0.71 of the number of adults counted for the Ring-billed Gull and 0.72 for the California, the ratios at Clear Lake in 1994 at colonies in open terrain where we could count both nests and adults. Though these ratios may vary by site and year, I applied them at Sheepy Lake to counts of adults obtained from aerial photographs in 1997 and at Goose Lake to counts of adults from the ground in 1999 and 2000, when the association of gulls with nesting Caspian Terns precluded nest counts. As we made all counts in the morning at the same stage of the nesting cycle, I judge these correction factors produce reasonable estimates of the number of nesting pairs at each colony. At Lake Shastina in 1994, R. Ekstrom (in litt.) counted nesting gulls from shore by looking out to the small unnamed nesting island off Milkhouse Island; in other years, observers counted nests using the spray-paint method.

Because the methods used to estimate nests, adults, or young varied widely among historical and recent sources, I categorized the accuracy and repeatability of each estimate as high (1), moderate (2), or unknown (3). 1: All counts taken near the late incubation period when the adult nesting population reaches its peak; individual nests counted in entire colony, or density of nests in a portion of a colony calculated then applied to the measured area occupied by the entire colony, or number of pairs estimated from counts of adults converted to nesting pairs from the ratio of adults to nests determined for a portion of the colony. I consider such data appropriate for population-trend assessment. 2: Counts taken on known date(s) in early to mid-nesting season and based on direct counts or (perhaps rough) estimates of adults or chicks, possibly from a distant vantage point. Such data should be viewed cautiously in assessment of population trends. 3: Date(s) and/or methods of surveys unavailable, or methods as in Category 2 but estimate made late in the nesting season, or estimate made visually from a fixed-wing aircraft. Such data should be used with great caution in interpreting population trends. The quality of estimates based on early- to midseason aerial photographs varies with the clarity and size of images and contrast of adult gulls and nests with the background and thus should be subjectively assigned to one of the three categories.

Caspian Tern

Caspian Terns in northeastern California typically breed with mixed assemblages of colonial breeders, particularly Ring-billed and California gulls. Because of the terns' association with gulls, my colleagues and I did not enter the colonies to count nests to avoid flushing birds and exposing the terns' eggs or chicks to gull predation. Instead we counted adults terns and nests (adults sitting in incubation posture) with a scope either from the shoreline or a distant spot on the nesting island or with binoculars from a boat or kayak. From 14 to 18 May 1997, we surveyed Caspian Terns opportunistically along with other species at Clear Lake NWR, Goose Lake, and Big Sage Reservoir. We also censused these terns on 8 June and 14 July 1997 at Honey Lake WA and at Meiss Lake, Butte Valley WA, respectively. On the latter date, when the Meiss Lake colony was first discovered during surveys for Forster's and Black terns, I observed Caspian Tern chicks of various sizes and some adults that still appeared to be incubating eggs or brooding small chicks. All the 1997 surveys, except at Honey Lake, were poorly timed. The May counts were too early, as Caspian Terns typically initiate nesting several weeks after the two species of gulls, and the July count was too late to obtain an accurate nest count. In 1999, when we surveyed all colonies in the state in the same year, we surveyed the colonies in northeastern California from 15 to 22 June, which improved the accuracy of counts over those in 1997. When direct nest counts were available, I used nest numbers as the estimated number of breeding pairs. If nest counts were lacking, I estimated the number of nests or breeding pairs as 0.62 of the number of adults counted, the average ratio of nests to adults at sites on the California coast (0.625, Carter et al. 1992, p. I-45) and the California interior (0.61, D. Shuford unpubl. data) (Shuford and Craig 2002).

Black Tern and Forster's Tern

From 18 May to 19 July 1997, my colleagues and I surveyed most potential breeding habitat in northeastern California for Black and Forster's terns. See Shuford (1998) and Appendix 2 and Tables 14 and 18, this document, for a list of all sites surveyed. In addition, Kevin Laves and I surveyed the south shore of Lake Tahoe, El Dorado County, on 14 June 1998, and Mike McVey surveyed most potential breeding wetlands in the Shasta Valley, Siskiyou County, in spring and summer 1998 and 1999. We also opportunistically resurveyed various sites in the summers of 1998 to 2001, as indicated in the text or tables. 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.

Black Tern. 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, only the method of apparent highest reliability is presented.

Methods included:

(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. I 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 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. I 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. I 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 colony, 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.

Forster's Tern. Methods of surveying Forster's Terns varied with respect to the stage of nesting, whether the terns were nesting on islands or in marsh vegetation, and whether entering colonies would cause undue disturbance. We directly counted nests at most colonies on islands and at some marsh colonies where adults incubating on floating tule, cattail, or algae mats were visible at a distance. At most other marsh sites, we made only undisturbed counts of adults because it would have been necessary to trample extensive areas of moderately tall marsh vegetation to enter the colony to count nests or mobbing adults. We counted disturbed adults in the vicinity of nesting islands at Goose Lake; only a partial nest count was possible there because the terns were still laying and because entering colonies on some islands would have caused undue disturbance to other species.

Thus, depending on circumstances, we obtained three types of counts and used three corresponding methods to estimate numbers of pairs of Forster's 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, only the method of apparent highest reliability is presented. It is likely that all methods provide conservative estimates, particularly because the timing of nest initiation at individual sites can vary considerably among years or subcolonies (Gould 1974, Shaw 1998).

Methods included:

(1) Total nests: obtained by thoroughly searching for all nests in open nesting areas. I estimated the number of breeding pairs as the total number of nests at the time of the survey. This method is very accurate when the terns are nesting on barren or sparsely vegetated islands, where nests are easily visible, and surveys are timed to coincide with the late incubation period, when the peak number of nests should be present.

(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. I 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.

(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. I estimated the number of breeding pairs as the best count divided by 1.43, the mean ratio of undisturbed adults counted to nests for the three sites where we collected both types of data (78 total adults, 56 total nests) during the incubation period. The method's primary biases, adjusted by a correction factor, are that it underestimates the 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.

Central Valley

The Central Valley, surrounded by mountains except at its western outlet into San Francisco Bay, averages about 644 km long and 64 km wide. It is divided into the Sacramento Valley, draining south, the San Joaquin Valley, draining north, the Sacramento–San Joaquin River Delta (hereafter Delta), where these rivers converge, and Suisun Marsh, where landlocked wetland habitats transition to tidal wetlands of the San Francisco Bay estuary. We did not survey colonies in Suisun Marsh for reasons stated above. 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 averages for these regions (Western Regional Climate Center, www.wrcc.dri.edu/divisional.html; n = 104 yrs). Hence, the breeding season of 1998, when we conducted the primary surveys of this region, 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 (on large areas of agricultural land intentionally or unintentionally flooded) and, secondarily, near Los Banos, Merced County (on refuges and flood-control bypasses).

Double-crested Cormorant

Potential breeding habitat for cormorants in the Central Valley is confined primarily to remnant riparian forests along rivers, oxbow lakes, and reservoirs and exotic tamarisk (*Tamarix* spp.) in flood control basins. My colleagues and I conducted surveys of nesting cormorants by boat, kayak, canoe, airplane, and on foot. Because it is difficult to obtain photographs of cormorant colonies in trees from an airplane that are suitable for nest counts, aerial surveys served primarily to locate colonies, which were then counted mainly on foot and occasionally from a boat or kayak.

Our use of boats or other watercraft to survey cormorants was limited. On 3 May 1998, Ted Beedy, Joe Silveira, and I canoed the portion of the Sacramento River from the Ord Ferry Bridge to the Butte City Bridge, landing on a near-shore island to count cormorant and egret nests in sycamore trees near the east bank on the Llano Seco Rancho, Butte County. To look for additional cormorant colonies on the Sacramento River, on 27 May 1998 I accompanied U.S. Fish and Wildlife Service (USFWS) biologists in a power boat on a Bank Swallow (*Riparia riparia*) survey of the river stretch from Princeton upstream to Snaden Island. On 18 and 19 June 1998, various volunteers and I used canoes, a kayak, and a small motor boat to survey cormorants at the South Wilbur Flood Area and the Hacienda Ranch Flood Basin, Kings County.

Joan Humphrey and I conducted aerial photographic surveys for cormorants from a twin-engine Partenavia airplane on 17 and 18 May 1998. Areas surveyed on 17 May included the Sacramento River and adjacent oxbow lakes from the city of Sacramento north to Keswick Dam above Redding, about 1.6 km up Battle Creek, Stoney Creek from the confluence of the Sacramento River up to and including Black Butte Reservoir, Little Butte Creek, Butte Creek from Midway Road/Esquon Ranch south to Highway 20 at the Sutter Bypass, the Butte Sink, the Feather River from Thermolito Diversion Dam south to the confluence with the Sacramento River, the Yuba River from the confluence of the Sacramento River up to the town of Timbuctoo, and Plumas Lake. Areas surveyed on 18 May included the East Toe Drain from Interstate 5 north to the Sutter Bypass; Sutter Bypass (east and west banks); Tisdale Bypass (north and south banks); riparian habitat at the confluence of the Sacramento River, Feather River, Sutter Bypass, and Yolo Bypass; Yolo Bypass (wetlands and all tall vegetation, including that along the Toe Drain, Cache Creek Settling Basin, Putah Creek Sinks, etc.); Sacramento River Deep Water Ship Channel; Sacramento River from Interstate 5 south to the vicinity of Rio Vista; Prospect Island; Liberty Island; Lindsay Slough; Cache Slough; the Cosumnes River from the confluence of the Mokelumne River upstream to Michigan Bar Road; parts of Deer Creek downstream from Highway 16; Valensin Ranch (southeast of jct. Dillard Rd. x Hwy. 99); Pellandini Ranch (south of Twin Cities Rd. between Cosumnes R. and Christensen Rd.); Tracy Lake/Jahant Slough; Dry Creek from the confluence of the Mokelumne River upstream to about 3.2 km east of Highway 99; the South Mokelumne River; the Mokelumne River from Walnut Grove upstream to and including Camanche Reservoir; and New Hogan Reservoir. On 17 May, we first located colonies found during the flight on road maps and then, on the ground, on the "Sacramento River Atlas" (USACE 1991). On 18 May, the pilot pinpointed geographic coordinates of colony sites with an onboard GPS (Global Positioning System) unit and simultaneously stored them on computer disk. We covered all other areas by ground. See Shuford et al. (1999) and Appendix 3 and Table 2, this document, for a list of all sites covered.

Caspian Tern

In 1998, my colleagues and I conducted comprehensive ground and boat surveys for the Caspian Tern by attempting to cover all of its potential breeding habitat in the Central Valley. See Shuford et al. (1999) and Appendix 3 and Table 13, this document, for a list of all sites covered. In 1999, we resurveyed sites in the San Joaquin Valley where Caspian Terns had bred in 1998. I estimated breeding pairs using the same methods as for northeastern California.

Black Tern

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, www.wrcc.dri.edu/divisional.html; n = 105 yrs). 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, my colleagues and I 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 mi (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 until temperatures reached 29° C; as temperatures often were below normal, this meant sometimes surveying 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 these data were not used 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 nonflying 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 determined 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 (Shuford et al. 2001). 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., 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) and Appendix 3 and Table 16, this document, for a list of all 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 (see Shuford et al. 2001). In the latter case, the correction factor used for the Central Valley was that derived in northeastern California in 1997.

Forster's Tern

In 1998, we conducted comprehensive ground and boat surveys for Forster's Terns by attempting to cover all of its potential breeding habitat in the Central Valley. See Shuford et al. (1999) and Appendix 3 and Table 19, this document, for a list of all sites surveyed. I estimated numbers of breeding pairs on the basis of thorough nest counts or counts of adults at sites with partial nest counts. We did not enter most colonies. Thus, we typically counted nests and adults from the periphery of colonies or from a vantage point within the wetland or field where the observer did not attract mobbing adults or flush birds from nests. We conducted thorough nest counts at colonies at which we saw nesting adults in exposed situations on islands, in marshes, or in flooded agricultural fields where they were nesting on large nest mounds, presumably abandoned nests of American Coots (*Fulica americana*). At other sites where some nests were obscured by vegetation, we took partial nest counts, and I estimated the size of the population from the count of undisturbed adults, as entry into the colony to make more complete nest counts would have caused undue disturbance.

Hence, depending on available data, I estimated numbers of pairs of Forster's Terns by either the "total nests" or a modification of the "undisturbed adults" method described above for northeastern California. In the latter case, I estimated the number of pairs as the best count of total undisturbed adults rounded to the nearest even number and divided by two (rather than by using a correction factor to account for visibility of terns). At sites in the San Joaquin Valley for which I used this method, visibility of adults generally was very good and hence there appeared to be little to be gained by conducting disturbed counts of adults. The modified "undisturbed adults" method has the same biases as the "undisturbed adults" method described above for northeastern California.

Coast Ranges, Sierra Nevada Foothills, and Salton Sea

In 1999, we conducted surveys of waterbirds in the interior Coast Ranges immediately adjacent to, and draining east to, the Central Valley; the outer (central and southern) Coast Ranges and coastal lowlands (collectively the coastal slope), draining to the Pacific Ocean, from Sonoma County south through San Diego County; the foothills on the west slope of the Sierra Nevada, draining west to the Central Valley; and the Salton Sea area (Salton Sink).

The Coast Ranges consist largely of hills and low mountains interspersed with small, narrow valleys, where potential waterbird nesting habitat is found mainly at reservoirs or around the few natural lakes. Precipitation (falling mainly as rain, or as snow in the higher peaks) in the climate year 1998–99 was 50.1 cm in the Central Coast Drainage Division and 24.5 cm in the South Coast Drainage Division, representing 93% and 56%, respectively, of the long-term averages for these regions (Western Regional Climate Center, www.wrcc.dri.edu/divisional.html; n = 105 yrs). Although precipitation was below average in 1998–99, reservoirs and lakes were probably maintained at relatively high levels in 1999 by a carry over of runoff from precipitation that was 201% and 198% of the long-term averages for these regions, respectively, in 1997–98.

The Sierra Nevada is a massive mountain range with the highest peaks exceeding 14,000 ft (4267 m), though potential waterbird nesting habitat is limited and found mainly in the foothills on the west slope below 1500 ft (457 m). Precipitation (falling as rain or as snow at higher elevations) in the climate year 1998–99 was 90.4 cm in the Sacramento Drainage Division and 41.6 cm in the San Joaquin Drainage Division, representing 94% and 81%, respectively, of the long-term averages for these regions (Western Regional Climate Center, www.wrcc.dri.edu/divisional.html; *n* = 105 yrs). Although precipitation was below average in 1998–99, reservoirs and lakes were probably maintained at relatively high levels in 1999 by a carry over of runoff from precipitation that was way above normal in 1997–98, as described above for the Central Valley, which shares these drainage divisions.

The Salton Sea is a large saline water body located 227 ft (69 m) *below* sea level in the Salton Sink of the Colorado Desert in extreme southern California. Suitable nesting habitat for waterbirds is found on islands in the sea or in adjacent freshwater impoundments, and in trees stranded in shallow water along the shoreline, at river deltas, or nearby at freshwater lakes in the Imperial Valley. Precipitation in the Southeast Desert Basins Division in the climate years 1997–98 and 1998–99 was 35.0 cm and 10.6 cm, respectively, representing 176% and 53%, respectively, of the long-term average for that region (Western Regional Climate Center, www.wrcc.dri.edu/divisional.html; *n* = 105 yrs).

In 1999, my colleagues and I attempted to survey all potential habitat for nesting cormorants and terns in these regions by airplane, airboat, kayak, motor vehicle, and on foot. See Appendix 4 for a list of all sites covered. At the Salton Sea, PRBO and cooperating biologists counted these species as part of a year-long avian reconnaissance survey (Shuford et al. 2000, 2002) coupled with ongoing studies of breeding larids (gulls, terns, and skimmers; Molina 2004) and other colonial waterbirds (Sonny Bono Salton Sea NWR biologists, Molina and Sturm 2004).

Double-crested Cormorant

In these regions, potential nesting habitat for cormorants is primarily at lakes and reservoirs at low to moderate elevations, where they nest in trees near the shoreline or in water. Additional potential breeding habitat also exists in riparian trees, largely exotic tamarisk, along the Colorado River and at the Salton Sea and vicinity. Although some of the region's other sites have barren islands, these are used by nesting cormorants only at the Salton Sea.

At the Salton Sea, we surveyed nesting cormorants by airplane, airboat, and on foot (Shuford et al. 2000, 2002). We used airboats as the primary means to survey cormorants nesting along the entire shoreline of the Salton Sea. Ken Sturm and associates conducted these surveys on 40 dates between 22 January and 16 July, but they did not visit all colonies on a particular date; surveys of some of the smaller colonies continued only through April. Airboat surveys were supplemented by vehicular visits by Ken Sturm or PRBO staff to an additional colony at Ramer Lake on 6 and 14 May. On each survey, observers recorded the number of active nests and the general stage of nesting at each site. See Shuford et al. (2000) for descriptions of the colony sites surveyed and their nesting substrates.

We used a fixed-wing aircraft to conduct aerial photographic surveys to avoid disturbance and maximize the accuracy of nest counts for the large cormorant colony on Mullet Island and for smaller ones that were least visible from a boat. We photographed nesting cormorants at Mullet Island at the south end of the Salton Sea on 1 February, 19 February, 25 March, and 16 April. We used the field methods described above for northeastern California, and Jennifer Roth counted adults and nests from the photographs as also described above. Using the same field methods, Ken Sturm or I photographed small cormorant colonies in tamarisk and on beds of broken-down common reed (*Phragmites australis*) at the New and Alamo river mouths on 25 March, 3 April, 16 April, 27 May, and 28 May. Subsequently, we converted slides to 10 x 15 cm glossy prints, which we first sorted to obtain a subset of reference photos of the highest resolution and contrast. We then overlapped and taped together the prints to provide a composite photo of the colonies, or subcolonies, from which we counted adults and nests directly.

Ultimately we used the peak single-day (19 February) count of nests on Mullet Island as the estimate of nesting pairs of cormorants for the entire Salton Sea area. This seems justified as the vast majority of cormorants had initiated nests on Mullet Island by early January, and the relatively small number of nests established elsewhere on the sea after 28 February may have represented the relocation of some adults that failed in initial attempts at Mullet. See Shuford et al. (2000, 2002) for additional discussion of the limitations to the survey methods at the Salton Sea.

In the Coast Ranges, Sierra Nevada foothills, and the interior of southern California (away from the Salton Sea), my colleagues and I surveyed for nesting cormorants primarily by airplane; when covering the former two areas we also surveyed portions of the adjacent Central Valley floor of northern California. In a few cases, cooperating observers supplemented our surveys with ground counts of known or newly discovered colonies. See Appendix 4 for a list of sites and areas surveyed in 1999. Aerial surveys in northern California covered wetlands and riparian stands along rivers in portions of the Delta and central and northern San Joaquin Valley and reservoirs in the foothills of the adjoining Coast Ranges and Sierra Nevada (14 and 18 May); various reservoirs in the Coast Ranges west of the Sacramento Valley and the Sacramento River from Fremont Weir up to Redding (19 May); and the northern San Joaquin Valley and reservoirs of the adjacent Sierra Nevada foothills, reservoirs of the Sierra foothills east of the Delta and southern Sacramento Valley, and the Feather River from Oroville Reservoir south to the confluence with the Sacramento River (20 May). Aerial surveys in southern California covered various reservoirs in San Diego County (28 May), western Riverside County (28 May, 7 June), and in San Bernardino, Los Angeles, Ventura, and Santa Barbara counties (7 June). In 1999, we did not survey the lower Colorado River because Robert McKernan and associates (pers. comm.) had surveyed the river and its backwaters for riparian birds annually since 1996 and had not seen any nesting cormorants on the California side.

Caspian Tern and Forster's Tern

Caspian Tern. Data on Caspian Terns at the Salton Sea were provided by Kathy Molina (Molina 2001, 2004; K. Molina in litt.). I counted nests on the ground at Lake Elsinore, Riverside County, on 8 June 1999 after first photographing the colony on an aerial survey the previous day. No additional evidence of Caspian Tern nesting was observed on any other surveys of the interior of southern California.

Forster's Tern. None of the surveys at the Salton Sea in 1999 detected any breeding Forster's Terns. From 3 to 8 June 1999, I conducted surveys on foot or by kayak at potential breeding habitats at various lakes, reservoirs, and wetlands inland in San Diego and Riverside counties. I identified potential sites from discussions with local biologists and from observations of terns at some sites on the aerial surveys for cormorants described above.

Corrections and Additions to Published Accounts

Prior to completion of this catalogue, my colleagues and I published much of the recent survey data, and the historical records compiled for this project, in papers or widely disseminated reports on the status of the Ring-billed and California gulls (Shuford and Ryan 2000), Black Tern (Shuford 1999, 2008a; Shuford et al. 2001), Caspian Tern (Shuford and Craig 2002), and American White Pelican (Shuford 2005, 2008b). Subsequently, during ongoing work on this catalogue, I unearthed some additional historical data on these species, mainly from the Annual Narrative Reports of the Klamath Basin NWR Complex. These additional historical data are incorporated in this catalogue, mainly in tables for the two gull species; in such cases, the data are more comprehensive here than in the corresponding peer-reviewed papers. Although the addition of these data provide a more complete historical record, they are *not* sufficient to alter my prior interpretations of population trends for these species. While working on the catalogue, I also made some changes to tables on recent survey data that correspond to those in published papers on the two species of gulls (Shuford and Ryan 2000) and the Black Tern (Shuford et al. 2001). For all of these species, I parsed some data for particular colonies to distinguish among subcolonies. For the Black Tern, I corrected some minor typos in the body of tables and added some limited recent colony data as footnotes to tables. These minor changes do *not* alter the breeding population estimates for California for the Black Tern nor do they substantially change any prior conclusions on the abundance or population trends of this species in the state. Additional data on the status and abundance of all seven key species discussed in this report are included in two reports on nongame waterbirds in the Klamath Basin of Oregon and California (Shuford et al. 2004, 2006).

Digital Atlas

I collaborated with PRBO's Landscape Ecologist, Diana Stralberg, and her staff, Chris Rintoul and Viola Toniolo, to use data from the surveys described above to produce a digital CD-ROM atlas of the colony locations for the seven species in the interior of California. A copy of this CD, which is an integral part (Chapter 3) of this catalogue, is found in a sleeve at the back of this document; the entire catalogue and the digital atlas are also available online at www.dfg.ca.gov/wildlife/nongame/waterbirdcatalogue/. Although the majority of survey work was conducted from 1997 to 1999, the atlas includes colony locations of Ring-billed and California gulls from 1994 to 2000 and those of the remaining five species from 1997 to 2000. The atlas does *not* identify the locations of the many colonies known to be active outside these periods; these data can be found in the appendices or in footnotes to some of the tables.

To make the digital atlas easier to use on its own, tables (2, 6, 13–16, and 18–19) and figures (1–7) from this catalogue presenting data from the 1994 to 1999 surveys (some supplemental data collected in 2000 and 2001) are duplicated in the atlas. Also, most of the descriptions of methods used for mapping are located both here and within the digital atlas.

Mapping Approach

Recognizing that the approach taken to mapping colonies may vary depending on regional or local conditions, we chose an approach that seemed to best suit inland-breeding waterbirds in California. Mapping of coastal colonies of seabirds typically is fairly straightforward because the islands, offshore rocks, and sea cliffs used for most nest sites are relatively stable both from year to year and over the long term. By contrast, many islands, marshes, and flooded trees at inland sites may be ephemeral in nature and hence their size or availability for nesting can change substantially from year to year or even over the course of a single nesting season.

For this reason, we generally considered the whole of an individual site (e.g., lake, wetland) as the unit for mapping a colony. Colony symbols, and their latitude-longitude coordinates, are typically located at either (a) a central location within the overall site; (b) where most nesting aggregations, or the largest, typically form; or (c) where colonies were found during a particular survey if knowledge of the dynamics of nesting locations for the site as a whole are not well known or if areas of suitable nesting habitat are ephemeral and not discrete in nature (e.g., agricultural lands submerged by natural, versus intentional, flooding). One exception to mapping the entire "site" as a colony is when cormorant colonies form where clumps of trees along streams are periodically isolated by high water. In such cases, the individual colony area is mapped, as it would not be informative to map an entire stream or river, as it would be for many lakes or marshes.

In some cases, we named the colony site as a whole but used a different symbol to map subcolonies in discrete areas within the overall site that are generally available for nesting annually. Such exceptions included lakes or wetlands where more than one island (or sets of islands or islets) are regularly available for nesting (e.g., Mono Lake), large lakes where nesting marshes are located in discrete coves or shoreline segments that typically do not dry out during the nesting season (e.g., Eagle Lake), or large lakes where a combination of islands and marshes or flooded trees in discrete areas are available for nesting more or less annually (e.g., Salton Sea). We also mapped subcolonies within well-defined units or impoundments of state or federal wildlife refuges regardless of whether suitable nesting substrate is generally available each year.

We did not try to map colonies of Black Terns in the extensive area of cultivated rice fields in California's Sacramento Valley both because it was not possible to locate all colonies and because colonies do not tend to form in the same fields year after year.

Digital Colony Maps

Colony sites were mapped on 1:100,000 scale USGS topographic quads. The atlas includes interactive maps for three general regions within California—Northern, Central, and Southern—using the HTML ImageMapper 3.0 extension (Alta4 2001) for ArcView 3.2a software (ESRI 2000). These interactive maps enable the user to zoom in on individual colony (or subcolony) sites at two levels and to retrieve information about them. For each of the three regions of the state, a base map delineates all the individual index quads in which at least one waterbird colony was located during the survey period; moving the mouse pointer to a quad reveals its name and, in parentheses, the number of colonies located within it. Clicking on a quad will reveal a topo map with individual colonies denoted by blue, circled stars and, in some cases, subcolonies denoted by purple, circled stars. Moving the pointer to the star will reveal the colony or subcolony name; clicking on the star will reveal a site table with additional colony information. These site tables provide information on the relevant:

(1) regional map – the Northern, Central, or Southern region in which the interactive map for the particular site occurs.
(2) colony code – a unique number for each colony or subcolony composed of the relevant USFWS Quad Code (found on the regional maps) + the last three digits of the 1:24,000 Quad Code + a three-digit number assigned to each site (generally from north to south, west to east) within the same quad.
(3) site name – the unique name assigned to each colony or subcolony (also used in all data tables in the catalogue and digital atlas). A subcolony name is readily distinguished by the overall colony name listed first with the subcolony name following in parentheses. For example, "Eagle Lake (Pelican Point)" is the subcolony at Eagle Lake located at Pelican Point.
(4) county name – the county in which the colony or subcolony occurs.
(5) 24K Quad – the name of the relevant 1:24,000 topo quad in which the colony or subcolony occurs.
(6) 100K Quad – the name of the relevant 1:100,000 topo quad in which the colony or subcolony occurs.
(7) species codes – AWPE, American White Pelican; DCCO, Double-crested Cormorant; RBGU, Ring-billed Gull; CAGU, California Gull; CATE, Caspian Tern; BLTE, Black Tern; FOTE, Forster's Tern. One or more of these species bred at each colony or subcolony site.
(8) breeding occurrence codes – different codes indicate which of the seven species bred at the colony or subcolony during at least one year of the survey period from 1997–2000 (1994–2000 for gulls), which bred at the exact colony or subcolony site in years outside the survey period, and which bred at least in the immediate area in years outside the survey period (when there is uncertainty if it bred at the exact colony or subcolony site).
(9) latitude and longitude – the coordinates (degrees-minutes-seconds) indicating the approximate location of each colony or subcolony.

Range Maps

For display in both the digital atlas and the hard-copy catalogue, we used ArcGIS 8.3 software (ESRI 2002) to create breeding range maps for interior California for each of the seven key waterbird species. The maps show the relative abundance of breeding waterbirds among colonies on the basis of data on the highest count of nesting pairs at each colony in any year during the three- to four-year period for which data were available for each of the species (see Figures 1–7). Relative abundance categories were determined by the program on the basis of equal intervals, with a few exceptions. If a species had a single colony that was much larger than all others it was given a separate category, and the remaining colony sizes were divided using equal intervals. Even when classified by equal intervals, we sometimes modified the numbers in the legend to more accurately describe the categories. If there was only a single colony within an interval, we used the size of that colony alone, rather than the interval range, in the legend. Similarly, when the sizes of all colonies in an interval were tightly clustered in a narrow portion of the interval, we used the range of the actual values, rather than the interval range, in the legend. Equal intervals were not used to classify relative abundance categories for the California Gull, for which there were large gaps between several clustered ranges of colony size, and the American White Pelican, for which there existed only three colonies of varying size. For both these species the relative colony sizes were classified manually to form the intervals.

RESULTS AND DISCUSSION

The seven species of colonial waterbirds surveyed in the interior of California during this study varied considerably in their patterns of abundance, distribution, and broad-scale habitat use, as described in detail in their respective species accounts in Chapter 2. Here the commonalities and differences in these patterns are compared across species. Because the Double-crested Cormorant, California Gull, Caspian Tern, and Forster's Tern also breed on the California coast, their patterns of coastal distribution are described briefly to provide additional perspective to the descriptions of their inland range in the state.

Abundance

During surveys from 1997 to 1999, the estimated size of the breeding populations of the seven key species in the interior of California were: American White Pelican (2346–3039 pairs), Double-crested Cormorant (6865 pairs), Ring-billed Gull (12,660 pairs), California Gull (30,720 pairs), Caspian Tern (794–1762 pairs), Black Tern (4153 pairs), and Forster's Tern (2357 pairs).

Distribution

Collectively, these seven species bred widely, though locally, over much of the interior of the state (Figures 1–7). The American White Pelican and Ring-billed Gull bred exclusively inland in northeastern California: the pelican in the Klamath Basin, the gull in the Klamath Basin, Modoc Plateau, and Great Basin Desert (Figures 1 and 3). Often breeding together in mixed-species colonies, the California and Ring-billed gulls exhibited very similar statewide ranges, except that the California also nested in outlying colonies to the south at Mono Lake and the Salton Sea and to the west on the coast in the San Francisco Bay estuary (Figure 4). The Caspian Tern also bred inland in proximity to gulls at a number of colonies in northeastern California but also locally in the Tulare Basin in the southern San Joaquin Valley, at one site on the coastal slope of southern California, and at the Salton Sea (Figure 5); see Shuford and Craig (2002) for information on the distribution of breeding colonies of this species on the coast (not mapped here). Likewise, the Forster's Tern bred inland mainly in northeastern California but also at scattered colonies in the San Joaquin Valley and at a single colony on the coastal slope of southern California (Figure 7). This species was not found nesting at the Salton Sea in 1999, though it has bred there irregularly (Molina 2004); it also breeds regularly along the California coast from the San Francisco Bay estuary southward (not mapped here; see Carter et al. 1992). The Black Tern bred exclusively inland, widely in northeastern California and in the rice country of the Sacramento Valley but very patchily in the San Joaquin Valley (Figure 6); in the latter area it typically breeds so locally and irregularly that it is best considered quasi-extirpated there (see species account). Overall, the Double-crested Cormorant was the most widespread of the seven species, as it bred in northeastern California, throughout the Central Valley (Sacramento Valley, Delta, San Joaquin Valley), in valleys of the central Coast Ranges, on the coastal slope of southern California, and at the Salton Sea (Figure 2). Although not mapped here, this cormorant also breeds widely on the California coast (Carter et al. 1992, 1995b).

Because the surveys were conducted in a period in which breeding seasons (particularly 1998) were preceded by winters of above average precipitation, most species appear to have bred at more sites than they might have under less favorable climatic conditions; even during the period of favorable conditions, not all sites were occupied in a single year. Still, the American White Pelican had the most restricted distribution of the seven species, as it bred at only three colonies in California (Figure 1); breeding is regular at only two of these (see species account). By contrast, the Black Tern bred at the most locations: 62 in northeastern California, 11 in the San Joaquin Valley, and at an unknown number of colonies scattered over the extensive area of cultivated rice fields in the Sacramento Valley (Figure 6). Of the other species, the Double-crested Cormorant, Forster's Tern, Caspian Tern, California Gull, and Ring-billed Gull bred at 37, 34, 13, 12, and 9 sites in the interior, respectively (Figures 2–5 and 7).

The number of colonies at which a species breeds is only one measure of concentration, as a particularly large proportion of a species' entire population may occur at one or a few colonies, irrespective of whether few or many are occupied overall. Species particularly concentrated at one or a few sites in California during the 1997 to 1999 survey period were: American White Pelican, 99% of statewide breeding population at Clear Lake NWR in 1999; Double-crested Cormorant, 79% of interior breeding population at the Salton Sea in 1999; Ring-billed Gull, 76% of statewide breeding population at three sites (Clear Lake NWR, Butte Valley WA, Honey Lake WA) in 1997; California Gull, 81% of the inland breeding population at Mono Lake in 1997; and Caspian Tern, about 68% of interior breeding population at the Salton Sea in 1997 (species accounts; Tables 2, 6, 13).

It is noteworthy that the inland breeding colonies of some of these seven species, such as the American White Pelican and California Gull, have been concentrated at the same sites in California for decades, whereas the colonies of others, such as the Double-crested Cormorant and Caspian Tern, have dramatically risen or waned in importance over relatively short periods. For example, 30 pairs of Caspian Terns recolonized the Salton Sea in 1992, increased to about 1500 pairs in 1996, then declined to 29 pairs by 2002 (Molina 2001, 2004; K. Molina in litt.). Likewise, Double-crested Cormorants colonized Mullet Island at the Salton Sea in 1996, reached a peak of about 5425 pairs in 1999 (Shuford et al. 2002, Table 2), but none were observed nesting there in 2001 and 2002 (Molina and Sturm 2004). These patterns at the Salton Sea appear to reflect comparable rapid increases and declines in the fish populations upon which these piscivorous birds depend (Molina 2004, Molina and Sturm 2004); fish declines perhaps are in response to increasing salinity or other stressful or deteriorating ecological conditions, which also appear to be linked to increased bird mortality from disease (Friend 2002). At Sheepy Lake on Lower Klamath NWR, Double-crested Cormorant numbers dropped from 978 pairs in 1997 to 62 pairs in 1999, as water levels kept too high in 1999 inundated or saturated much of the cormorants' tule-mat nesting islands (D. Mauser pers. comm.). Great annual or periodic fluctuations in the size of some gull colonies in northeastern California typically reflect changes in the availability of nest-

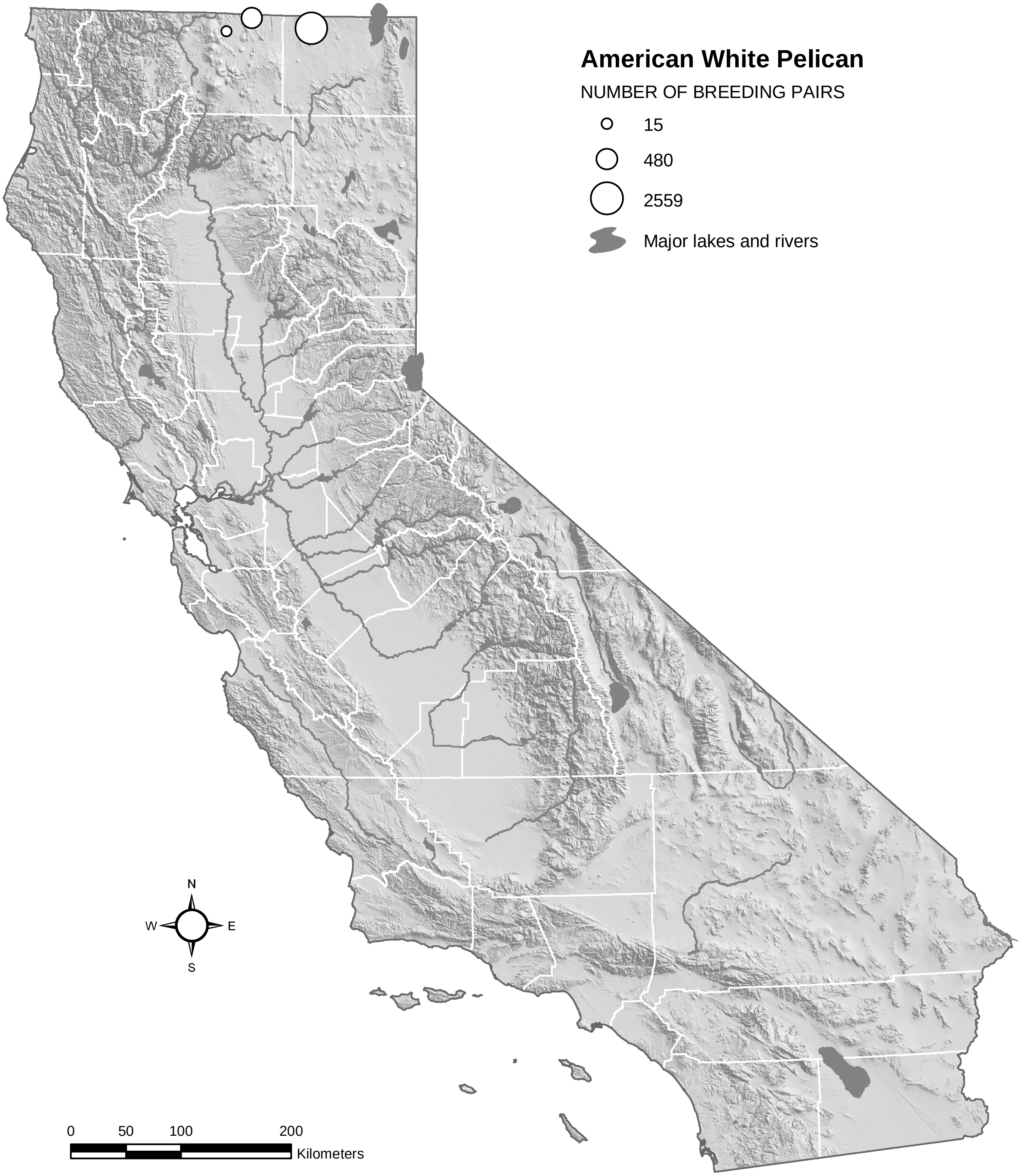

Figure 1. Relative size of three colonies of the American White Pelican in California on the basis of the highest count of nesting pairs in any year, 1997 to 1999.

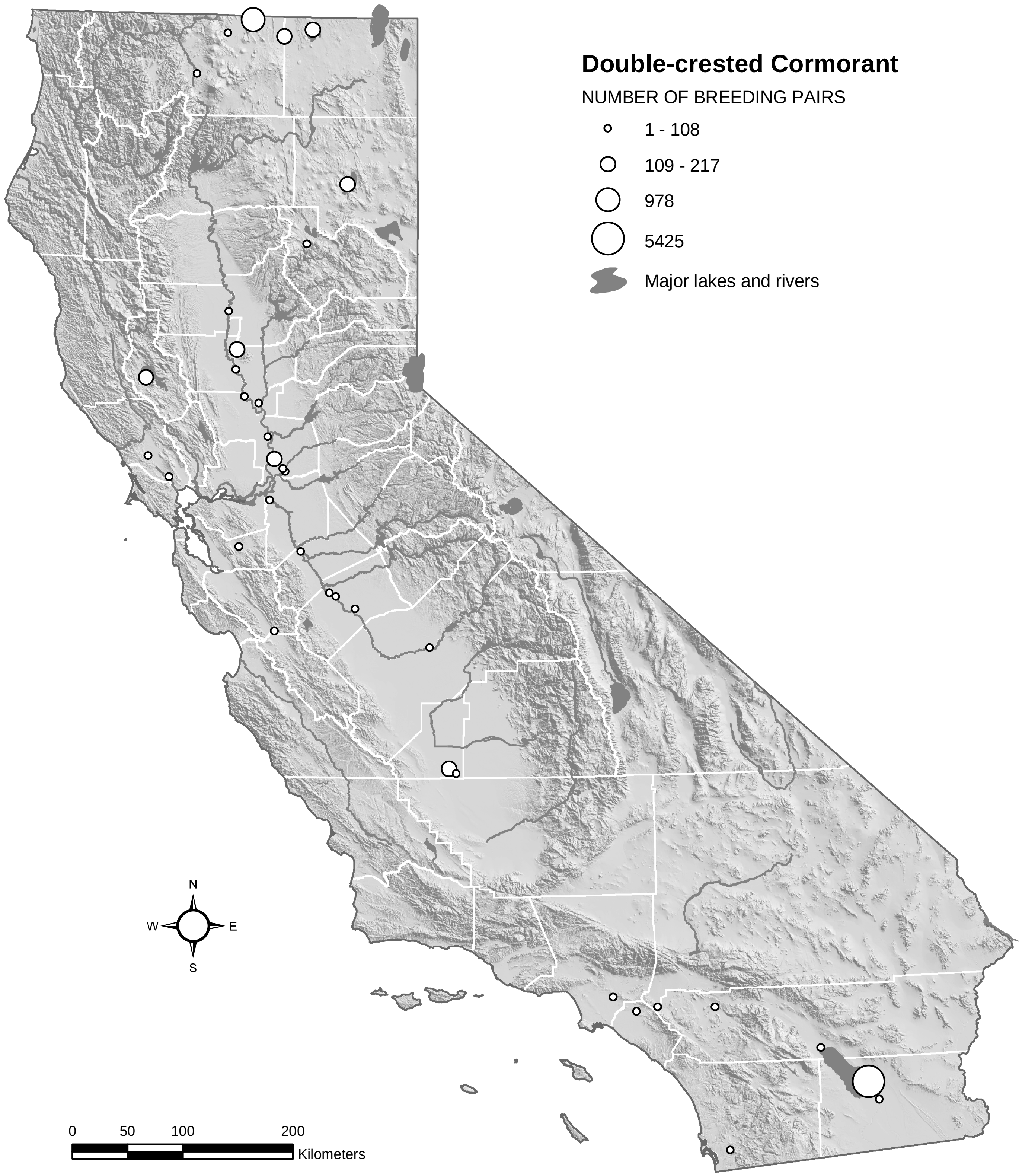

Figure 2. Relative size of 37 colonies of the Double-crested Cormorant in the interior of California on the basis of the highest count of nesting pairs in any year, 1997 to 1999 (Table 2).

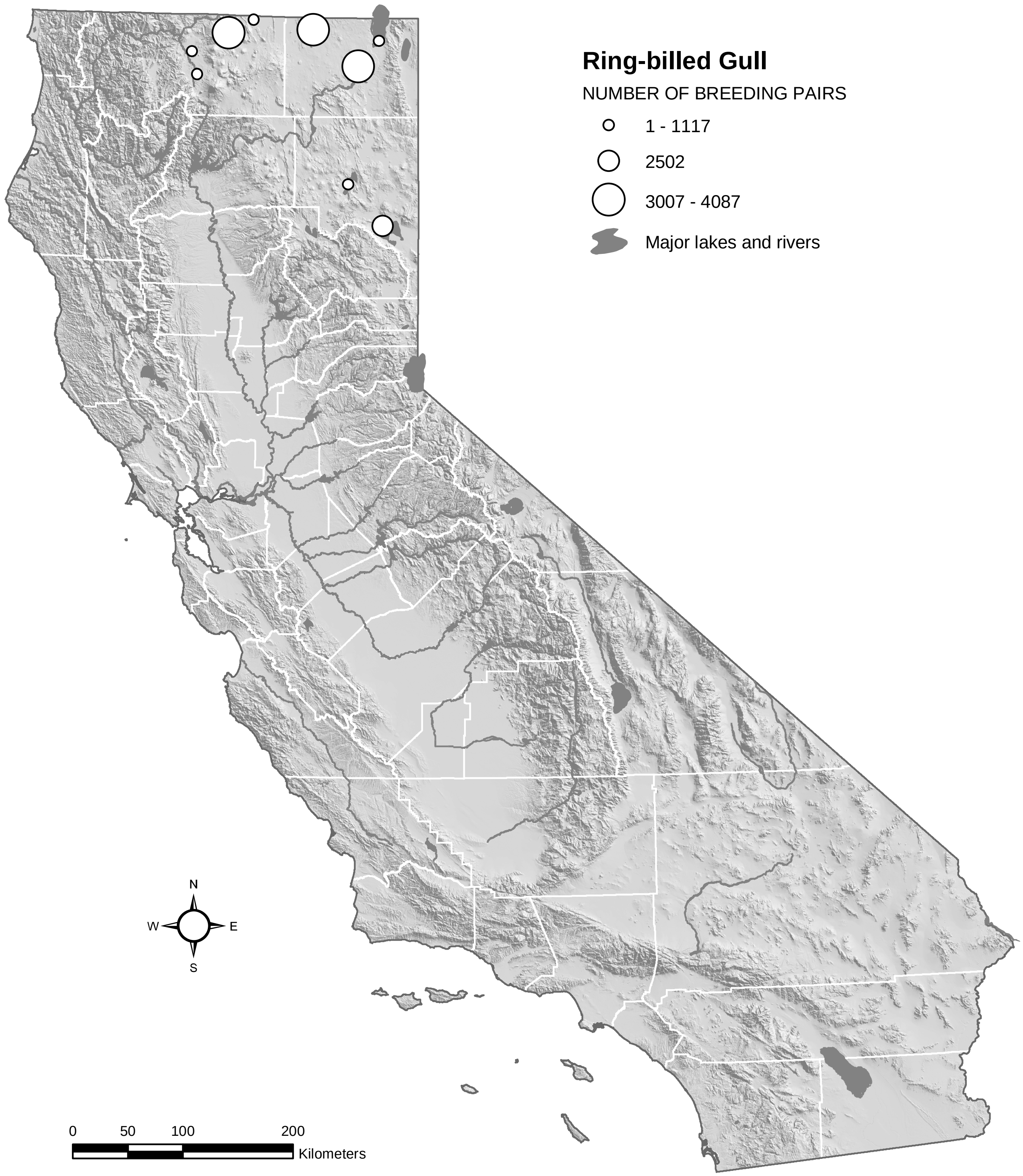

Figure 3. Relative size of nine colonies of the Ring-billed Gull in California on the basis of the highest count of nesting pairs in any year, 1994 to 1997 (Table 6).

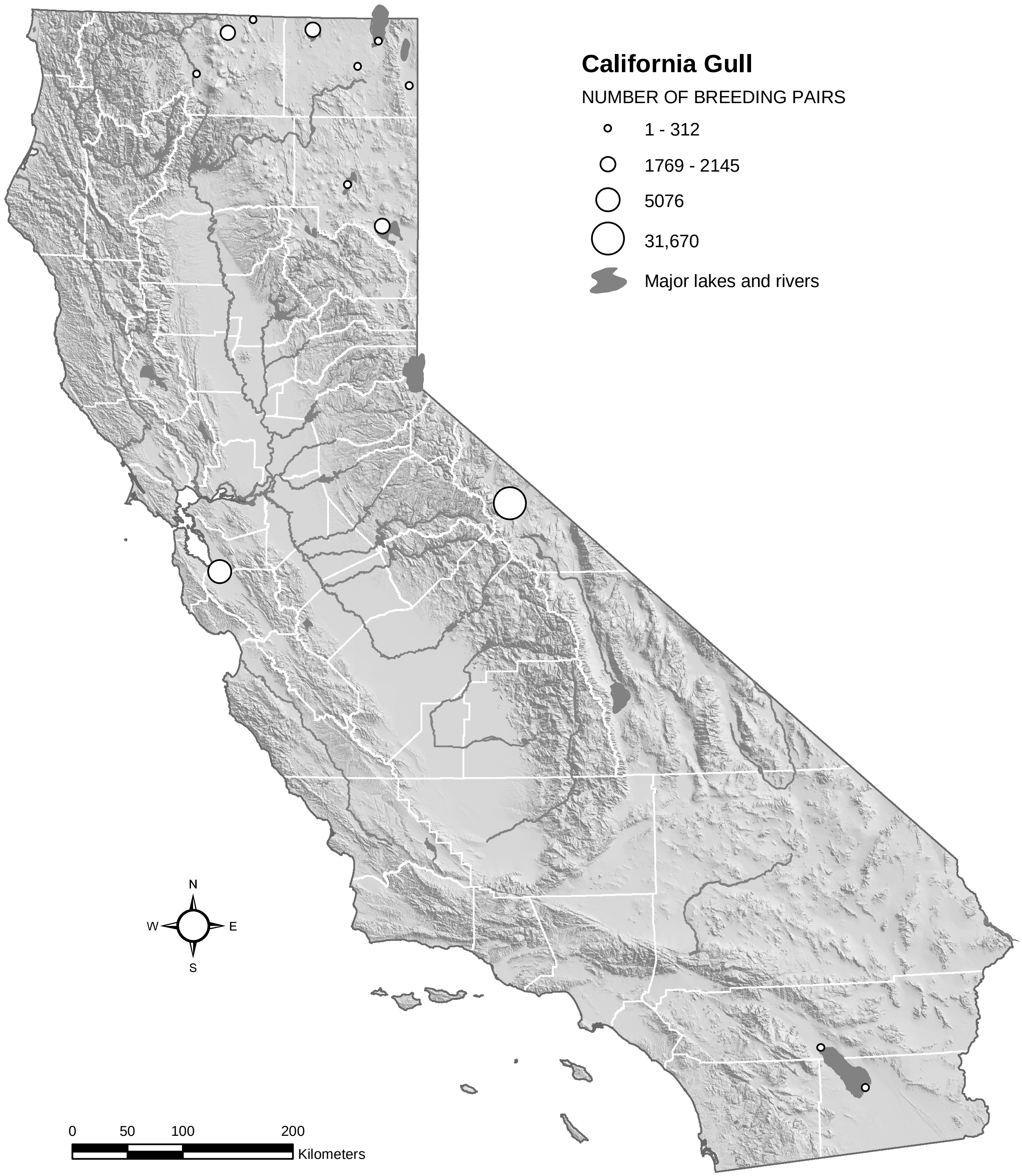

Figure 4. Relative size of 12 colonies of the California Gull in the interior of California, and the single coastal colony in south San Francisco Bay, on the basis of the highest count of nesting pairs in any year, 1994 to 1997 (Table 6).

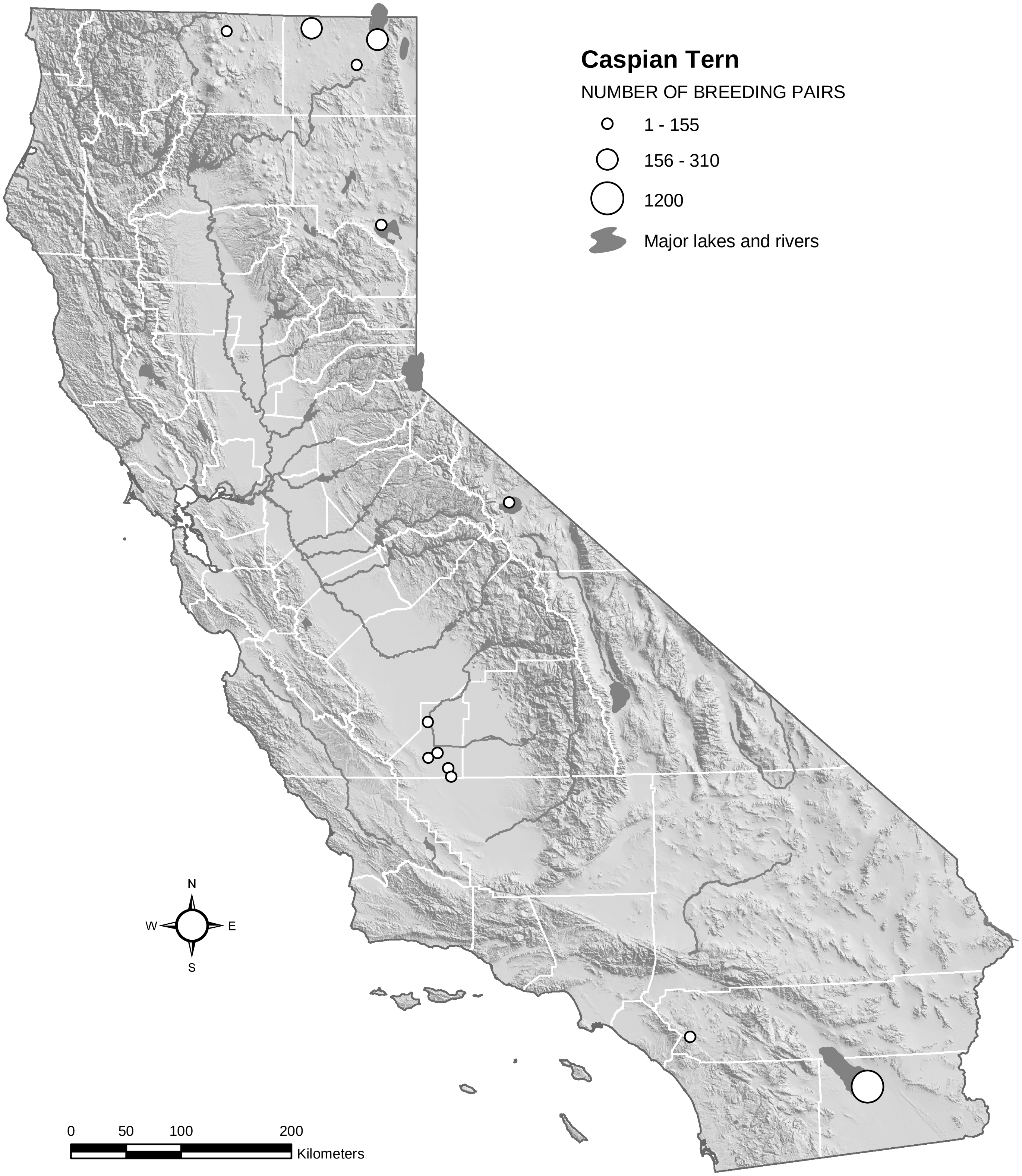

Figure 5. Relative size of 13 colonies of the Caspian Tern in the interior of California on the basis of the highest count of nesting pairs in any year, 1997 to 2000 (Table 13).

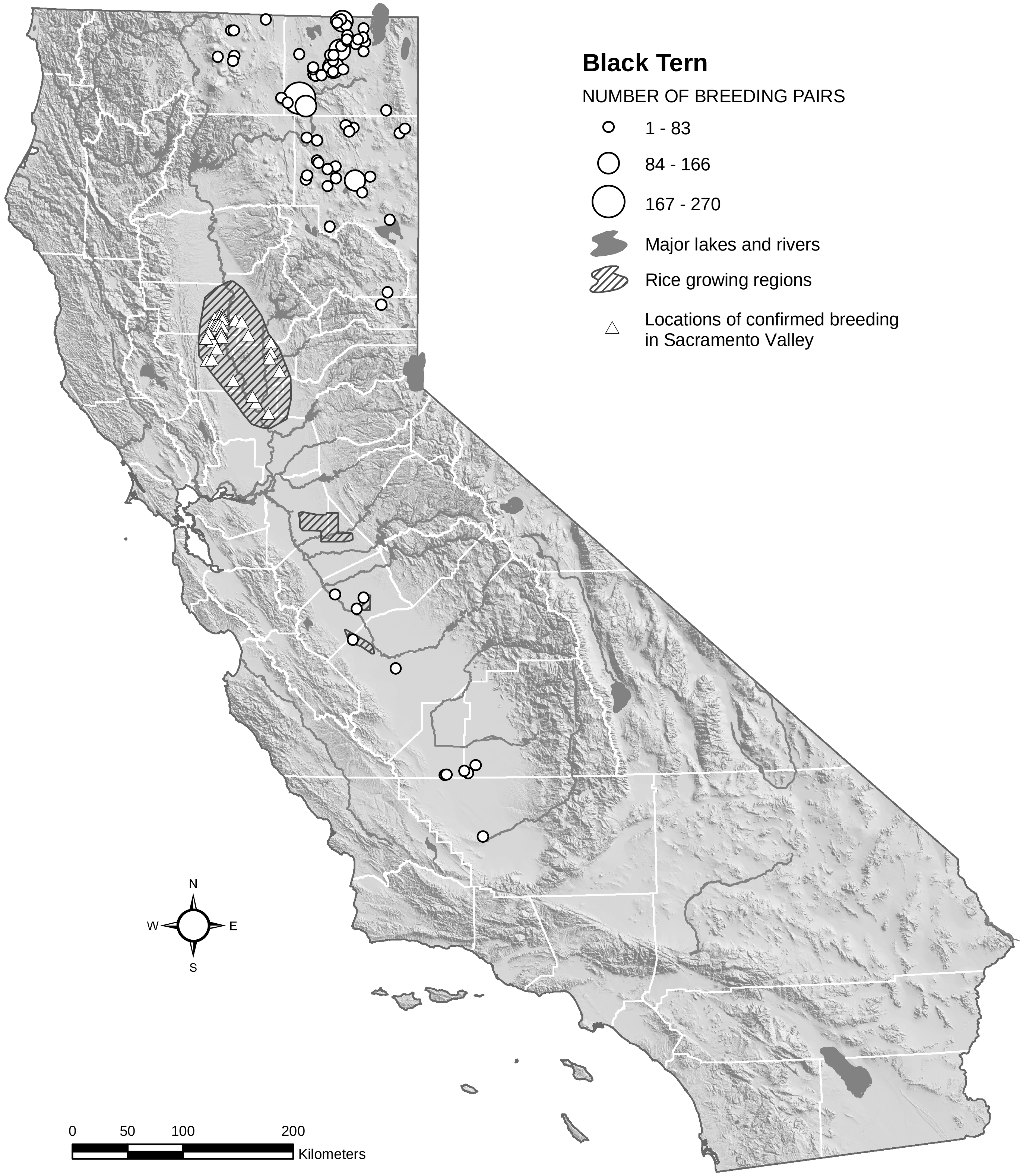

Figure 6. Relative size of 73 colonies of the Black Tern in California on the basis of the highest counts of nesting pairs in any year, 1997 to 1999 (Tables 14 and 16). An estimated 2523 adult Black Terns were in Sacramento Valley rice fields in 1998 on the basis of sampling this habitat using roadside surveys (Table 15); mapped sites in this area represent locations of confirmed breeding found while sampling, as it was not possible to locate all colonies in this extensive area of nearly continuous habitat (see Methods).

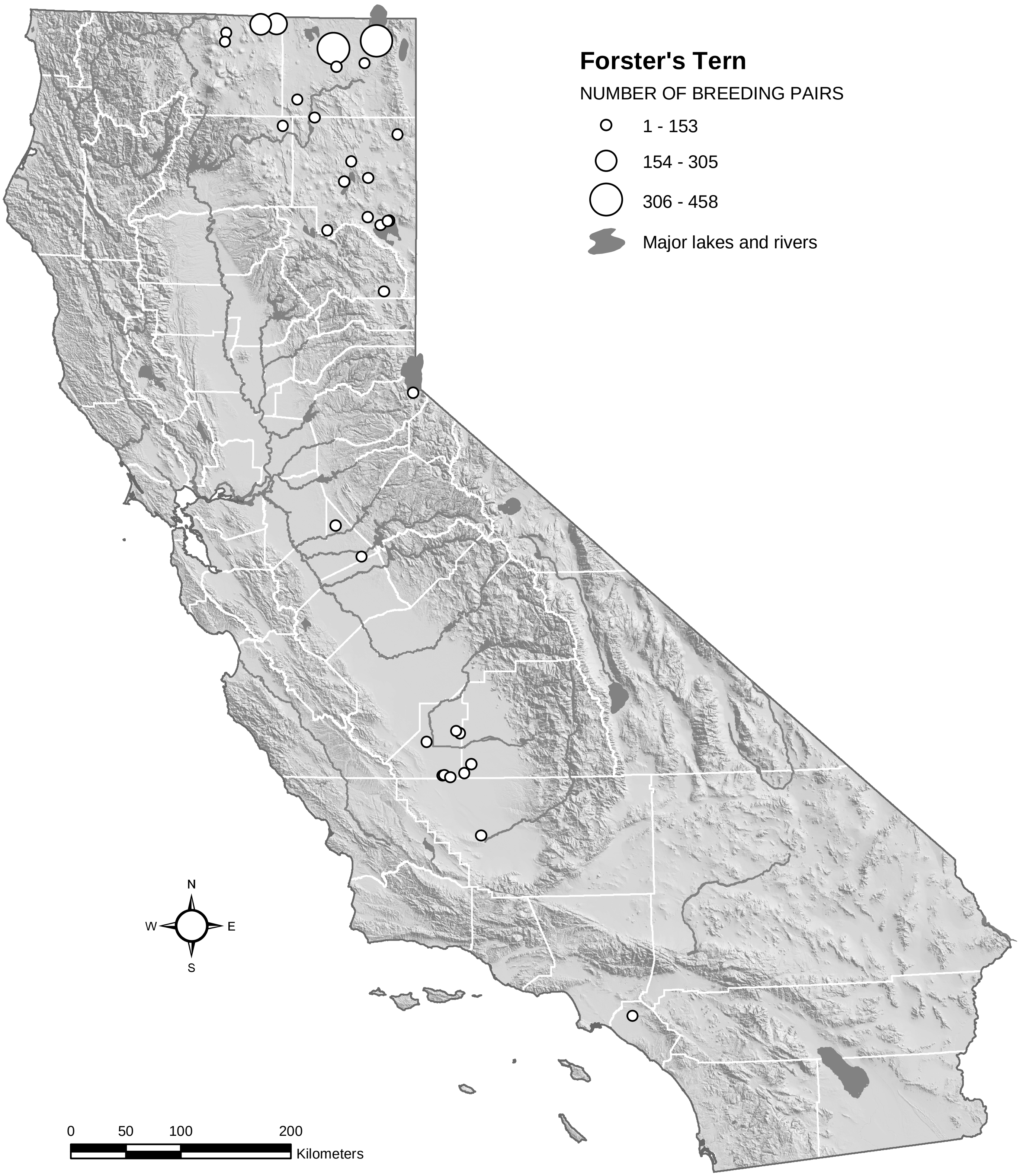

Figure 7. Relative size of 34 colonies of the Forster's Tern in the interior of California on the basis of the highest counts of nesting pairs in any year, 1997 to 1999 (Tables 18 and 19).

ing islands, as shallow lakes expand or contract, even disappear, with periods of flood and drought (Shuford and Ryan 2000). Reductions in the level of Mono Lake from water diversions of its tributary streams has caused abandonment of nesting islands as coyotes crossed landbridges to prey on eggs and chicks of California Gulls (Winkler and Shuford 1988). In the southern San Joaquin Valley, Black Terns now typically breed only in extremely wet years because damming of rivers and streams has greatly altered the natural hydrologic regime, all but eliminating the shallow, ephemeral wetlands the terns historically used for nesting (Shuford et al. 2001).

Nesting Habitat Use

The habitats used for nesting and foraging varied considerably among the seven species of inland-breeding waterbirds, all of which, as a rule, are adapted to exploit shifting nesting and foraging sites in response to cycles of drought and flood. The surveys in this study gathered specific information on nesting habitat but only cursory anecdotal information on foraging habitat use. Consequently, only the patterns of nesting habitat use are described here; the reader is referred to the species accounts in Chapter 2 for a summary of foraging habitat use and diet of individual species derived from the published and unpublished literature.

Species varied in their use of nest sites (see details in species accounts). American White Pelicans, Ring-billed and California gulls, and Caspian Terns all nested almost exclusively on barren, rocky, or sparsely (sometimes moderately) vegetated earthen islands but also on tule-mat islands at Sheepy Lake in the Klamath Basin. Sometimes they also nested on peninsulas, when these had formed after nest initiation as water levels dropped to connect islands to the mainland, or, more rarely, when no isolated islands were available at the start of the nesting season. Double-crested Cormorants also nested commonly on islands, including the tule-mat variety; frequently in various species of live or dead trees in open water, on islands, or on the shores of lakes or rivers; and rarely on mats of reeds at river deltas (e.g., Salton Sea). Forster's Terns sometimes nested on islands but also frequently in marshes within or adjacent to clumps of emergent vegetation or on mats of floating vegetation, abandoned coot or grebe nests, or other island- or moundlike structures, such as platforms built for nesting Canada Geese (*Branta canadensis*). The Black Tern was the only one of the seven species that nested only within emergent vegetation (Shuford et al. 2001). Low emergents, primarily spikerush (*Eleocharis* spp.) and *Juncus* spp., dominated most nesting marshes in northeastern California. In the Sacramento Valley, these terns nested almost exclusively in rice fields. In the San Joaquin Valley in 1998, they nested primarily in flooded agricultural fields with residual crops or weeds and secondarily in rice fields; the latter, though of relatively limited extent, may be the only suitable nesting habitat there in most years.

For species breeding on islands, isolation from ground predators and humans was of paramount concern when adequate foraging habitat was available within a reasonable distance. This is well illustrated by Caspian Terns nesting at the small colony at hypersaline Mono Lake (devoid of fish), where they must fly at least 15–20 km to forage at freshwater reservoirs. What is a "reasonable distance" to foraging grounds varies tremendously among species, as indicated by radio-tagged pelicans breeding in western Nevada making repeated roundtrip flights over the Sierra Nevada to forage in California's Central Valley (Yates 1999). Of the island nesters, pelicans and cormorants seem the most prone to disturbance, and hence remoteness of their breeding sites is crucial to ensure nest initiation and success.

Reflecting species' differences in habitat use, the digital atlas documents that individual sites varied in the number of species they supported. Overlap in species' use of nesting habitat was highest at some sites in the Klamath Basin, particularly at Clear Lake NWR where American White Pelicans, Double-crested Cormorants, Ring-billed and California gulls, and Caspian Terns nested on the same island or sets of islands. The south end of the Salton Sea also hosts a diverse suite of species, including the Double-crested Cormorant, California Gull, Caspian Tern, and Forster's Tern (irregular), and, though not surveyed during the present study, the Brown Pelican (*Pelecanus occidentalis*, extralimital), Laughing Gull (*Leucophaeus atricilla*), Gull-billed Tern (*Gelochelidon nilotica*), and Black Skimmer (*Rynchops niger*) (Molina 2004, Molina and Sturm 2004), which breed inland in California only at this water body. Although many sites held only a single species, overall, at a regional scale, species richness was lowest in Sacramento Valley rice fields, where over broad areas the Black Tern was the only one of the seven species that nested and foraged. The surveys in the present study did not document the overall richness of nesting colonial waterbirds, however, as a number of sites also host colonies of various grebes, herons, egrets, night-herons, and ibis (e.g., Salton Sea, Molina and Sturm 2004; Klamath Basin, Shuford et al. 2004, 2006).

Historic Trends

The population sizes of all seven primary species considered in this catalogue have varied markedly over time in response to both natural environmental fluctuations and human perturbations. The species accounts in Chapter 2 describe the main patterns of historical change in abundance and distribution for each species, summarized briefly here, on the basis of prior published and unpublished (largely anecdotal) information and the recent baseline from the 1997 to 1999 surveys. Unfortunately, the historical record is so sketchy that it is possible to document only very large changes in species' population sizes or distribution. For species that have declined, habitat loss and degradation are the prime contributing factors.

The distribution and abundance of the American White Pelican has undoubtedly changed the most of any of the seven species considered. Having formerly nested widely but locally in lakes and marshes of the Klamath Basin, Modoc

Plateau, and Great Basin Desert of northeastern California, in overflow lands of the Sacramento Valley, terminal lakes in the Tulare Basin of the San Joaquin Valley, and at the Salton Sea in the Colorado Desert, this pelican is now restricted as a breeder in California to only two National Wildlife Refuges in the Klamath Basin near the Oregon border (Shuford 2005). In the late 1800s and early 1900s, at least thousands of pelicans bred at each of six sites: Lower Klamath Lake, Clear Lake, Tule Lake, the lower Sacramento Valley, Tulare Lake, and the Salton Sea. Including lesser numbers at other sites, the statewide total may have exceeded 20,000 pairs. Currently, the state's nesting numbers are about 3000 pairs in peak years. The primary cause of this decline was the loss of habitat from water diversions and land reclamation for agriculture, particularly via a reduction of the dynamic natural processes, such as flooding, that formerly created and maintained large productive wetlands.

Historically, Double-crested Cormorants bred locally throughout the state wherever suitable conditions existed. Although data are few, it is clear that some historic sites held hundreds and perhaps thousands of nesting pairs (Appendix 6). Massive historic wetland loss and alteration of the state's natural hydrology for agricultural and urban needs caused marked reductions in cormorant numbers and colonies. It is unlikely that these losses were offset by the creation of reservoirs or human-altered sites such as the Salton Sea. As the historical record of interior colonies is particularly fragmentary, it is unclear if inland cormorant numbers have increased in recent decades as they have on the California coast. The comprehensive survey of inland-nesting cormorants in 1999 provides only a snapshot of this dynamic population, as evidenced by large and rapid changes in nesting numbers over short periods at some key sites such as Sheepy Lake at Lower Klamath NWR and at the Salton Sea.

Most historical estimates of the size of the state's various colonies of Ring-billed and California gulls are too rough for sensitive trend assessment (Shuford and Ryan 2000, Tables 7–10). Nevertheless, California Gulls, at least, have increased substantially in the state in the 20th century. Statewide trends are driven largely by patterns at Mono Lake and San Francisco Bay (first colonized in 1980), both of which have been continuously monitored since the early 1980s (Shuford and Ryan 2000, Table 11; Strong et al. 2004).

Early knowledge of the distribution and abundance of Caspian Terns in California is fragmentary and of very limited value for assessment of population trends or distributional shifts (Shuford and Craig 2002, species account below). Up to the mid-1940s, inland colonies were known from only five sites, only one of which, the Salton Sea, is active today (after a decades-long absence and recolonization in 1992; Molina 2004). Since then, documentation of additional colony sites undoubtedly reflects both expansion of observer coverage to include sites long occupied and colonization by terns of sites, such as reservoirs, that subsequently were created and thereby offset to an unknown degree the loss of historic wetlands. The fate of interior colonies is also intertwined with that of coastal sites. Since the turn of the 20th century, the Pacific Coast population, including that in California, shifted from breeding at numerous small colonies associated with freshwater marshes to nesting primarily in large colonies on human-created habitats along the coast (Gill and Mewaldt 1983).

As with Caspian Terns, the historic status of Forster's Terns in the interior of California is poorly documented, and estimates of the size of historic breeding colonies are few (see species account below). In northeastern California, extensive wetland loss, particularly in the Klamath Basin, may have been partially offset on the Modoc Plateau by historic creation of shallow-water reservoirs for livestock grazing and recent enhancement for waterfowl. Currently, Forster's Terns no longer breed in the Sacramento Valley. They breed only very locally in the San Joaquin Valley, mainly in very wet years when they tend to concentrate in the closed Tulare Basin, where potential breeding habitat is formed as winter flood waters are diverted into shallow storage basins or reservoirs or run unchecked into fields. The major population decline in the Central Valley over the last 100 years has been offset statewide to an unknown degree, primarily by substantial colonization of the California coast. Forster's Terns were severely affected by the great historic loss of Central Valley wetlands and the massive alteration of the natural hydrologic regime, as described below for Black Terns. Although Black Terns have adapted to breeding in cultivated rice in the Central Valley, Forster's Terns have not.

Black Terns still breed widely in northeastern California, where, again, extensive wetland loss there may have been partially offset on the Modoc Plateau by historic creation of shallow-water reservoirs for livestock grazing and recent enhancement for waterfowl (Shuford et al. 2001, species account below). Black Terns were severely affected by the great historic loss of Central Valley wetlands and the massive alteration of the natural hydrologic regime. In the Sacramento Valley, however, they adapted by breeding in cultivated rice fields. Extensive wetland loss in the Sacramento Valley was offset by expansion of rice to the current annual level of 160,000 to 200,000 ha, which may far exceed the average historic extent of shallow-water wetlands available there in spring and summer. By contrast, wetland loss in the San Joaquin Valley was offset to only a minor degree by rice, which has declined there slowly since the mid-1950s. The current tenuous status of the species in the San Joaquin Valley documents a major decline in numbers there over the last 100 years. An apparent shift of abundance to the Sacramento Valley may be illusory, as that area may always have been an important, though poorly documented, breeding area.

Sites or Regions of Importance

Although all of their breeding sites, both individually and collectively, are important to California's inland-breeding waterbirds, certain regions stand out in their current value to these species. These include the Klamath Basin (freshwater wetlands, reservoirs); the Modoc Plateau, Great Basin Desert, and northern Sierra Nevada (freshwater wetlands, reservoirs, saline terminal lakes); the Central Valley (rice fields, remnant and artificial wetlands); and the Salton Sea (saline and freshwater wetlands). These areas vary greatly in the extent to which they have been altered by human activities.

Klamath Basin

Among the greatest losses to waterbirds in the Klamath Basin was the draining of Lower Klamath and Tule lakes. Historically, Lower Klamath Lake consisted of about 22,267 ha of marsh and 12,146 ha of open water (Akins 1970). It was then intermediate between an undrained basin and a thoroughly drained floodplain, as water flowed seasonally either from the Klamath River to the lake or vice versa (Weddell 2000). A large reclamation project begun in 1906 had cut off all water from the Klamath River by 1917, and subsequently it took about five years for most of the lake's waters to evaporate. Currently, Lower Klamath NWR has 8907 ha of wetlands; 4858 to 6478 ha are seasonally flooded and 2024 to 3644 ha are permanently flooded marshes (USBR 1998). Historically, Tule Lake fluctuated in size from about 22,267 to 44,534 ha between extremes of dry and wet cycles (Akins 1970). Today, however, it consists of only 5263 ha of permanent sumps within Tule Lake NWR fed by return flows from agricultural fields (USBR 1998). In contrast to Lower Klamath Lake, Tule Lake was primarily an evaporative basin, which received water from the Klamath River via Lost River Slough only in extremely wet periods, though apparently high rates of seepage into the Lava Beds kept Tule Lake's waters relatively fresh (Abney 1964). Drainage of Tule Lake was facilitated by a dam on the Lost River at the outflow of Clear Lake, which greatly increased the open water of that lake but drowned a 2000-ha marsh, and downstream diversion of the Lost River into the Klamath River by means of a canal (Akins 1970). Drainage of the Klamath Basin's lakes and marshes was controversial at the time and protested by conservationists to little avail (Foster 2002).

The effects on waterbirds of these dramatic changes to the Klamath Basin wetlands overall were profound. Wetland restoration and intensive management on state wildlife areas, federal refuges, and some private preserves have offset these losses to some degree, but all rely on sufficient water in an over-allocated basin. A 2008 agreement among most stakeholders (tribal, agricultural, agency, environmental) to settle major water disputes in the basin has not yet been implemented. Today all of the remaining wetlands in the Klamath Basin are important to waterbirds. Still, certain wetlands or large water bodies stand out in supplying breeding or foraging habitat not only for the seven key species discussed in this catalogue but for many other waterbirds as well. Among the region's most important wetland complexes to waterbirds are Lower Klamath NWR, Clear Lake NWR, and Tule Lake NWR in California and Upper Klamath Lake and associated wetlands, Klamath Marsh NWR and associated wetlands, and Sycan Marsh in Oregon (Shuford et al. 2004, 2006). Although the present catalogue focuses on California, waterbirds meet their needs irrespective of political boundaries and readily use wetlands on both sides of the California-Oregon border. Hence, conservation of the entire wetland complex in this basin is needed.

Modoc Plateau, Great Basin, and Sierra Nevada

Although the wetlands and water bodies in northeastern California are among the most intact left in the state, and generally are remote from human disturbance, many have been greatly altered by human activities. Still, a diverse array of sites in this region are important to waterbirds. These include many large alkali lakes (Alkali Lakes in Surprise Valley, Goose Lake, Honey Lake, Mono Lake), fewer large freshwater lakes (e.g., Eagle Lake, Lake Tahoe), numerous low-stature wetlands dispersed widely over the landscape (e.g., Devil's Garden Ranger District, Modoc National Forest) or concentrated in certain large valleys (e.g., Big Valley, Sierra Valley), federal or state refuges (e.g., Honey Lake WA), and various reservoirs (e.g., Big Sage Reservoir, Mountain Meadows Reservoir).

Drainage of wetlands for irrigated agriculture or damming of streams to create reservoirs apparently has benefited some species (e.g., Ring-billed and California gulls). Extensive wetland loss in northeastern California as a whole may have been partially offset on the Modoc Plateau by the historic creation of shallow-water reservoirs for livestock grazing and recent enhancement for waterfowl (T. Ratcliff, G. Studinski pers. comm.). Still, the overarching theme in the entire region is one of wetland loss, from conversion for agriculture or diversion of water for crops or other human uses, and consequent diminishment of the region's value for wildlife.

Although initially subject to human persecution for perceived competition for fish, American White Pelicans at Eagle Lake ultimately suffered from a loss of island nesting habitat as the lake level dropped from diversions for agriculture (references in Shuford 2005). Habitat loss and degradation from development and lowering of water levels eliminated breeding Black Terns and reduced other waterbird populations at Lake Tahoe (Orr and Moffitt 1971, Cogswell 1977, Shuford et al. 2001), where today only small remnant wetlands remain on the south shore. Wetlands in Sierra Valley or the Honey Lake basin are potentially at risk from future water diversions to fuel the continuation of burgeoning growth nearby in the greater Reno area of Nevada. The large alkali lakes have all been deprived of natural inflows by diversion of their tributary streams for agricultural or municipal needs. Because the historical record of bird use is so sketchy at many of these sites, it is largely unknown what effects these losses of water had or continue to have. At Mono Lake, dropping water levels from diversions of tributary streams, begun in 1941, have threatened the world's second largest aggregation of breeding California Gulls. Since the late 1970s, the lowered lake level periodically enabled coyotes to reach some of the islands and caused the gulls to abandon their nesting efforts; protection of the nesting islands now seems assured, however, by a 1994 decision allowing the lake to rise to a level of dynamic equilibrium well above that of recent low stands (Winkler and Shuford 1988, Shuford and Ryan 2000). Owens Lake, now a ghost of a large hypersaline lake in the Owens Valley, was lowered somewhat by agricultural diversions in the late 1880s but soon dried almost completely after the Owens River was diverted in 1917 to fuel urban growth in Los Angeles (Jehl 1994). Recent shallow-water flooding to mitigate for alkali dust storms on the playa of the exposed lake bed has attracted large numbers of migrant and nesting shorebirds and other waterbirds. Among the latter, some California Gulls have attempted unsuccessfully to nest (G. Page, G. Santolo pers. comm.). Although very little is known of the avifauna of Owens Lake before it dried up (Jehl 1994), the California Gull is likely the only one of the seven species considered here that might have nested there historically if islands were available.

Central Valley

Before European settlement, California's Central Valley contained extensive shallow-water wetland habitat, which varied dramatically both seasonally and annually depending on the amount of flooding from winter rains or high spring runoff from snowmelt. These ephemeral wetlands were highly productive, and when they persisted into spring and summer provided important habitat for many species of breeding waterbirds. Now the Central Valley is among the most altered landscapes in North America, as its historic wetlands and deep, fertile soils enabled its conversion to the most productive agricultural area on the continent. With almost nothing remaining of the natural wetlands and landscape in this region, most nesting waterbirds currently rely on various agricultural habitats (e.g., rice fields, agricultural evaporation ponds), reservoirs, managed wetlands, modified major river channels, and (rarely) naturally flooded fields that remain wet through the summer. Reliance on the many shallow-water environments maintained for agricultural, municipal, or industrial needs is generally risky, as future changes in management practices may serve human efficiencies and economies but reduce benefits to wildlife.

Over 90% of the Central Valley's historic wetlands have been lost (Frayer et al. 1989, Kempka et al. 1991). This figure, however, underestimates the true extent of habitat loss for breeding waterbirds, as it is calculated on the basis of winter, rather than summer, habitat and does not fully reflect the almost complete loss of the valley's natural hydrologic regime. Subsequent compensation for the loss of historic habitat, though modest, has been far greater in winter than summer. Today extensive acreage of managed wetlands—principally on private duck clubs (two thirds) and state and federal refuges (one third)—is available in winter. These managed wetlands support large numbers of waterfowl, shorebirds, and other waterbirds from fall through early spring, when most acreage is flooded. But very little of this habitat, mostly in deep-water brood ponds, is maintained through late spring and summer when it would be valuable to breeding waterbirds. Flooded agricultural fields (particularly rice) also support large numbers of various wetland-dependent birds in winter but overall are less important for breeding waterbirds.

It is hard to imagine the extent of waterbird breeding habitat, particularly ephemeral overflow lands, available in the Central Valley prior to the massive alteration of its natural hydrology. Formerly, almost annual flooding in winter and spring of the Sacramento Valley's major rivers formed vast flood basins and huge, shallow seasonal lakes, which occurred in a diverse mosaic with permanent wetlands, vernal pools, and an array of upland habitats (Thompson 1961, Katibah 1984, Scott and Marquiss 1984). 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—formerly the largest freshwater lake and marsh system west of the Mississippi River (Johnson et al. 1993, Thelander and Crabtree 1994)—could engulf many thousands of additional hectares after a series of wet winters. Although it is unclear how much ephemeral habitat remained through the 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 expansive floodwaters slowly drained back into the rivers, sometimes through July, or evaporated (The 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 (Dec–Mar) were predominate in the Sacramento Valley, whereas prolonged snowmelt floods (Apr–June) were the norm in the San Joaquin Valley, particularly in the Tulare Basin (The Bay Institute 1998). Hence, the latter region likely had the most ephemeral habitat for breeding waterbirds.

Today's water management infrastructure keeps rivers behind dams or within their banks, except during extreme flood events after which water usually rapidly drains or is pumped back into river and bypass channels, leaving few areas of shallow water as breeding or foraging habitat for waterbirds. 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 occurred historically about every 2 years now occur once every 7 to 13 years and 10-year floods every 100 years (The Bay Institute 1998). Valleywide, the volumes of large floods remain largely unchanged, but only in very heavy snowpack years do flood flows approach historic levels in the San Joaquin Valley.

The great historic loss of wetlands was inadvertently mitigated in the Sacramento Valley by expansion of rice cultivation to the current annual level of 160,000 to 200,000 ha (Figure 6 in Shuford et al. 2001), which may far exceed the average extent of shallow-water habitat available there historically 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. Although rice is currently very important for Black Terns, none of the other species of key waterbirds that currently nest in the Central Valley (Double-crested Cormorant, Caspian Tern, Forster's Tern) use this habitat for breeding, nor did two other species that formerly nested in the Central Valley (American White Pelican, California Gull). Other than the rice fields for Black Terns and the major rivers on the valley floor for cormorants, there currently are few areas of the Central Valley, even at a local scale, that consistently support large numbers of any of the key species of waterbirds discussed in this catalogue (Figures 1–7). The potential for restoration is great, however, if reliable summer water can be made available.

Salton Sea

The Salton Sink once held very large ephemeral natural lakes and associated wetlands, at times much larger than the present day Salton Sea, that ebbed and waned with the wanderings of the wild Colorado River and intervening periods of desiccation (Patten and Smith-Patten 2004). The Salton Sea was formed during a brief period in the early 1900s when floodwaters broke through infrastructure designed to bring irrigation waters to the Imperial Valley. With the subsequent taming of the Colorado's flows through damming, such flooding no longer occurs, and the sea is now maintained by irrigation wastewater. Exploration of the area by ornithologists began soon after the Salton Sea's creation (Garrett et al. 2004), but not until recently has its great importance to Pacific Flyway waterbirds been relatively well documented (Shuford et al. 2002, Patten et al. 2003, Shuford and Molina 2004). In recent decades, the sea's waters simultaneously slowly rose and increased in salinity (Schroeder et al. 2002), but its level is now declining while salinity continues to increase. The initial freshwater fish fauna has been replaced with one dominated by marine or salt-tolerant species introduced beginning in the early 1950s; likewise the invertebrate fauna is dominated by a few introduced salt-tolerant species (Molina and Shuford 2004). Additional freshwater foraging and nesting habitat for waterbirds has been created in federal and state refuges near the southern shoreline, and irrigated agriculture in the Imperial Valley immediately to the south—important to many waterbirds—has expanded from initial plantings at the turn of the 20th century to an average of about 1900 km^2 today. Despite increasing salinity and other signs of a deteriorating ecosystem, in recent years the Salton Sea has hosted large numbers of colonial waterbirds, including several of the key species considered in this catalogue (Molina 2004, Molina and Sturm 2004).

Conservation Status

As with most birds today, the seven key species of waterbirds considered here have been ranked for their level of conservation concern at various scales. The three rankings considered most pertinent are described here.

North American Waterbird Conservation Plan

This plan has ranked the continental conservation status of all species of colonial or semi-colonial waterbirds. Of the seven species considered in the present study, the American White Pelican, California Gull, Forster's Tern, and Black Tern are considered of "moderate" conservation concern, the Caspian Tern of "low" conservation concern, and the Double-crested Cormorant and Ring-billed Gull "not currently at risk" in North America (Kushlan et al. 2002).

Birds of Conservation Concern 2002

USFWS (2002) has ranked the conservation status of all bird species in the United States at various scales: by the entire country, by USFWS regions, and by Bird Conservation Regions (BCRs). Of the seven key species considered here for the interior of California, none are ranked by USFWS as being of conservation concern at the national level. Below this level, the only one of these species ranked of concern in a region encompassing California is the Caspian Tern for BCR 5 (Northern Pacific Rainforest), which encompasses only a small portion of the interior of California and one not occupied by nesting Caspian Terns. This ranking may seem paradoxical given Caspian Tern numbers are increasing at both the continental (Wires and Cuthbert 2000) and regional levels (Suryan et al. 2004), but concern in BCR 5 is warranted because of the extreme concentration of terns at relatively few sites in the Columbia River estuary of Oregon (Shuford and Craig 2002).

California Bird Species of Special Concern

For California, the American White Pelican and Black Tern are currently considered Bird Species of Special Concern (Shuford and Gardali 2008). The Double-crested Cormorant and California Gull formerly merited this status but they no longer do so because their populations in the state have increased or threats to them have lessened (Shuford and Gardali 2008).

Conservation and Management Issues

To reinforce the specific conservation concerns and needed management actions outlined in individual species accounts, themes common to most or all of these seven key species of inland-breeding waterbirds are summarized here. These may or may not apply to these species on the California coast or elsewhere in their ranges during breeding, migration, or winter, or they may be replaced or augmented in those regions by other concerns. Readers are referred to the North American Waterbird Conservation Plan (Kushlan et al. 2002) for a summary discussion of conservation issues and threats to waterbirds at the continental scale. It is important, however, that information on local or regional conservation concerns are effectively integrated into regional waterbird plans (e.g., Ivey and Herziger 2006), which generally are the nexus for on-the-ground implementation of conservation actions for these species, often through Joint Ventures of the North American Waterfowl Management Plan.

Secure Nesting Sites

Because of their colonial or semicolonial breeding habits, all seven of the key species are limited to some degree by a lack of secure nesting sites. Although waterbirds are adapted to periodic droughts, water diversions for human uses may increase the frequency of predator access to islands connected to the mainland or of desiccation of foraging habitat. In addition to isolation from ground predators, nesting waterbirds also need to be secure from human disturbance, which may force adults to flee, leaving eggs and chicks vulnerable to predation or exposure to the elements. Although seasonal closure of nesting islands holds promise, to be effective such restrictions or interpretive signing usually require adequate personnel for enforcement or interpretation. In some instances such efforts might be counterproductive in drawing undue attention to nesting colonies.

High Quality Water

The other main conservation concern common to all species is the availability of high quality water for wetlands. It will do little good to provide secure nesting sites if adequate water is unavailable to supply foraging habitat or if that habitat lacks abundant, uncontaminated prey. The concern for the availability of high quality water has been heightened in recent years by deformities caused by high selenium levels in Central Valley wetlands, water shortages in the Klamath Basin, and projections that increasing salinity at the Salton Sea will soon cause a crash of fish populations and, hence, the birds that depend on them. Solving or preventing such problems will require broad-based support, collaboration among various conservation initiatives at both the national and regional level, and extensive education of the general public and their local and legislative representatives.

Regional Concerns

Key statewide and regional conservation concerns are heightened because of tremendous prior loss and degradation of wetland habitat both in California and throughout the West (Dahl et al. 1997) and by ongoing threats to many wetlands and large water bodies (e.g., Jehl 1994). Although conservation concerns are highlighted here for just the Klamath Basin, Central Valley, and Salton Sea, the regional and local concerns discussed further in the individual species accounts also need focused conservation attention.

The availability of high quality water for remaining wetlands is increasingly of concern for Klamath Basin waterbirds (D. Mauser pers. comm.). The U.S. Bureau of Reclamation's Klamath Project was established in 1905 with the goal of irrigating as much of the Klamath Basin below Upper Klamath Lake as was practical. From inception until 1994, Upper Klamath Lake and the Klamath River were manipulated to achieve the project's agricultural purpose. Remaining wetlands on National Wildlife Refuges were maintained largely via drain water deemed surplus to agricultural need. Under this scenario, water availability to refuges was an issue only during years of extreme drought, such as 1992 and 1994. A Federal Solicitor's Opinion in 1995 ruled that project priorities were now endangered species (lakes and rivers), tribal trust (lakes and rivers), agriculture, and refuges. Because of a reduction in water availability and a low priority for remaining water, shortages to wetlands on Lower Klamath NWR, particularly in summer and fall (USBR 1998, D. Mauser pers. obs.), subsequently occurred with increasing frequency. In fact, Lower Klamath NWR experienced either shortages of water or inappropriate timing of water delivery in each of the four years during the period 2001–2004. A projected scenario to have fairly chronic problems in this regard off and on into the foreseeable future (D. Mauser pers. comm.) is now less likely given a tentative settlement to major water disputes in the basin made in 2008 but not yet implemented. In addition, water quality in Klamath Basin wetlands is often poor because of high background nutrient concentrations coupled with loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Fortunately, the important foraging grounds at Tule Lake—for Forster's Terns and other colonial nesters breeding there, for American White Pelicans nesting elsewhere in the Klamath Basin, and for staging Black Terns in fall—will retain some priority for summer water to maintain remnant populations of the endangered Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). From the 1960s to the mid-1980s, pelicans in the Klamath Basin experienced heightened mortality and reproductive impairment from organochlorine pesticide contamination but this does not appear to be a substantial problem today (see pelican account below).

Currently, the main known or potential threats to waterbirds in the Central Valley are limited availability of water; poor or toxic water quality; habitat loss or degradation to urbanization; changing agricultural, municipal, or industrial practices; and wetland designs that may lead to high levels of predation. Waterbirds remain limited both by the great historic loss of Central Valley wetlands and the massive alteration of the natural hydrologic regime. Today the inundation of bottomlands by annual or periodic overflow of floodwaters, which formerly created the extensive ephemeral breeding habitats favored by terns, has been greatly curtailed (The Bay Institute 1998). Water management infrastructure now reduces the frequency of floods 5- to 10-fold and likewise limits their duration. Still, today in the closed Tulare Basin following winters of extreme precipitation, flood waters are diverted into shallow storage basins or run unchecked into fields, leaving potential breeding habitat.

Although waterbirds generally should benefit from the recent creation and enhancement of extensive acreage of wetlands for waterfowl in the Central Valley (USFWS 1990, CVJV 2006), prior efforts were mainly directed at enhancing habitat in the nonbreeding season, and, as such, they likely were of limited value to colonial waterbirds when nesting. Recently, there has been heightened interest in increasing the amount of wetland habitat in the valley in summer (C. Hickey pers. comm.). Still, securing a dependable, high quality water supply for wetlands will be an ongoing challenge in light of California's expanding human population, its arid climate, and a water delivery system already stretched to its limits. Competition with other interests (mainly agricultural and urban) for increasingly expensive water is bound to intensify, and recent gains from legislation providing a reliable water supply for wetlands (e.g., 1992 Central Valley Project Improvement Act; Title 34 of Public Law 102-575) potentially could be reversed in the future. In addition, wetland managers must balance wildlife needs with efforts to reduce standing water in summer to limit the risk of disease transmission, particularly of West Nile virus, from mosquitoes to humans (Kwasny et al. 2004).

In the early 1980s, high selenium levels—bioaccumulated from agricultural drain water used to flood wetlands near Los Banos in the San Joaquin Basin—caused mortality and deformities in embryos of aquatic birds at Kesterson NWR (Ohlendorf et al. 1989) and were sufficient to harm reproduction of several species in parts of the broader Grasslands Ecological Area (Ohlendorf et al. 1987). After closure of Kesterson Reservoir and replacement of contaminated with uncontaminated water elsewhere in 1985, selenium levels in the Grasslands declined steadily, although concentrations in some species still exceeded those known to impair reproduction (Paveglio et al. 1992, 1997; Hothem and Welsh 1994a, b). Concentrations of salts and trace elements, particularly selenium, at evaporation ponds in the Tulare Basin have impaired reproductive success of shorebirds and other aquatic birds (Skorupa and Ohlendorf 1991, Ohlendorf et al. 1993). Sublethal effects of selenium demonstrated for shorebirds (Hoffman et al. 2002) potentially can also occur in other waterbirds breeding at contaminated sites; most terns that breed at evaporation ponds, however, appear to forage in drainage canals or other sites where selenium levels in their prey are likely to be lower than at the ponds (J. Seay pers. comm.). Nesting habitat has been lost as owners have closed some ponds and strived to further reduce the risk of contamination by hazing and by physically altering remaining ponds to make them less attractive to waterbirds (Moore et al. 1990, Steele and Bradford 1991, Bradford 1992). Alterations include the removal of nesting islands and the reduction in shallow-water foraging habitat. These losses are offset to some degree by the creation of nearby uncontaminated wetlands as alternative habitat, which overall tend to reduce exposure of shorebirds, and presumably other waterbirds, to selenium (Gordus 1999). Predation rates on aquatic bird nests at both these wetlands and the evaporation ponds, however, are extremely high, unless extreme measures, such as construction of sturdy electric fences, are implemented to exclude predators (Davis et al. 2008, R. Hansen and J. Seay pers. comm.).

Use of pesticides in rice fields has caused periodic mortality of some waterbirds and raptors but no chronic problem has been documented (Littrell 1988). It is unclear, however, what effect pesticides may have on the invertebrate resources in rice fields upon which a large portion of the state's breeding Black Terns depend. Loss of invertebrate diversity or biomass potentially could lead to chick starvation. Some Snowy Egret (*Egretta thula*) and, particularly, Black-crowned Night-Heron (*Nycticorax nycticorax*) eggs collected in the San Joaquin Valley had levels of DDE exceeding those associated with reproductive impairment; selenium concentrations in eggs, though elevated, were well below reproductive impairment levels (Ohlendorf and Marois 1990, Hothem et al. 1995). These findings suggest that the key species of waterbirds considered in this catalogue that nest in the Central Valley and feed high on the food chain (i.e., cormorants and terns) may also be affected by these contaminants.

Urbanization continues to reduce agricultural lands in the valley at a rate among the highest in North America (American Farmland Trust 1995, Sorensen et al. 1997), although its effect on waterbirds remains undocumented. Urban encroachment also directly threatens Central Valley wetlands, most notably at the Grasslands Ecological Area (D. Marciochi pers. comm.), the largest wetlands complex in the Central Valley. Likewise, rice lands are being lost to urban expansion in the American Basin of the Sacramento Valley between Sacramento and the Marysville–Yuba City area. Additional rice lands could potentially be lost to the expansion of cotton, a crop useless to Black Terns, though such loss, if realized, would be modest, as 80% of these rice lands are incapable of supporting other economically viable crops (J. Roberts pers. comm.). Agricultural practices that rapidly draw down water levels in rice fields have exposed Black Tern nests to rat predation only to later destroy renesting attempts when fields were reflooded above original levels (Lee 1984). A $28 billion agriculture industry (NASS 2008) dominates land use in the Central Valley, and its future could tremendously influence waterbird habitat either positively or negatively via shifting cropping patterns and farming practices in response to national or global economic forces and technological advances.

Great concern recently has been expressed about the future of the Salton Sea ecosystem because of increasing salinity, eutrophication from excess input of nutrients, contamination from agricultural and urban sources, disease outbreaks, and large die-offs of fish and waterbirds (e.g., Tetra Tech 2000, Molina and Shuford 2004). The technical, political, and financial difficulties of identifying and implementing a solution for restoration of the Salton Sea are compounded by the need for California to reduce its use of Colorado River water and recent agreements to transfer additional water from that source to urban users in southern California; the transfers, made possible by water conservation measures by agricultural users in the Imperial Valley, will greatly reduce freshwater inflows to the sea. Even before the transfer agreements, the sea's salinity was predicted within about one to two decades to reach concentrations that will severely affect populations of invertebrates and fish and, by extension, those of its fish-eating birds (Tetra Tech 2000), including many of the key waterbird species considered here. The rapid changes in numbers of Double-crested Cormorants and Caspian Terns nesting at the Salton Sea in the 1990s and comparable changes in the sea's fish populations (Molina 2004, Molina and Sturm 2004) may perhaps already reflect a response of fish to increasing salinity or other stressful or deteriorating ecological conditions, which also appear to be linked to increased bird mortality from disease (Friend 2002).

In the 1990s, die-offs of an estimated 150,000 Eared Grebes (*Podiceps nigricollis*), mostly from unknown causes (Meteyer et al. 2004), and over 10,000 pelicans and nearly 10,000 other fish-eating birds, from botulism (Rocke et al. 2004), focused renewed and intensified interest in restoring ecological balance to the Salton Sea (Molina and Shuford 2004). Although contaminants at the sea have not been shown to cause large-scale die-offs or other major problems, there is still ongoing concern for the potential risk to waterbirds of reproductive impairment or immunotoxicity from selenium, boron, and DDE (e.g., Setmire et al. 1990, 1993; Bruehler and de Peyster 1999). Exceptionally high concentrations of DDE were found in eggs of Great Egrets (*Ardea alba*) and Black-crowned Night-Herons nesting at the Salton Sea in 1985; although reproductive success of these species was not determined, on the basis of studies elsewhere it most likely would have been impaired (Ohlendorf and Marois 1990).

Research Needs

Although the species considered in this catalogue vary greatly in the amount of information that is known about them, all would benefit from an increase in research on certain aspects of their biology. Studies that will lead to improvement in the implementation of management and conservation actions are especially needed. In particular, it would be valuable to conduct demographic studies on each species to determine what reproductive parameters or life history stages (e.g., adult or juvenile survival, hatching success, etc.) most limit them so that appropriate management actions can be taken on their behalf. Likewise, it would be valuable to identify which colonies of each species are successful in producing young and which are not, and the factors responsible. Such information would enable restoration and enhancement projects to incorporate the features likely to produce habitats that support both high numbers of nesting individuals and high rates of productivity. Knowing that proximity of other features in the landscape may influence the distribution of foraging and nesting waterbirds (e.g., Elphick 2008, Kelly 2008), additional research is needed on what landscape features are important to various groups and species of waterbirds to inform optimal site selection for restoration and enhancement projects.

Very little is known about the diet and foraging ecology of any of the waterbirds considered here. It also would be valuable to use color-marked or radio-tagged individuals to study the foraging, dispersal, and migratory movements of each species to understand the suite of habitats upon which they depend, the linkages among them, and how species' patterns of use change with fluctuating environmental conditions. For species breeding both inland and on the coast, such studies might elucidate the extent of interchange between these colonies and if the degree or timing of mixing is influenced by climatic or oceanic conditions, breeding failures, or other factors. It also would be valuable to periodically assess water quality at key wetlands and contaminant levels in birds' eggs and tissues to detect deteriorating environmental conditions that need attention.

Monitoring Needs

Current Status of Monitoring

Monitoring the population trends of most of the seven species of inland-breeding waterbirds considered here could use considerable improvement. This catalogue provides the first concurrent baseline data on breeding colony sizes of all these species for the entire interior of California. Long-term abundance data for these birds, however, are of variable quality and exist for only a few local sites, for a few species, and mainly for just the last two decades. The difficulty of collecting long-term abundance data, particularly over a broad region, is often underappreciated, and many biologists consider this work uninteresting relative to ecological or other hypothesis-driven studies. Still, without such data it will be very hard to identify the conservation problems of waterbirds or to further focus on identifying their causes and remedies. The importance of coordinated monitoring cannot be overemphasized. Abundance estimates or trend assessments for broad regions made by compiling incomplete data gathered independently in different years, by different methods, and under varying climatic conditions typically provide ambiguous results (e.g., King and Anderson 2005) of limited value for conservation.

Given the general inadequacy of the Breeding Bird Survey for monitoring colonial waterbirds and its undersampling of marshes (Bystrak 1981, Robbins et al. 1986), there currently is no statewide or regional monitoring program in California for the species considered here. Other than for the exceptional case of the Caspian Tern explained below, monitoring for all other species currently is conducted at the local scale by wildlife areas and refuges, nonprofit organizations, or independent researchers focusing on individual colonies (e.g., Mono Lake) or suites of colonies at large sites (e.g., Salton Sea). Sometimes fortuitously, rather than by design, these efforts collectively amount to a de facto monitoring program, but may lack coordination, standardization, and a high likelihood of long-term continuity. Of the seven species considered here, three of them—the Double-crested Cormorant, Forster's Tern, and Black Tern—are monitored at so few sites that no meaningful information is now being gathered on their population trends in the interior of California.

Because of the need for current information on which to base management decisions regarding the large concentration of breeding Caspian Terns and associated fisheries conflicts at the Columbia River estuary in Oregon, USFWS has been coordinating the collection of data on the population size of individual colonies of this species throughout the Pacific Coast region. Most colonies in this region, including those in California, have been surveyed annually from 1997 to the present (Table 5 in Shuford and Craig 2002, USFWS unpubl. data).

Annual population estimates are currently being made for many or most of the state's colonies of American White Pelicans, Ring-billed Gulls, and California Gulls. Unfortunately, however, in some cases methods are inconsistent from year to year, methods or timing of surveys are not coordinated among sites, metadata on dates and methods of surveys are not kept, and data are not submitted to a central repository and may be hard to retrieve for individual sites.

Biologists for the Klamath Basin NWR Complex conduct annual surveys of the size of the state's two regular colonies of American White Pelicans at Clear Lake NWR and Sheepy Lake at Lower Klamath NWR (see Table 1). Most surveys have been visual estimates from a plane or counts from a boat, but in some years aerial photographs, which provide the most accurate counts, are taken; for many past years, the methods or dates of annual surveys are unrecorded.

Although there have been fairly consistent surveys at some of their colonies in the Klamath Basin since the 1950s (see Tables 7–9), census data on Ring-billed and California gulls adequate for population trend assessment first began to be collected at various sites in the state starting in the 1980s or 1990s (Shuford and Ryan 2000). For California Gulls, standardized censuses have been conducted annually at the state's largest colony at Mono Lake since 1983 (see Table 11, PRBO unpubl. data) and at the small colony at the Salton Sea since it was established in 1996 (Molina 2004); complementing these are annual censuses of the lone set of coastal colonies in the San Francisco Bay estuary since establishment in 1980 (Shuford and Ryan 2000, Strong et al. 2004, San Francisco Bay Bird Observatory unpubl. data). Censuses of mixed colonies of Ring-billed and California gulls have been conducted annually or nearly annually at Clear Lake NWR and at Meiss Lake on Butte Valley WA since the early 1990s, and at Honey Lake WA at intervals since that time (Shuford and Ryan 2000; Shuford et al. 2004, 2006; B. Tatman pers. comm.).

Monitoring Recommendations

Although it is beyond the scope of this catalogue to recommend detailed monitoring protocols for each species considered, some suggestions for monitoring are provided below in the individual species accounts. In addition, some issues common to all species with respect to the design and implementation of such protocols are addressed here.

In the past, censuses of waterbirds varied with respect to survey methods, the spatial scales they considered, and the use for which they were intended. Thus, on a continental scale, they produced data sets that were not comparable and hence were not adequate for accurately assessing population trends. To rectify this, scientifically rigorous and standardized monitoring protocols for various species of colonial waterbirds are currently being developed under the auspices of the North American Waterbird Conservation Plan (Waterbird Monitoring Partnership, www.pwrc.usgs.gov/cwb/). Beyond implementing comparable population monitoring techniques, this initiative emphasizes the contribution of data to a centrally managed waterbird database. This effort is to be lauded, as there is little point in monitoring populations if the data collected are inadequate for trend assessment and not widely available.

The survey work for this catalogue, however, emphasized the need for such protocols to accommodate variation in survey methods among sites when logistical constraints preclude their consistent application. For example, aerial photographs appear to provide the most accurate nest counts for pelican and cormorant colonies located on the ground on islands but not for cormorant colonies in trees, where nests can be obscured by the multi-layering of leaves and limbs (see Methods). Hence, surveys of tree colonies are best made by other methods. If access or views are adequate, ground surveys allow leisurely counting or mapping of tree nests; otherwise, they are best surveyed visually from an airplane, where the better views are offset to some degree by the rapidity with which counts or estimates need to be made. Likewise, depending on local conditions, censuses of gull colonies might best be made by one of several methods: (1) counting nests one by one within the colony when the gulls are nesting by themselves, (2) counting adults from a distance (later adjusting counts by ratios of adults to nests from other colonies) when other species highly susceptible to disturbance are present, or (3) counting nests from aerial photographs when access on the ground is restricted and background conditions provide adequate contrast to distinguish nests on developed images (Shuford and Ryan 2000; Shuford et al. 2004, 2006). Similarly, methods of counting or estimating the number of nests of Caspian Terns may vary depending on whether they are nesting in close proximity to gulls, which may prey on tern nests if the adults are disturbed, or whether or not terns' nests are easily visible on a barren substrate or are obscured by annual vegetation grown up since the terns began incubation (see Methods above). Finally, methods for counting Forster's Terns may vary between nest sites on open islands versus within emergent marsh vegetation, and for Black Tern's between sites in relatively small discrete wetlands and those in vast areas of cultivated rice fields (Shuford et al. 2001, Methods above).

Monitoring also needs to adequately account for California's highly seasonal precipitation and runoff and the great year-to-year variation in these parameters, which can cause wetlands or terminal lakes to vary markedly in extent, or temporarily disappear, over relatively short periods of time. This is particularly the case if the monitoring program is designed to collect data only at repeated intervals of several years rather than each year. If so, the intervals should be relatively short, otherwise data may better reflect the variation in climate rather than the long-term trends of the species' population. For example, it would be best to avoid surveying during a drought, then, after a long interval, surveying next during a wet period.

Even if considerable effort is expended to design survey protocols that are scientifically rigorous and take into account logistical and climatic constraints, equal or greater effort will need to be made to ensure that there is strong long-term support at the national, regional, and local levels to train or otherwise enable biologists to consistently conduct surveys, coordinate data collection, submit data to a central depository, analyze data, disseminate the results of analyses, and implement research and management as needed when analyses document consistent population declines.

When continental or national monitoring programs are developed, those biologists monitoring waterbirds in

California should make every effort to participate in those programs and to follow their protocols. This will be successful, however, only when biologists have strong support from higher in their organizations to participate fully in the relevant steps described above. Work on this catalogue has shown that biologists typically are eager to conduct needed surveys, but often the long-term commitment and financial support from their organizations for this work is inconsistent or unavailable, meaning this work is sacrificed for priorities judged more important at the local level. That support for ongoing monitoring of waterfowl populations in North America is institutionalized (Pacific Flyway Council, http://pacificflyway.gov/Monitoring.asp) suggests that it may be possible to develop long-term monitoring programs for colonial and other nongame waterbirds. A lack of such a program for these species will make it very difficult to ensure their long-term conservation. If early warnings of decline are unavailable and actions are not taken to reverse them, further declines may progress to the point that listing is needed and recovery may be difficult, expensive, and contentious.

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Chapter 2

Species Accounts

Multi-species colony, dominated by American White Pelicans (*Pelecanus erythroryhnchos*) and Ring-billed (*Larus delewarensis*) and California (*L. californicus*) gulls, on a large rocky islet in the east lobe of Clear Lake National Wildlife Refuge, Modoc County, California, 18 May 2009.

Aerial image of a large nesting island in the north-central portion of Clear Lake National Wildlife Refuge, Modoc County, California, 13 May 1999. Larger bright white dots are nesting pelicans, smaller indistinct white specks are nesting gulls.

The following accounts for seven species of inland-breeding waterbirds each provide a summary of the particular species' general range and abundance in North America; its continental, regional, and statewide conservation status; and its seasonal status, historic and current range and abundance, ecological requirements, threats, management and research recommendations, and monitoring needs in California. Because these accounts are meant to stand on their own, there is some duplication of material among them, particularly with respect to threats common to multiple species or particular regions. For these accounts, the *breeding season* is defined as the period from the laying of the first eggs through the fledgling of the last young. Following these detailed accounts, there are brief summaries of the historic and current status of six other related species that have bred very locally or irregularly inland in California but were not surveyed in the field by this project.

AMERICAN WHITE PELICAN (*Pelecanus erythrorhynchos*)

General Range and Abundance

The American White Pelican currently breeds primarily in the interior of North America from the Canadian and U.S. Prairies patchily south and west through the Intermountain West, reaching its southwestern limit in southern Oregon, northeastern California, and western Nevada (Evans and Knopf 1993, AOU 1998). The North American population can be separated into two groups, one breeding and migrating east, the other west, of the continental divide (Evans and Knopf 1993, AOU 1998). Additional small nonmigratory groups of pelicans breed irregularly on the central Texas coast, on the northern Gulf coast of Mexico, and, in winter, in north-central Mexico. Estimates of the total breeding population in Canada and the United States were about 109,000 adults at 55 colonies in 1979–1981 (Sidle et al. 1985) and 132,000 at 36 colonies in 1998–2001 (King and Anderson 2005). Interpretation of the suggested increasing trend is confounded, however, by incomplete surveys of colonies (particularly in the latter period), counts taken in different years under different climatic conditions, and a lack of standardized census protocols.

American White Pelicans winter primarily on the Pacific Coast and lowlands from central California and southern Arizona south through Baja California and west Mexico to Nicaragua, and from Florida and the Gulf States south through the Gulf coast and central plateau of Mexico to the northern Yucatán Peninsula. These pelicans generally winter where minimum January ambient temperature is >40ºF; highest densities occur where minimum January temperature is >45ºF and average minimum winter temperature is >50ºF (Root 1988). Exceptional concentrations of fish in waters shrunk by drought may entice large numbers of pelicans to winter as far north as the Great Basin of western Nevada (Keith and O'Neill 2000). Postbreeding individuals from western colonies may disperse widely (many north and east) before migrating south (Yates 1999, Keith and O'Neill 2000). Small numbers of nonbreeders may summer, or disperse to, nearly anywhere in the normal migrant and winter ranges.

Conservation Concern

The North American population exhibited a long-term decline thorough the 1960s but increased through the 1980s (Evans and Knopf 1993, Johnsgard 1993) and apparently since (King and Anderson 2005); for details, see Thompson (1933), Lies and Behle (1966), Boeker (1972), Sloan (1973, 1982), Sidle et al. (1985), Koonz (1987), and King and Anderson (2005). The North American Waterbird Conservation Plan considers this species to be of "moderate" conservation concern (Kushlan et al. 2002). In California, this pelican is designated a high priority Bird Species of Special Concern because of long-term population declines and range retraction in the state (Shuford and Gardali 2008).

Seasonal Status in California

American White Pelicans occur year round in California but their seasonal status varies regionally. Birds are found at or in the vicinity of breeding colonies in the Klamath Basin, and at high elevations in the Great Basin away from nesting areas, primarily from March to October (Gaines 1992, Summers 1993). Occurrence on the coast (Bodega Bay southward) and in the Central Valley is primarily from July to January (Cogswell 1977, Shuford et al. 1989), and at the Salton Sea mainly from mid-October to mid-April (Patten et al. 2003). This pelican also occurs widely during migration and may summer nearly anywhere in the normal migrant and winter ranges; occurrence of numbers of pelicans in lowland areas in May and June may perhaps signal departure from colonies after early-season breeding failures (Shuford et al. 1989). The breeding season extends mainly from March through July (Cogswell 1977, Appendix 5). Breeding may be asynchronous among subcolonies, such that a single island may simultaneously contain large young and also adults on eggs; subcolony formation may span a three-month period (Knopf 1979).

Breeding Range and Abundance in California

American White Pelicans formerly nested widely but locally in lakes and marshes of the Klamath Basin, Modoc Plateau, and Great Basin Desert of northeastern California, in overflow lands of the Sacramento Valley, at terminal lakes in the Tulare Basin of the San Joaquin Valley, and at the Salton Sea (since early 1900s) in the Colorado Desert (Shuford 2005). Sites of documented former nesting include Tule Lake (up to at least 1899) and Goose Lake (prior to 1879, 1976–1977), Modoc County; Eagle Lake (up to 1932), Lassen County; the lower Sacramento Valley (up to at least 1910); Tulare Lake (up to at least 1942), Kings County; Buena Vista Lake (up to 1953), Kern County; and the Salton Sea (up

Table 1 Numbers of Nesting American White Pelicans at Lower Klamath and Clear Lake National Wildlife Refuges, 1912 to 2000[a]

	Lower Klamath NWR		Clear Lake NWR	
Year	Nests	Young Fledged[b]	Nests	Young Fledged[b]
1912	3500	—	1000	3000
1932	—	—	—	5000 hatched
1935	—	—	"6000 seen"[c]	700 banded
1936	—	—	200	165
1937	—	—	2500	—
1938	—	—	2000	—
1940	—	—	1000	—
1941	200	—	2000	—
1942	—	—	several 100	—
1947	—	—	1200	2000
1948[d]	—	50	200	500
1949	—	900	—	600
1950	—	—	1450	—
1952[e]	1000	1800	1380	2500
1953	—	900	1177	650
1954	—	1620	1386	1750
1955	925	1570	656	919
1956	550	400	900	900
1957	600	600	1200	1200
1958	300	300	600	1000
1961	—	400	800	300
1962	250	700	400	600
1963	733[f]	600	430	900
1964[g]	400	250	609	800
1965	350	200	1200	1000
1966	270	400	1640	800
1967	330	520	673	600
1968	812	1000	773	700
1969	630	1100	510	500
1970	365	370	1189	820
1971[h]	199	141	2376	633
1972	249	280	787	1800
1973	—	362	—	860
1974	—	—	—	1340
1975	—	230	—	720
1976	—	206	—	670
1977	—	285	—	905
1978	—	—	—	806
1979	—	500	—	725
1980[i]	—	420	—	880
1981[j]	391	194	400	472

(continued)

to 1957), Imperial County (Thompson 1933, Grinnell and Miller 1944; Appendix 5). It is unclear whether accounts of pelicans nesting at Lower Klamath Lake (up to at least 1915) all pertain to the Oregon, rather than California, portion, as suggested by the lack of reference to this site in Grinnell and Miller's (1944) definitive summary of the status and distribution of California birds. Although Thompson (1933) suggested Kern Lake, Kern County, and Lake Elsinore, Riverside County, were former nesting sites, Grinnell and Miller (1944) did not consider these documented breeding locales.

American White Pelicans currently breed regularly in California only in the Klamath Basin at Sheepy Lake, Lower Klamath NWR (since at least 1941), Siskiyou County, and Clear Lake NWR, Modoc County (since at least 1918; Table 1, Figure 1). Pelicans also have nested sporadically at Meiss Lake, Butte Valley WA (1999 and 2000), Siskiyou County, and Hartson Reservoir, Honey Lake WA (since 1976, perhaps early 1950s), Lassen County (Appendix 5).

American White Pelicans also occasionally "dump" eggs at sites where they do not form breeding colonies, e.g., Lake

Table 1 *(continued)*

Year	Lower Klamath NWR Nests	Lower Klamath NWR Young Fledged[b]	Clear Lake NWR Nests	Clear Lake NWR Young Fledged[b]
1982[j]	498	514	1004	1094
1983[k]	695	464	1593	1074
1984	600	605	—	2100
1985	—	40	—	1800
1986	—	350	—	1900
1987	400	400	2435	2400
1988	—	140	—	200
1989	—	340	—	1250
1990	—	0	1750	<50
1991	335	310	670	107
1992	400	400	1700	2650
1993	300	30	820	0
1994	250	130	1590	1020
1995	—	320	—	480
1996	300	480	—	954
1997	480[l]	330	2559[l]	1010
1998	—	60	994	482
1999	0[m]	0	2334[m]	—
2000	0	0	—	1600

[a]Data from files and Annual Narrative Reports (ANR) of Klamath Basin NWR Complex unless otherwise noted. Data quality generally Category 3 (should be used with great caution in interpreting population trends; Shuford and Ryan 2000), as in only very few instances are descriptions of methods and dates of surveys available. Lower Klamath Lake proper has been practically dry since 1919 (Thompson 1933), and all accounts of pelican nesting thereafter are either attributed to, or likely refer to, Sheepy Lake on Lower Klamath NWR. —, no data available.

[b]Number of young fledged estimated from counts of large young on nesting islands late in breeding season.

[c]Files state "6000 seen in colony" but unclear if this is just adults or adults and young; similarly, C. G. Fairchild in Bailey (1935) estimated 6000 "birds in the colony."

[d]Refuge file card says "2500 or more present on Bird Is. and two islands east of peninsula," but ANR says 200 nests and 500 young.

[e]Five "colonies" at Lower Klamath, six "colonies" at Clear Lake; two "colonies" (100 and 150 nests) located on a peninsula were destroyed by coyotes (AFN 6:292).

[f]ANR indicates 300 nests but a count in 2001 of a photo in the 1963 ANR estimated 733 nests (D. Shuford pers. obs.).

[g]Numbers of nests and young for 1964 presented in Lies and Behle (1966) are reversed from those reported here taken from the refuges' ANRs.

[h]Numbers of nests apparently based on 11 May aerial photographic survey described in ANR. Boeker (1972), however, reported 120 and 1130 nests for Lower Klamath and Clear Lake, respectively, also from a 11 May aerial photographic survey.

[i]Sidle et al. (1985) estimated 750 and 1571 nests at Lower Klamath and Clear Lake, respectively, in 1980. Their estimates appear to be based on raw counts of 420 and 880 fledged young at Lower Klamath and Clear Lake, respectively (USFWS 1984), and a rate of 0.56 fledged young/nest; it is unclear why they used this rate of reproductive success (e.g., rates at undisturbed colonies at these sites ranged from 1.03–1.18 young/nest in 1981 and 1982 [Boellstorff et al. 1988]).

[j]Data from counts of nests and young from aerial photographs; see Boellstorff et al. (1988) for details.

[k]Data from counts of nests and young from aerial photographs; see Smith et al. (1984) for details.

[l]Data from counts of nests on aerial photos taken 12 May (Shuford 1998). Visual estimates from an airplane on 15–16 May were about 400 nests at Sheepy Lake and 1100 at Clear Lake (Klamath Basin refuge files). A count from a boat at Clear Lake on 14 May estimated about 1890 adult pelicans (Klamath Basin refuge files).

[m]Data from counts of nests on aerial photographs taken 13 May (PRBO unpubl. data).

Tahoe, El Dorado County (Rowlands Marsh, 16–17 May 1927, Orr and Moffitt 1971), Mono Lake (in gull colonies, 28 May 1981, Gaines 1992), and Lake Henshaw, San Diego County (Willett 1933; Appendix 5).

The anecdotal nature of most nesting reports makes it impossible to accurately characterize the abundance of breeding American White Pelicans in California in the late 1800s and early 1900s (Shuford 2005). Still, it is clear that during this period at least thousands of pelicans bred at Lower Klamath Lake, Clear Lake, Tule Lake, the lower Sacramento Valley, Tulare Lake, and the Salton Sea, with lesser numbers at Eagle Lake and Buena Vista Lake; almost nothing is known of the size of the Goose Lake colony (Appendix 5). Although data are lacking, the statewide breeding population historically may have exceeded 20,000 pairs.

Although shooting (out of fear of competition for fish, for sport, and for plumes for the millinery trade) caused population reductions during this period, the primary cause of declines was the loss of habitat from water diversions and land reclamation for agriculture (Thompson 1933). Compounding the tremendous loss of wetland habitat in California (Dahl et al. 1997) is the extensive disruption of the dynamic natural processes, such as flooding, that formerly created and maintained large wetlands, particularly in the Central Valley (The Bay Institute 1998).

Since the late 1950s, the species' breeding colonies in California have been restricted mainly to the Klamath Basin (Shuford 2005). After the drying of Lower Klamath Lake by 1919, the regional population concentrated chiefly at Clear Lake, which likely did not hold nesting pelicans until the damming of its outflow in 1910 more than doubled the amount of open water (see Shuford and Ryan 2000, p. 147). Since the 1930s, refuge biologists have estimated numbers of nests and fledged young at the colonies at Clear Lake NWR and Sheepy Lake, Lower Klamath NWR (Table 1). Variation in the methods and timing of counts, however, make them difficult to interpret. Still, during this period numbers of nests at Lower Klamath generally ranged from about 250–700 except for estimates of about 1000 in the early 1950s. Numbers of nests at Clear Lake ranged from about 2000–3000 in the 1930s to early 1940s. Thereafter, they seemed to decrease and have varied considerably from year to year, presumably in response to prey availability mediated by climate (e.g., prey concentration during drought) or weather-induced nest abandonment (see Shuford et al. 2004). In four years since the early 1970s, nest counts at Clear Lake have reached 2300–2500. These high counts may reflect especially favorable nesting conditions or may be largely, or partly, an artifact of the methods used, as accurate counts from aerial photos produced the high counts in 1971, 1997, and 1999 (Table 1). The total number of nesting pairs estimated at active colonies in the Klamath Basin were 3039 in 1997 (Clear Lake NWR, 2559; Sheepy Lake, Lower Klamath NWR, 480) and 2346 in 1999 (Clear Lake NWR, 2334; Meiss Lake, Butte Valley WA, 12) (Table 1, Appendix 5).

Ecological Requirements

American White Pelicans are limited by the availability of remote nesting sites and rich foraging habitats. Although adapted to exploit shifting nesting and foraging sites in response to cycles of drought and flood, pelicans form the largest colonies where these resources are most predictable and islands are subject to minimal disturbance by humans or ground predators (Evans and Knopf 1993). Pelicans often breed in multispecies assemblages of colonial nesters (cormorants, gulls, terns, herons, and egrets), generally choosing sites on flats or moderate slopes, for flight access and visibility, and avoiding low-lying areas prone to flooding; island substrate is usually loose earth suitable for heaping into nest mounds (Palmer 1962, Evans and Knopf 1993). Known nesting situations in California have been on the ground on earthen, sandy, and rocky islands or (rarely) peninsulas and (locally) on floating tule-mat islands, particularly in the Klamath Basin; nests range from being in open sand to interspersed with or adjacent to tall weeds and open, low-stature shrubs (Smith et al. 1984; Appendix 5). Nests typically are shallow depressions with low rims formed by sitting birds raking in nearby gravel, soil, vegetation, or goose or cow dung with their bills (Palmer 1962, Smith et al. 1984, Evans and Knopf 1993, Johnsgard 1993). Breeding islands are commonly 50–100 km from foraging areas.

American White Pelicans typically forage, often cooperatively in flocks, in shallow inland waters (0.3–2.5 m in depth), such as open areas in marshes and along lake or river edges; wintering and nonbreeding birds also feed in shallow coastal marine habitats (Palmer 1962, Evans and Knopf 1993, Johnsgard 1993). During less frequent foraging in deep water, pelicans steal prey brought to the surface by other species, particularly Double-crested Cormorants; pelicans also may rob gulls or other pelicans trying to swallow large fish. Fish spawning in shallow water or concentrated or stranded by dropping water levels appear to be particularly vulnerable to pelican predation (Knopf and Kennedy 1980). American White Pelicans forage both in the day and at night (McMahon and Evans 1992).

American White Pelicans nesting at Lower Klamath and Clear Lake forage extensively in the Klamath Basin, particularly at Tule Lake, Lower Klamath NWR, marshes and canals between the latter area and Upper Klamath Lake, and various small reservoirs, lakes, and rivers within 100+ km (Smith et al. 1984, L. A. Moreno-Matiella unpubl. data, D. Anderson in litt.). Although not attributable to colony of origin, foraging pelicans also are found widely over southeastern Oregon and northeastern California (Smith et al. 1984). Pelicans from individual colonies may shift their primary foraging sites at least two to three times during the nesting season as they opportunistically select sites where fish are most readily available (Knopf and Kennedy 1980). American White Pelicans often feed long distances from colonies, as documented by breeding birds in western Nevada making repeated roundtrip flights over the Sierra Nevada to forage in California's Central

Valley (Yates 1999). Rising in one thermal updraft and gliding to another, these pelicans can attain airspeeds of over 113 kph (70 mph) and reach heights of >3.2 km (2 mi) above the ground; roundtrips of >322 km (200 mi) are common.

The diet of these pelicans is mainly "rough" fish of low economic value—predominately small (<½ bill length) schooling fish but also larger sluggish bottom feeders—as well as salamanders and crayfish (Palmer 1962, Evans and Knopf 1993, Johnsgard 1993). A sample of 20 regurgitations (*n* = 246 diet items) from flightless juvenile pelicans at Clear Lake NWR on 28 June 1983 included 71.1% largemouth bass (*Micropterus salmoides*), 17.9% bluegill and pumpkinseed (*Lepomis macrochirus and L. gibbosus*), 5.3% yellow perch (*Perca flavescens*), 2.4% bullhead (*Ictalurus* spp.), 2.4% chub (*Gila* spp.), 0.4% white crappie (*Pomoxis annularis*), and 0.4% crayfish; by weight, largemouth bass accounted for 80.2%, bluegill and pumpkinseed 9.3%, bullhead 5.8%, chub 3.5%, and yellow perch 1.2% (Smith et al. 1984).

Threats

Historically, American White Pelicans were negatively affected primarily by the loss of foraging and nesting habitat and by human disturbance, factors still of concern today (Shuford 2005). Given the water and recreational demands of the state's rapidly expanding human population, it is unlikely that restoration efforts will enable these pelicans to establish many new colonies or reoccupy much of their historic breeding range. The extreme concentration of the state's breeding population leaves it very vulnerable to catastrophic losses, particularly at the Clear Lake colony. Both Klamath colonies are remote but not immune to human disturbance on an irregular basis (refuge files), ground predators during drought years (refuge files), or rapid transmission of disease at any time. Boellstorff et al. (1988) reported that research activities lowered reproductive success of a disturbed colony at Lower Klamath NWR.

The effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland habitat for waterbirds, including American White Pelicans. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR and Clear Lake NWR, where nesting pelicans are concentrated. Fortunately the important pelican foraging grounds at Tule Lake will retain some priority for summer water to maintain habitat for remnant populations of the endangered Lost River and shortnose suckers. The long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented.

The Sheepy Lake colony is at risk from fluctuations in water levels, which need to be maintained within a narrow range; when kept too high in 1999 and 2000, water saturated the tule-mat nesting islands and no pelicans nested (D. Mauser pers. comm.).

American White Pelicans were susceptible to organochlorine pesticide contamination and eggshell thinning from the 1960s to mid-1980s. High pelican mortality in the Klamath Basin in the early 1960s was attributed to contamination of their foraging areas by toxaphene and endrin via run-off from surrounding agriculture (Keith 1966, Godsil and Johnson 1968). With greatly reduced mortality by the mid-1960s, concentrations of dieldrin and DDT + DDD in pelican eggs decreased from 1969 to 1981, paralleling reduced use, but those of DDE (highly persistent) and PCBs (industrial origin) did not (Boellstorff et al. 1985). Deaths of 19 of 38 pelicans from 1975 to 1985 appeared to be caused by endrin or possible additive effects of endrin and dieldrin poisoning. The source of endrin may have been from illegal use after it was banned (Anderson et al. 1984). Eggshell thickness of pelican eggs in the Klamath Basin increased from 1969 to 1981 but remained significantly thinner than in eggs collected before widespread use of DDT began in 1947 (Boellstorff et al. 1985). Pelicans appeared to have minimal exposure to organochlorine pesticides in the Klamath Basin in 1981, hence birds probably accumulated these chemicals on the wintering grounds or migration routes in spring. Differences in PCB residues between eggs collected at Lower Klamath and Clear Lake suggest that pelicans breeding at these sites have different migration routes or wintering areas.

American White Pelicans also are subject to catastrophic losses where large numbers congregate during migration or winter. These pelicans are particularly vulnerable at the Salton Sea and Río Colorado Delta, as most of the western subpopulation passes through this area in the nonbreeding season (D. Anderson in litt.). High counts of American White Pelicans at the Salton Sea in the 1980s and 1990s ranged from about 25,000 to 33,000 (Shuford et al. 2002), and nearly 9000 American White Pelicans died in an avian botulism disease outbreak there in 1996 (Rocke et al. 2004). At least some pelicans from the Clear Lake and Lower Klamath breeding colonies have been detected at the Salton Sea during their southward migration (D. Anderson pers. comm.).

American White Pelicans from the western subpopulation also are shot where they consume fish at aquaculture operations in Mexico (D. Anderson in litt.).

Management and Research Recommendations

USFWS's (1984) management recommendations for the western subpopulation, which should be consulted for additional details, are modified here for California:

- Provide or maintain nesting islands of suitable size, substrate, and isolation. Manage water levels to avoid flooding (eliminating habitat) or connecting islands to the mainland (allowing predator access), and, if necessary, prevent erosion by planting vegetation or by other mechanical means. Islands are available at a wide range of water levels at Clear Lake and only a narrow range at Lower Klamath. When peninsulas form at Clear Lake during drought, continue to erect temporary electric fences to deter ground predators from entering colonies, as has been done in the past (Moreno-Matiella and Anderson 2005, Klamath Basin refuge files). As a longer-term solution, study the feasibility of physically modifying some islands in the west lobe of Clear Lake so nesting habitat would be available at the lowest water levels (Moreno-Matiella and Anderson 2005).

- Maintain or enhance nongame fish populations for pelicans, restoring prey species at pelican foraging areas as necessary. Ensure prey availability by maintaining shallow (1–2 m) water depths and, when feasible, drawing down levels to provide foraging opportunities.
- Minimize human disturbance at colonies by restricting access by land or boat (posting and patrolling nesting areas), prohibiting discharge of firearms nearby, and requiring aircraft to stay at least 610 m (2000 ft) above nesting islands. Carefully review all research protocols to evaluate whether expected results are worth the risks of disturbance. Researchers should avoid or minimize disturbance to nesting pelicans by entering colonies only when absolutely necessary; colonies are particularly vulnerable when eggs or small young are present, which may occur even late in the season because of subcolony asynchrony.
- Establish a taskforce of biologists and managers to evaluate the feasibility of restoring former nesting sites or developing new ones and the best methods for doing so. Consider whether natural pioneering will be sufficient at restored or enhanced sites or if placement of pelican decoys and playing taped vocalizations or transplanting of young (restocking) might be needed. Assess the benefits of new nesting islands to other colonial nesters and the potential for any unintended effects on other wildlife populations. Present these findings to partners active in wetland conservation and enhancement.
- Educate the public about the history of population declines, pelican ecology, and the effects of human disturbance.
- Conduct a population viability analysis to see if the Klamath population is maintained by local production and to determine which population parameters contribute the most to population limitation.
- Initiate detailed studies of the foraging ecology of Klamath Basin pelicans to assess how they might be affected by water quality or by current water allocation priorities under varying climatic conditions.
- Conduct radio- and satellite-telemetry studies to determine foraging movements, dispersal patterns, and migration routes of Klamath pelicans to assess risks at foraging areas in both the breeding and nonbreeding seasons.
- Conduct diet studies of pelicans in the Klamath Basin and study the ecology of important fish species. Also, study pelican foraging ecology at key migratory or wintering areas.
- Periodically evaluate pesticides and contaminants in pelicans, and study disease events at the Salton Sea or elsewhere where pelicans concentrate in the nonbreeding season.

Monitoring Needs

Numbers of pairs of breeding American White Pelicans should be monitored by nest counts from aerial photographs taken annually at known colonies during the peak of the incubation period (early May in Klamath Basin). Such monitoring has proven effective elsewhere in the breeding range (Beaver and Lewin 1981, Sidle and Ferguson 1982) and has been used sporadically in the Klamath Basin since at least 1971 (Klamath Basin refuge files). See Smith et al. (1984) and Shuford (1998, this document) for a description of methods used. Reproductive success also should be monitored annually using early July counts of the number of young reaching fledging age.

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DOUBLE-CRESTED CORMORANT
(*Phalacrocorax auritus*)

General Range and Abundance

The Double-crested is the most numerous and widespread of the six cormorant species in North America; in the United States and Canada, it is the only one that occurs in large numbers both on coasts and in the interior (Hatch and Weseloh 1999). The five major breeding zones are: (1) Alaska (southeastern Bering Sea, eastern Aleutians, southern coast), (2) Pacific Coast (southern British Columbia south to Sinaloa, Mexico; mostly on coast but also inland), (3) Canadian and U.S. interior (mainly Prairie provinces, eastern portions of Intermountain West, Rocky Mountain and Prairie states, and the Great Lakes region to the lower St. Lawrence River), (4) Atlantic Coast (mainly on coast from southern Newfoundland south to New York; smaller numbers on coast to mid-Atlantic states and inland), and (5) Florida and western Caribbean (Florida, except the Panhandle, and locally along Gulf Coast to Texas; locally in northern Bahamas, Cuba, and the coast of the Yucatán Peninsula and northern Belize) (Wires et al. 2001). The continental and worldwide breeding population is estimated to be about 350,000 to 370,000 pairs (Hatch 1995, Hatch and Weseloh 1999, Tyson et al. 1999).

This species winters mainly on the Pacific Coast (including Alaska) and near-coastal lowlands (Columbia River southward) south to Nayarit, Mexico; on the Atlantic Coast and coastal lowlands (mostly from the mid-Atlantic states southward); on the Gulf coast of the United States and Mexico south to the Yucatán Peninsula and Belize; inland in the southern United States and northeastern Mexico; and in the northern Bahamas south to Cuba (Howell and Webb 1995, Hatch and Weseloh 1999). In winter in southern areas, migrants from the north mix with resident birds. Nonbreeders can be found widely in

Table 2 Numbers of Pairs of Double-crested Cormorants Breeding at Sites in the Interior of California, 1997 to 1999[a]

		Survey dates			Number of nesting pairs			
Site	Colony code	1997	1998	1999	1997	1998	1999	CS[b]
Siskiyou County								
Lake Shastina (north)	326-254-001	15 May	17 May	—	5[2]	8[2]	—	TI/Wj
Butte Valley WA (Meiss Lake)	326-271-001	14–15 May	14 May	13 May	18[1]	20[1]	79[1]	GI
				13 May			**84**[3]	
Lower Klamath NWR (Sheepy Lake)	327-187-001	12 May	24 June	13 May	978[3]	80[3]	**62**[3]	GI
Modoc County								
Tule Lake NWR (lower) Sump 1-B	327-174-001	12 May	26 May	13 May	217[3]	120[3]	**172**[3]	GI
Clear Lake NWR	327-182-001	12 May	27 May	13 May	133[3]	37[2]	**114**[3]	GI
Lassen County								
Eagle Lake (Pelican Point)	354-066-001	13 May	—	13 May	43[3]	—	**118**[3]	GI
		14 June			41[2]			
Plumas County								
Butt Valley Reservoir	354-122-001	14 May	7 Apr	10 May	21[1]	10[3]	**24**[3]	SWp
			22 June			15[3]		
Butte County								
Llano Seco Rancho	380-158-001	—	3 May	26 May	—	59[1]	**15**[1]	TEm
			27 May			61[1]		
Colusa County								
Sacramento R. between Meridian and Grimes	380-118-001	—	29 May	26 May	—	1[1]	0[1]	TEc
Sutter County								
North Butte Country Club, Butte Sink	380-138-001	—	22 May	26 May	—	109[1]	**65**[1]	TW/Ec
Sutter Bypass, ~8 km NE of Knights Landing	405-176-001	—	22 May	17 May	—	7[1]	**12**[1]	TW/Ec
				25 June			1[2]	
Yolo County								
Beaver Lake, Sacramento R. near Tyndall Landing	405-187-001	—	3 May	19 May	—	16[1]	**16**[1]	TW/Em
Port of Sacramento	405-155-001	—	16 Apr	16 May	—	2[1]	0[1]	TEc
			18 May			5[1]		
			9 July			0[1]		
Sacramento County								
North Stone Lake, Stone Lakes NWR	405-144-001	18 Feb–31 Aug	1 Mar–30 Aug	6 Mar–2 Jul	116[1, c]	180[1, c]	**154**[1, c]	TEcw
				6 Mar			117[1]	
				4 Apr			150[1]	
				18 Apr			153[1]	
				23 May			138[1]	
				13 June			88[1]	
				2 July			19[1]	
Horseshoe Lake, Valensin Ranch, Cosumnes River Preserve	405-134-001	—	15 May	10 Apr	—	0[1]	3[1]	TEo
				16 May			**3**[1]	
				29 June			3[1]	
Pellandini Ranch, W of Twin Cities	405-133-001	—	21 May	25 May	—	38[1]	**29**[1]	TEo
San Joaquin County								
Venice Tip	405-115-001	—	—	26 May	—	—	**9**[2]	TIe
Lake County								
Clear Lake Mouth of Holiday Cove	379-218-001	—	?	?	—	0	**25**[2]	TE

(continued)

Table 2 *(continued)*

Site	Colony code	Survey dates 1997	Survey dates 1998	Survey dates 1999	Number of nesting pairs 1997	Number of nesting pairs 1998	Number of nesting pairs 1999	CS[b]
Long Tule Point	379-217-001	—	?	23 May	—	0	**57**[1]	TEo
East of Quercus Point	379-217-002	—	?	—	—	175[2]	—	TE
Slater Island, Anderson Marsh	404-286-001	—	?	?	—	0	**15**[1]	TE
Sonoma County								
Petaluma wastewater plant	404-225-001	2 May–23 June	6 Apr	11 Apr	2[1]	1[1]	5[1]	TEe
			26 Apr	2 May–13 July		1[1]	**6**[1]	
			10 May			3[1]		
			31 May			4[1]		
			9 June			4[1]		
			21–30 June			2[1]		
Laguna de Santa Rosa, Alpha Farms	404-247-001	12 Apr	15 Mar	3 Mar	16[1]	21[1]	14[1]	TEe
		11 May	3 May	12 Apr	15[1]	17[1]	45[1]	
		15 June	7 June	8 May	20[1]	42[1]	43[1]	
			23 June	4 June		55[1]	**59**[1]	
				22 June			45[1]	
				5 Aug			2[1]	
Alameda County								
Arroyo del Valle, Shadow Cliffs Regional Park	430-167-001	—	16 Apr	—	—	1[1]	—	GI
Stanislaus County								
Christman Island, San Joaquin River NWR	430-162-001	—	20 May	25 Mar	—	34[1]	**12**[1, d]	TEo
Merced County								
San Joaquin River, Kesterson Unit, San Luis NWR	430-038-001	—	4 June	6 Apr	—	7[2]	0[1]	SEo
			25 June	10 May		7[1]	0[1]	
				2 June			0[1]	
West Bear Creek Unit (San Joaquin River), San Luis NWR	430-037-002	Feb–June	6 May	6 Apr	0[1]	6[1]	12[1]	TW/Eo
			21 May	10 May		25[1]	**22**[1]	
			22 June	2 June		50[1]	13[1]	
			24 July			27[1]		
			28 Aug			11[1]		
Merced NWR (East Side Bypass)	430-026-001	—	11 May	Apr–June	—	1[1]	0[1]	TWw
			23 May			0[1]		
San Benito County								
San Felipe Lake	454-184-001	—	11 Apr–25 May	—	—	11[1]	—	TWw
Fresno County								
Milburn Unit, San Joaquin River Ecological Reserve	455-977-001	—	9 July	27 May	—	3[1]	**9**[1]	TEe
Kings County								
South Wilbur Flood Area, Tulare Lake Drainage District	478-976-001	31 May	18 June	9 June	24[2]	95[2]	**119**[2]	TWtw, SWtw
		28 July			22[2]			
East Hacienda Ranch Flood Basin, Tulare Lake Drainage District	478-975-001	30 May–29 July	19 June	10 June	0	63[2]	**6**[2]	TWt
Los Angeles County[e]								
San Gabriel River, Pico Rivera	524-881-001	—	?	?	—	~6[1]	**~6**[1]	TWm

(continued)

Table 2 *(continued)*

Site	Colony code	Survey dates 1997	1998	1999	Number of nesting pairs 1997	1998	1999	CS[b]
Orange County[f]								
Anaheim Lakes, Orange Co. Water District	525-777-001	—	—	24 May	—	—	**105**[1]	TIe
San Diego County								
Sweetwater Reservoir	545-668-001	31 Mar	8 May	15 Apr	[g]	27[2]	**28**[2]	TWw
Riverside County								
Prado Basin	525-786-001	—	23 July	"April"	—	~40[1]	**30**+[1]	TIe
Mystic Lake	525-781-001	—	—	8 June	[h]	—	**64**[2]	TWw
North End Salton Sea (Johnson Street)	525-651-001	—	?	22–29 Mar	—	2[2]	2[1,2]	SWt
Imperial County								
South End Salton Sea								
East side Poe Road	526-516-001	—	—	7 May	—	—	13[2]	TSWt
New River mouth	526-526-002							
West		—	—	16 June	—	—	2[2]	?
Delta		late May	Apr–June	3 Apr[i]	~600[2]	~500[2]	26[3]	TSEt
East		—	—	18 Apr–13 July	—	—	2[2]	?
Alamo River Delta	526-525-002	—	mid-May	27 May	—	75[2]	106[3]	GEr, TEt
Mullet Island	526-525-001	12 Dec	21 Jan	1 Feb	109[1]	~400[1]	4959[3]	GI
		17 Jan	3 Feb	19 Feb	697[1]	1500+[1]	**5425**[3]	
		14 Feb	3 Mar	25 Mar	1777[1]	~2000[2]	4525[3]	
		27 Mar	5 Mar	16 Apr	~1977[2]	~2700[3]	2077[3]	
			13 Apr			~1000[1]		
Ramer Lake, Imperial WA	526-515-001	?	?	6 May[j]	13[1]	7[1]	18[1]	SWt

[a]Colonies located and counted using various methods (see text): 1, ground; 2, boat; 3, aerial. Numbers of cormorant nests from aerial surveys were counted from photographs (see Methods); exceptions were visual counts from a helicopter at Butt Valley Reservoir in 1998 and 1999 and visual estimates from an airplane at Lower Klamath NWR (Sheepy Lake) and Tule Lake NWR (lower) Sump 1-B in 1998. —, no survey made; ?, count taken in nesting season but date of survey unavailable. *Note bene*: For 1999, an estimated total of 6865 nesting pairs of cormorants for the interior of the state was obtained by adding the highest (peak-day or seasonal) count for each site that year; these counts are indicated in bold in the body of the table. For this purpose, we treated the entire Salton Sea area (North End Salton Sea, Riverside Co., and South End Salton, Imperial Co. [and their respective subcolonies]) as a single site and used the peak single-day (19 February) count of nests on Mullet Island as the estimate of nesting pairs for that area/site (see Methods).

[b]CS = Colony Situation. All colonies were surrounded by or adjacent to water, but nest locations varied among colonies. Primary codes describing nest sites: G, on ground; T, in live tree; S, in snag. Modifying codes used to further describe nest location: I, on island; E, on or near shoreline edge; W, in water. Plant species used for nest support: c, Fremont cottonwood *(Populus fremontii)*; e, eucalyptus (*Eucalyptus* spp.); j, western juniper (*Juniperus occidentalis* var. *occidentalis*); m, western sycamore (*Platanus racemosa*); o, valley oak (*Quercus lobata*); p, Pacific ponderosa pine (*Pinus ponderosa*); r, common reed (*Phragmites australis*); t, tamarisk (*Tamarix* spp.); w, willow (*Salix* spp.).

[c]Season-long surveys were conducted but the entire colony often was not covered in a short period, except in 1999 (P. Stackpole in litt.). In 1997, a total of 116 cormorant nests was recorded, but the high count for a short period was 108 on a 13–19 April 1997 colonywide survey. In 1998, a total of 180 cormorant nests was recorded, but the high count for a short period was 161 on a 10–16 May 1998 colonywide survey. In 1999, all nests were counted on 6 dates, resulting in a total of 154 nests with the high count of 153 nests on a single date.

[d]Entire colony destroyed by high winds between 25 March and 28 April 1999 (K. Sande in litt.), presumably before all nests were established.

[e]Although no nest counts were available until 2002, another colony had been active in the county since about 1995 at the Rio Hondo Spreading Grounds (K. Powell *fide* B. Daniels). A third colony was active at the Sepulveda Wildlife Area in 2003 (M. Kotin *fide* K. Garrett).

[f]Another colony of at least three nests was active at Bolsa Chica Ecological Reserve in 2002 (P. Knapp, B. Daniels).

[g]Nests occupied in 1997 but no count taken; the colony was first formed in 1996 (Unitt 2004).

[h]Lake dry, cormorants presumably did not nest.

[i]Colony abandoned by 16 April.

[j]Colony abandoned by 16 May.

the general breeding range, including far from colonies, and some birds remain in the wintering range.

Conservation Concern

Considered a species of concern in many regions in North America in 1970, the Double-crested Cormorant has since increased greatly in numbers, leading to its widespread perception as a pest (Hatch and Weseloh 1999, Wires et al. 2001). Although protected in the United States by the Migratory Bird Treaty Act of 1918 (following amendment of the U.S. Convention with Mexico in 1972), USFWS issued an order (50 CFR 21.47) in 1998 to reduce depredation of aquacultural stock at private fish farms and state and federal fish hatcheries. In 2003, a second depredation order (50 CFR 21.48) was issued to reduce the occurrence and/or minimize the risk of adverse impacts to public resources (fish, wildlife, plants, and their habitats). The former order allows the control of Double-crested Cormorants at commercial aquaculture facilities and state and federal hatcheries in 12 southeastern states and Minnesota. The latter order allows the control of Double-crested Cormorants in 24 states, in the East and Midwest, when the cormorants are damaging public resources as defined above. Control programs for Double-crested Cormorants, requiring federal permits, also exist in individual states to reduce cormorant impacts on island vegetation and other colonial waterbirds.

The North American Waterbird Conservation Plan considers the conservation status of this species to be "not currently at risk" (Kushlan et al. 2002). In California, the Double-crested Cormorant formerly was considered a Bird Species of Special Concern (Remsen 1978, CDFG 1992) but no longer warrants that status because of increasing populations in the state (Shuford and Gardali 2008).

Seasonal Status in California

Double-crested Cormorants occur year round in California, but their seasonal status varies by region. Birds occur at moderately high elevations in the Klamath Basin, Great Basin Desert, or mountains primarily from March or April through November (McCaskie et al. 1979, Garrett and Dunn 1981, Gaines 1992, Summers 1993). Cormorants are present year round at low elevation breeding or wintering areas, mainly on the coast or coastal slope, Central Valley, Salton Sea, and lower Colorado River valley. They also occur widely during migration and may summer nearly anywhere in the normal migrant and winter ranges. It is uncertain if increased numbers on the coast and in interior lowlands in winter represent an influx of breeders from other parts of California, from outside the state, or both. Most breeding in California spans from March through July or August (Stackpole and Hall 1998, Appendix 6, D. Shuford pers. obs.). Nesting at Mullet Island at the Salton Sea, however, has begun as early as December and January (Salton Sea NWR files).

Breeding Range and Abundance in California

Grinnell and Miller (1944) described coastal breeding colonies of Double-crested Cormorants from Bear Valley, Marin County, south to La Jolla, San Diego County. Carter et al. (1995b) concluded that historic declines and extirpations probably occurred at coastal colonies in northern and central California in parallel with declines that began in the mid- to late 1880s at the South Farallon Islands, where numbers remained low until the 1970s. Numbers of breeding Double-crested Cormorants began to expand elsewhere in northern California in the 1960s and at the Farallons in the 1970s. The species colonized San Francisco Bay in the late 1970s and has since increased dramatically, breeding mainly on artificial structures such as bridges. Colonies in southern California declined in the early 1900s through the 1970s then increased. The only comprehensive surveys of all marine and estuarine habitats on the California coast estimated 1926 breeding birds (*not* pairs) at 18 sites from 1975–1980 and 10,184 birds at 39 sites from 1989–1991 (Sowls et al. 1980, Carter et al. 1995a, b).

Grinnell and Miller (1944) reported the northernmost interior breeding sites as (or having been) Tule and Clear lakes, Modoc County, Eagle Lake, Lassen County, and Clear Lake, Lake County, and the southernmost as the Salton Sea, Imperial County, and Lake Henshaw, San Diego County. They also listed former nesting sites in the Sacramento and San Joaquin valleys as Butte Creek, Sutter County, and Tulare and Buena Vista lakes. Additional pre-1944 records for the Central Valley include egg sets from the "vicinity of Sacramento" in 1901 and "3 mi inland from San Joaquin River" in 1907 (Appendix 6). Although there are few data on historic colony sizes, it is clear that some sites held hundreds and perhaps thousands of nesting pairs (Appendix 6). Massive wetland loss and alteration of the state's natural hydrology earlier in the century for agricultural and urban needs (see Shuford et al. 2001) caused marked reductions in cormorant numbers and colonies (Grinnell and Miller 1944, Carter et al. 1995b, Appendix 6), and it is unlikely that these losses were offset by creation of reservoirs or human-altered sites such as the Salton Sea. As the history of breeding Double-crested Cormorants in the interior of California is particularly fragmentary, it is unclear if total numbers at inland colonies have increased in recent decades as they have on the coast. The only interior cormorant colonies with a fairly continuous record since the early 1950s are Tule Lake, Lower Klamath, and Clear Lake NWRs, where no clear trends are evident (Table 3).

Carter et al. (1995b) estimated that at least 2806 Double-crested Cormorants bred at inland colonies in the early 1990s but acknowledged that the interior had not been surveyed adequately. A statewide survey in 1999 found about 6865 pairs of cormorants breeding at 29 inland sites (Table 2); at least 37 interior sites were occupied from 1997 to 1999 (Figure 2). Conditions in the interior are dynamic as evidenced by large and rapid population changes at some key sites. A drop in numbers at the Sheepy Lake colony at Lower Klamath NWR from 978 pairs in 1997 to 62 pairs in 1999 was apparently a result of water levels being kept too high in 1999, thereby inundating and saturating much of the cormorants' tule-mat nesting islands (D. Mauser pers. comm.). At Clear Lake, Lake County, numbers of nesting pairs ranged from about 97–200 pairs in four years from 1995 to 1999, then increased to about 375 pairs in 2000 (Table 4). At the Salton Sea, cormorants colonized Mullet Island in 1996, reached a peak of about 5425 pairs in 1999 (Shuford et al. 2002, Table 2), but none were observed nesting there in 2001 and 2002 (Molina and Sturm 2004). A similar pattern for another fish-eater at the Salton Sea, the Caspian Tern (recolonization in 1992, peak of 1500 pairs in 1996, decline to 29 pairs in 2002; Molina 2001, 2004; Molina in litt.), suggests that changing prey populations at the sea may be driving these trends in bird populations. These large changes in short time periods suggest that historic patterns supported only by sporadic anecdotal data should be interpreted very cautiously (e.g., Salton Sea, Table 5).

Table 3 Numbers of Nesting Double-crested Cormorants at Tule Lake, Lower Klamath, and Clear Lake National Wildlife Refuges, 1949 to 1996[a]

	Tule Lake		Lower Klamath		Clear Lake	
Year	Nests	Young[b]	Nests	Young[b]	Nests	Young[b]
1949	—	175	—	600	—	—
1952	95	270	650	1800	45	150
1953	117	440	525	1470	44	125
1954	38	163	—	1135	53	164
1955	57	164	411	1110	77	189
1956	30	90	250	600	45	125
1957	20	60	250	700	45	120
1958	15	40	200	400	30	60
1959	15	40	—	—	—	—
1961	—	—	—	300	20	50
1962	—	30	100	300	27	19
1963	15	40	100	200	9	10
1964	17	50	420	360	17	30
1965	—	—	200	200	20	60
1966	—	—	145	380	25	70
1967	—	—	236	250	21	60
1968	—	—	163	270	7	10
1969	—	—	118	220	10	18
1970	—	—	177	110	8	32
1971	—	—	63	247	45	90
1972	—	—	411	320	50	110
1973	—	35	—	370	—	120
1974	—	—	140	—	—	—
1975	—	38	—	568	—	45
1977	—	120	—	295	—	80
1979	100	200	—	600	—	150
1981	—	—	—	—	—	65
1982	25	—	300	—	—	—
1983	120	—	—	—	300	—
1984	100	—	400	—	300	—
1987	—	—	—	900	—	600
1988	—	—	300	—	—	300
1989	—	—	—	600	—	600
1990	—	—	—	200	—	300
1991	150	—	400	300	150	—
1992	0	0	600	—	200	—
1993	—	—	—	—	40	—
1994	30	—	150	—	—	—
1995	65	180	—	400	61	—
1996	100	70	450	700	12	—

[a]Data from the files and Annual Narrative Reports of the Klamath Basin NWR Complex unless otherwise indicated. Data quality generally Category 3, as in very few instances are descriptions of methods and dates of surveys available. —, no data available.

[b]Estimated number of young fledged.

Ecological Requirements

Double-crested Cormorants forage in a diverse suite of inshore marine, estuarine, and freshwater habitats. Important inland foraging areas for Double-crested Cormorants in California include freshwater lakes, saline lakes with fish (e.g., Salton Sea), large open-water marshes, reservoirs, floodwater impoundments, ponds, and large rivers. They also need suitable daytime loafing areas, nighttime roosts, and nest sites secure from ground predators and close (typically <10 km) to foraging areas (Hatch and Weseloh 1999, Wires et al. 2001).

In California's interior, Double-crested Cormorants nest on barren sandy or rocky islands, on tule-mat islands (Lower Klamath NWR), on mats of reeds at river deltas (Salton Sea), and in a variety of live or dead trees in open water, on islands, or on the shores of lakes or rivers (Table 2). The structure of nesting trees or groves is generally open, presumably to accommodate the relatively clumsy landing flights of these cormorants. Trees were the nest substrate used at most sites, except in northeastern California where cormorants used islands at five of seven colonies. In 1997, 98% of the nesting birds (1415 pairs) in northeastern California were on islands; of these, almost 1000 pairs nested on tule-mat islands in Sheepy Lake at Lower Klamath NWR (Table 2). Even though Double-crested Cormorants nested in trees at seven subareas at the Salton Sea, Mullet Island alone, with 5425 pairs, supported about 79% of the entire cormorant population nesting inland in the state in 1999. Inland in California, these cormorants often share nesting trees with herons and egrets and nesting islands with those birds as well as American White Pelicans, Ring-billed and California gulls, Caspian Terns, and, at the Salton Sea, Gull-billed Terns and Black Skimmers. The cormorants' nests are fairly substantial cuplike structures. Nest materials depend on what is available near the nesting colony but characteristi-

Table 4 Numbers of Double-crested Cormorant Nests at Clear Lake, Lake County, California, 1995 to 2000[a]

Subcolony sites	1995	1996	1998	1999	2000
East of Quercus Point	150	175	175	—	75
Slater Island, Anderson Marsh	—	0	0	15	0
Long Tule Point	—	0	0	57	100
Mouth of Holiday Cove	—	0	0	25	200
Totals	150	200	175	97	375

[a]Data from D. W. Anderson and colleagues (unpubl. data), except for Long Tule Point in 1999 (see Table 2). —, no survey made; 0, site surveyed but no nests observed. Data for 1991 and 1994 presented in Carter et al. (1995b) have serious limitations or are in error. In 1991, numbers reported for Rodman Slough actually pertain to the Quercus Point area; few if any cormorants have nested at Rodman Slough in any year (D. W. Anderson in litt.). Regardless, the 300–400 "breeding birds" reported in Carter et al. (1995b) is from a 15 Aug 1991 estimate of the number of cormorants "in the breeding colony" (D. W. Anderson in litt.), which at this date may have represented local breeding adults, large young, or even birds from other colonies. In 1994, the 400 and 500 "breeding birds" attributed, respectively, to the "S. Shore colony #1" (Quercus Point) and "S. Shore colony #2" (Long Tule Point area) again represent numbers of cormorants "in the breeding colony" based on late-season (July–Aug) observations. Finally, a "few" cormorants were nesting in 1997 but survey data are lacking (D. W. Anderson in litt.). Cormorants were nesting at the Mouth of Holiday Cove, Long Tule Point, and East of Quercus Point in 2001 and 2002 but no estimates of nests were made; no visits were made to any of these subcolonies in 2003 (D. Anderson in litt.).

Table 5 Numbers of Nesting Pairs of Double-crested Cormorants at the Salton Sea, 1908 to 2000[a]

Site	Year: first observed (peak count)[b]	Number of nests
Pelican Island	20 Apr 1908	147
near Mecca	1913[c]	"400 pairs"
~0.5 mi from shore near Mecca	6 Feb 1913[d]	~500
Salton Sea	May–June 1956[e]	>100
Salton Sea	1957[f]	nested in greatly reduced numbers
North Shore	1981	0
North Shore	1982	75
South Shore	"	17[g]
North Shore	1983	43
North Shore	1984–1985	0
North Shore	1986	0
South Shore	"	24
North Shore	1987	63
South Shore	"	0
North Shore	1988	57
South Shore	"	0
North Shore	1989–1994	0
South Shore	"	0
Johnson Street	1995	8
Poe Road	"	48
	1996	
Alamo River	unknown date(s)	100
Mullet Island	early June	500
New River	unknown date(s)	150
	1997	
Mullet Island	12 Dec 1996 (27 Mar)	~1977
New River	early Feb (late May)	~600
Ramer Lake	unknown date(s)	13
	1998	
Johnson Street	unknown date(s)	2
Alamo River	mid-May	75
Mullet Island	early Jan (5 Mar)	~2700
New River	early Feb (June)	~500
Ramer Lake	unknown date(s)	7
	1999[h]	
Johnson Street	22 Mar	2
Mullet Island	22 Jan (19 Feb)	5425
Alamo River Delta	27 Apr (27 May)	106
New River East	18 Apr	2
New River Delta	2 Mar (3 Apr)	26
New River West	16 June	2
Poe Road	28 Apr (7 May)	13
Ramer Lake	6 May	18
	2000	
Mullet Island[i]	16 Dec 1999 (8 Feb 2000)	1138

[a]Data from 1981 to 1998 and 2000 to 2001 primarily from Salton Sea NWR files; data for North Shore, 1981–1991, collected by N. D. Hogg. Comprehensive surveys of the Salton Sea for colonial waterbirds were begun by refuge staff in 1991, but in some years (e.g., 1995) numbers underestimated because of the limited seasonal duration of surveys. Eggs were also collected at "Salton Sea" on 18 Apr 1909 (2 sets, F. Stephens, MVZ) and at "Cormorant Island" on 11 May 1916 (1 set, L. H. Wallis, CAS).

[b]Data on first observations of nesting and peak nest counts provided when available.

[c]From Dawson (1923:1947).

[d]From W. L. Dawson egg set (WFVZ); 7 other egg sets 5–7 Feb 1913 (SBMNH).

[e]From AFN 10:410.

[f]From AFN 11:429.

[g]Data from J. Garcia in CDFG Bird Colony Nesting Report. Survey at rookery east of New River (Vail Ranch?) on 7 June noted 19 nests; surveys on 24 June found 9 adults and 5 young at rookery near Noffsinger Rd. and 17 adults at rookery in snags off Beach Rd.

[h]From Shuford et al. (2000) and PRBO (unpubl. data). Colonies at New River Delta and Ramer Lake were abandoned by 16 April and 16 May, respectively. The conservative best estimate of total nesting pairs is the 5425 on Mullet Island, as the few nests elsewhere may represent adults that relocated after failed initial attempts at Mullet.

[i]Colony abandoned by 14 Mar 2000; other sites not surveyed for nesting cormorants this season. Similarly in the 2000–2001 season, estimates of 560 and 1000 nests on Mullet on 9 and 22 December, respectively, were followed by near total abandonment by 15 February when only about 100 pairs were left on the island (S. Johnson in litt.).

cally include finger-sized sticks and other bulky items and may include rope, plastic, or other human cast offs; the nest lining typically consists of grasses, rootlets, and similar materials (Hatch and Weseloh 1999). Over the breeding season, nests may accumulate pebbles and bones from pellets, and an outside coating of the birds' guano cements the whole together; nests may increase in size over time if annual additions exceed deterioration from weather or other factors.

Double-crested Cormorants are opportunistic foragers that take a wide variety of prey depending on availability. At most sites they prey almost entirely on fish (>250 species of >60 families reported); less frequently they take other aquatic animals, including insects, crustaceans, and amphibians (Hatch and Weseloh 1999). Birds typically feed close to shore (<5 km) in shallow, open water (<8 m deep). From the surface, they pursue prey underwater by foot-propelled dives, often feeding on the bottom but also in mid water. Solitary versus flock foraging appears to vary according to prey type, season, and water clarity. There is very limited published information on the diet of Double-crested Cormorants nesting inland in California, though it likely varies considerably depending on the local availability of prey. Wolfe and Norman (1998) reported that Sacramento hitch (*Lavinia exilicauda*) was the main prey item fed to cormorant young at Clear Lake, Lake County.

Threats

In the interior of California, the greatest threats to Double-crested Cormorants historically have been the loss of suitable nesting and foraging habitat and human disturbance

(Grinnell and Miller 1944, Remsen 1978, Sowls et al. 1980, Carter et al. 1995b). Today the greatest threats are a lack of high quality water at wetlands and potential human disturbance at nesting colonies. Although cormorants in the interior of California currently breed mainly at relatively remote sites, they are particularly vulnerable to human disturbance at colonies, which may lead to abandonment and loss of eggs and chicks to exposure or predation by gulls (Hatch and Weseloh 1999). There is increased potential for human disturbance with the burgeoning human population in California.

Organochlorine contamination, found in Double-crested Cormorant eggs at several sites on the California coast, has been linked to reproductive failures of that species on the Channel Islands (summarized in Carter et al. 1995b). Mercury and organochlorines found in nestling Double-crested Cormorants at Clear Lake, Lake County, in 1993–1994 were at levels well below those known to cause health problems (Wolfe and Norman 1998). A lack of reported effects of contaminants on cormorants inland in California, however, may simply reflect an absence of studies at sites where agricultural chemicals concentrated during the height of the DDT era in the 1960s and early 1970s.

At the Salton Sea, salinity is predicted within about one to two decades to reach concentrations that will severely affect populations of invertebrates and fish and, by extension, populations of the sea's fish-eating birds (Tetra Tech 2000), such as Double-crested Cormorants. As noted above, changes in fish populations in the last few years may have already been responsible for declines in numbers of breeding cormorants. Although contaminants at the Salton Sea have not been shown to cause large-scale die-offs or other major problems, there is still ongoing concern for the potential risk to waterbirds of reproductive impairment or immunotoxicity from selenium, boron, and DDE (e.g., Setmire et al. 1990, 1993; Bruehler and de Peyster 1999). Although large-scale mortality at the Mullet Island cormorant colony at the Salton Sea in 1998 was attributed to Newcastle disease (Friend 2002), this event was poorly studied and mortality and colony abandonment may have had other or multiple causes. Regardless, Newcastle disease subsequently is not known to have had population-level effects on cormorants at the Salton Sea or elsewhere in California.

The effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland habitat for waterbirds, including cormorants. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR and Clear Lake NWR. As noted above, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented. Even when adequate water is available, the large cormorant colony at Sheepy Lake on Lower Klamath NWR is at risk from fluctuating water levels, which need to be maintained within a narrow range (D. Mauser pers. comm.).

Although cormorants have been killed under permits issued to fish farmers in the San Joaquin Valley in the early 1990s and have also been shot at aquaculture facilities near the Salton Sea (Carter et al. 1995b), conflicts with commercial and recreational fishermen do not appear to be a substantial problem for cormorants in California at this time.

Management and Research Recommendations

Island-nesting Double-crested Cormorants are likely to benefit from the management actions for nesting American White Pelicans described above. These include providing or maintaining nesting islands of suitable size, substrate, and isolation, and maintaining water levels within a range that avoids flooding or connecting islands to the mainland. At colonies both on islands or in trees, cormorants would also benefit from efforts to minimize human disturbance by restricting public access by land, boat, and air, and by limiting colony entry to researchers unless absolutely necessary.

Other recommendations are to:

- Educate the public about the effects of human disturbance on colonial nesting waterbirds and the particular sensitivity of cormorants in that regard.
- Conduct studies of colonies in trees surrounded by water to see how long such trees last before toppling and to assess whether long-term loss of such sites might reduce the overall pool of potential cormorant nesting sites.
- Initiate detailed studies at the Salton Sea to assess the degree to which cormorant reproductive performance is linked to the population dynamics of their fish prey or the adverse impacts of diseases or pesticides and contaminants.
- Identify cormorant populations that are not being maintained by local reproduction and determine which population parameters contribute the most to population limitation in inland-nesting cormorants.
- Use color-marked or radio-tagged individuals to study the foraging, dispersal, and migratory movements of cormorants to better understand the suite of habitats they use, the linkages among them, and how habitat use patterns change with fluctuating environmental conditions.
- Similarly, use marked birds to elucidate the extent of interchange between inland and coastal breeding populations and if the degree or timing of mixing is influenced by climatic or oceanic conditions, breeding failures, or other factors.

Monitoring Needs

A comprehensive survey of numbers of nesting Double-crested Cormorants at all interior colonies should be conducted about once every 10 years. Nest counts should be conducted at the height of the nesting season and should use the most effective method (aerial photographic, boat, or ground counts) depending on local conditions. If possible, it would be valuable to count nests annually at the suite of sites in the Klamath Basin and at the Salton Sea because of rapid changes in cormorant numbers at these sites in recent years and the known and suspected threats in these areas. It also would be valuable to monitor reproductive success at a subset of colonies, particularly those at which threats seem pressing or imminent, and to periodically assess contaminant levels at sites where the risk of exposure seems high.

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RING-BILLED GULL (*Larus delawarensis*)

General Range and Abundance

The Ring-billed Gull breeds widely across North America from central and southern Canada (north to Great Slave Lake) to the northern United States, reaching the limit of its range to the northeast in Newfoundland and Labrador and to the southwest in northeastern California and northwestern Nevada (Ryder 1993, AOU 1998). The continental and worldwide breeding population is roughly 880,000 pairs (Ryder 1993). These gulls winter mostly on the Pacific Coast and near-coastal lowlands from British Columbia (local) south through Baja and the Gulf of California to Nayarit (sparingly to El Salvador), the Atlantic Coast and coastal plain from southern New England to Florida, and the Gulf coast of the United States and the east coast of Mexico south to central Veracruz (sparingly to Yucatán Peninsula) (Ryder 1993, Howell and Webb 1995). Large numbers also winter inland in the south-central United States (particularly Mississippi Valley) and in California's Central Valley, coastal lowlands, and Salton Sea/Imperial Valley; low to moderate numbers winter elsewhere in the interior from

Table 6 Numbers of Nesting Pairs of Ring-billed and California Gulls in California, 1994 to 1997[a]

		Ring-billed				California[b]			
Site	Colony code	1994	1995	1996	1997	1994	1995	1996	1997
Siskiyou County									
Lake Shastina (south)[c]	326-254-002	~15	73	~50	221	~300	151	~103	123
Steamboat Lake,									
Shasta Valley WA	326-264-001	~15	0	0	0	0	0	0	0
Butte Valley WA (Meiss Lake)[d]	326-271-001	3190	3158	4087	3475	327[e]	1803	1873	2145
Lower Klamath NWR[f]									
Sheepy Lake	327-187-001	178	—	—	79	269	—	—	8
Unit 6A	327-186-002	0	0	0	0	43	52	87	96
Modoc County									
Clear Lake NWR[g]	327-182-001	2868	2942	3747	3680	1175	1769	1488	1355
Goose Lake	327-074-001	0	0	0	1117	0	0	0	73
Big Sage Reservoir	327-056-001	3007	2052	—[h]	1586	76	11	—[h]	28
Middle Alkali Lake	327-041-001	0	0	0	0	71	0	0	0
Lassen County									
Eagle Lake (Pelican Point)	354-066-001	0	132	0	0	0	201	0	0
Dakin Unit, Honey Lake WA[i]									
Hartson Reservoir	354-034-003	1637	1465	1642	2451	1247	1317	1510	1913
Pond 5A	354-033-001	0	0	0	51	0	0	0	0
Pond 6G	354-034-002	0	3	85	0	0	0	0	0
Pond 6J	354-034-001	289	493	0	0	0	0	0	0
Fleming Unit (Pond 15),									
Honey Lake WA	354-033-003	5	0	0	0	0	0	0	0
Mono County									
Mono Lake[j]									
Negit Islets	406-911-001	0	0	0	0	23,488	17,596	19,416	19,249
Paoha Islets	406-911-003	0	0	0	0	8182	7331	4334	5708
Imperial and Riverside counties									
North End Salton Sea									
(Johnson Street)	525-651-001	0	0	0	0	0	0	2	0
South End Salton Sea									
(Obsidian Butte)	526-526-001	0	0	0	0	0	0	0	22
Santa Clara, Alameda, and S.F. counties									
San Francisco Bay[k]		0	0	0	0	4500	4357	4312	5076
Totals		11,204	10,318	(9611)[l]	12,660	39,678	34,588	33,125	35,796

[a]Data from direct nest counts or other methods meeting Category 1 quality standards (see Shuford and Ryan 2000). —, no survey made; 0, survey taken but no nesting gulls found.

[b]No nesting gulls found at Lake Almanor, Plumas County, where they previously bred at least sporadically, or at Tule Lake in 1994 and 1997, and it is unlikely that they nested at the latter site in 1995 and 1996, despite prior irregular occupancy.

[c]In 1994, counts taken from shore by spotting scope; in 1996, count of total nests made on island but apportioned to species by ratio found in 1995.

[d]Observers (K. Novick in litt.) counted 2298 and 2956 pairs of the California and 3484 and 2525 pairs of the Ring-billed nesting at Meiss Lake in 1998 and 1999, respectively.

[e]Count low as many nests already destroyed by coyotes when colony censused on 11 May (J. King in litt.).

[f]Aerial photographs taken in 1994 and 1997 of the pelican and cormorant colony at Sheepy Lake showed about 178 and 79 pairs of the Ring-billed and 43 and 8 pairs of the California, respectively. In 1999 and 2000, high water saturated the nesting island and no gulls nested. About 450 gull nests were observed at Sheepy Lake on 2 June 1993; this small gull colony has been active since at least the early 1950s (refuge's annual narratives and files). Hence, the gull numbers attributed to Lower Klamath probably were slightly underestimated in 1995 and 1996. Counts at Unit 6A of Lower Klamath NWR in 2000 (J. Beckstrand in litt.) allowed estimation of 48 pairs of the Ring-billed and 6 pairs of the California.

[g]Biologists erected an electric fence across a peninsula to Bird Island in late May 1994 to prevent access by coyotes. Counts of adults at Clear Lake NWR (J. Beckstrand in litt.) allowed estimation of 1345, 1245, and 432 pairs of the California and 3922, 1957, and 1739 pairs of the Ring-billed nesting in 1998, 1999, and 2000, respectively.

[h]No surveys made, but gulls were thought to be nesting. In 1994 and 1997 all gulls nested on Bird Island, the traditional large nesting island in the south-central portion of the reservoir. In 1995, 1629 nests of the Ring-billed and 7 of the California were counted on Bird Island and 423 of the Ring-billed and 4 of the California on a smaller low-lying, unnamed island to the northeast of Bird Island.

[i]A 17–18 May 2000 nest count estimated 1794 pairs of California and 1964 pairs of Ring-billed gulls at Honey Lake WA; all were at Hartson Reservoir, except 544 pairs of the Ring-billed on islands in the Dakin Unit (Pond 5A) (B. Tatman pers. comm.). On 18 June 2000, there was at least one California Gull nest in Pond 5A (D. Shuford pers. obs.).

[j]See Table 11 for breakdowns of nest numbers at Mono Lake by individual Negit Islets, Negit Island (subcolony 406-911-002), and the Paoha Islets combined, 1983–2000.

[k]See Table 5 in Shuford and Ryan (2000) and Appenix 3 in Strong et al. (2004) for numbers of pairs at subcolonies in San Francisco Bay, 1980–2003.

[l]The total for the Ring-billed in 1996 is probably low by at least 1500 to 2000 pairs because Big Sage Reservoir was not surveyed.

Table 7 Numbers of Nests (and Young) of California and Ring-billed Gulls at Lower Klamath National Wildlife Refuge, 1945 to 1991[a]

Year	California	Ring-billed	Unidentified
1945	? (75)		
1952[b]	1820 (3600)	2400 (5500)	
1953[c]	930 (1580)	46 (80)	
1954[d]	1680 (3025)	860 (1810)	
1955[d]	1533 (2759)	746 (1720)	
1956	1350 (1350)	750 (750)	
1957	1220 (1220)	900 (900)	
1958	800 (1000)	500 (600)	
1961	? (500)	? (400)	
1963			900 (2000)
1964	2500	400	
1965			1514 (2000)
1966			2000 (2500)
1967			2500 (2000)
1968	1300 (1500)	800 (1000)	
1969	900 (1300)	600 (850)	
1970	548 (700)	950 (1200)	
1971	1550 (620)	700 (350)	
1972	1670 (508)	685 (322)	
1972[e]			? (3000)
1973	? (600)	? (580)	
1976	210 (400)	700 (955)	
1977[f]			present
1980[g]	4000 adults		
1985[h]	3000–5000		~2000 adults
1986[i]	1000's (0)		
1990			~100
1991			~100

[a]All data from refuge's Annual Narrative Reports, and Category 3 in quality (see Methods, Shuford and Ryan 2000), unless otherwise noted.

[b]Of total nests of the California, 120 were from Sheepy Lake and the rest from the dike between Units 7 and 8.

[c]Gulls did not nest on the dike between Units 7 and 8 because of construction operations; instead they settled on five islands in Unit 4, which held 708 and 46 nests of the California and Ring-billed, respectively. The colony of the California at Sheepy Lake produced 130+ young.

[d]Gulls nesting in pelican colonies at Sheepy Lake, and in Unit 4 on 6 and 11 islands in 1954 and 1955, respectively.

[e]From AB 26:884.

[f]Gulls nested successfully on islands in a dry lakebed (E. O'Neill fide D. W. Winkler in litt.).

[g]A visit on 1 June produced a rough estimate of 2000 pairs (data quality Category 2; Conover 1983, S. A. Laymon pers. comm.).

[h]Based on visits from mid-June through mid-July (data quality Category 2; R. Ekstrom in litt. and Annual Narrative Reports).

[i]From R. Ekstrom (in litt.).

British Columbia and the southern Great Lakes south to the Central Volcanic Belt of Mexico (sparingly to Chiapas and Guatemala). Nonbreeding birds occur in summer from slightly north of the breeding range south through the wintering range (AOU 1998).

Conservation Concern

The Ring-billed Gull has no formal conservation status. Rangewide, numbers declined and distribution retracted from human persecution and development from 1850 to 1920 (Ryder 1993). Since then, the continental population has rebounded from protection and an increase in food supplies and nesting sites resulting from human activities. Hence, the North American Waterbird Conservation Plan considers the conservation status of this gull to be "not currently at risk" (Kushlan et al. 2002). In California, trends in nesting numbers are uncertain (Shuford and Ryan 2000), and the state's few colonies warrant protection.

Seasonal Status in California

Ring-billed Gulls occur year round in California, but their seasonal status varies substantially by region; the breeding season extends mainly from mid-April through July (D. Shuford pers. obs.). In the northern mountain valleys, Klamath Basin, Modoc Plateau, and Great Basin Desert, greatest numbers occur from March to October or November (Cogswell 1977, McCaskie et al. 1979). In the main wintering grounds along coastal beaches and estuaries and in various habitats in interior lowlands the length of the state (particularly the Central Valley, Salton Sea, Imperial Valley), numbers begin to build in July, reach peaks from August to March, and dwindle to summer lows by mid-May (Cogswell 1977, McCaskie et al. 1979, Garrett and Dunn 1981, Patten et al. 2003). In summer, most nonbreeding subadults concentrate in the wintering range; far fewer occur within the breeding range (D. Shuford pers. obs.).

Breeding Range and Abundance in California

Historic locations of confirmed breeding include Tule Lake, Siskiyou County; Honey Lake, Lassen County; and, probably, Clear Lake, Modoc County (Grinnell and Miller 1944, Shuford and Ryan 2000). Subsequently, colonies have been active, at least intermittently, at Lake Shastina, Shasta Valley WA (Steamboat Lake), Butte Valley WA (Meiss Lake), Lower Klamath NWR, and Tule Lake NWR, Siskiyou County; Clear Lake NWR, Goose Lake, and Big Sage Reservoir, Modoc County; Honey Lake WA (mainly Dakin Unit, usually Hartson Reservoir or adjacent diked ponds) and Eagle Lake, Lassen County; and Lake Davis, Plumas County (Shuford and Ryan 2000, G. Sibbald in litt.). The latter authors summarized the details of historic Ring-billed Gull status at all of these colonies, except for the one at Lake Davis, which was discovered only recently (see below). The sites with the most extensive historical records are the three Klamath Basin National Wildlife Refuges (Tables 7–9) and Honey Lake WA (Table 10).

Currently all known Ring-billed Gull colonies in California are located in the northeastern part of the state (Shuford and Ryan 2000; Table 6, Figure 3). Surveys from 1994 to 1997 estimated at least 9611 to 12,660 pairs of Ring-billed Gulls nested

Table 8 Numbers of Nests (and Young) of California and Ring-billed Gulls at Clear Lake National Wildlife Refuge, 1918 to 1993

Year	California	Ring-billed	Unidentified
1918[a]	~1800 adults	~200 adults	
1933[b]	? (# banded)		
1947[c]	present	present	
1952[d]	500 (950)	554 (1200)	
1953[d]	475 (900)	450 (950)	
1954[d]	685 (1850)	565 (1730)	
1955[d]	423 (994)	527 (1325)	
1956[d]	200 (210)	250 (260)	
1957[d]	670 (700)	160 (200)	
1958[d]	300 (600)	300 (600)	
1961[d]	? (70)	? (30)	
1962[d]	800 (1900)	450 (800)	
1963[d]			600 (1750)
1964[d]	500 (600)	432 (500)	
1965[d]	100 (300)	470 (1500)	
1966[d]	250 (500)	500 (1000)	
1967[d]	500 (500)	140 (300)	
1968[d]	350 (500)	1885 (2300)	
1969[d]	150 (200)	2000 (2500)	
1970[d]	868 (950)	1165 (1800)	
1971[d]	878 (500)	2134 (1000)	
1972[d]	400 (460)	1690 (1200)	
1973[d]	? (520)	? (1080)	
1977[d,e]	? (900)	? (1890)	
1979[d]			? (2500)
1983[d]	600 (?)	1200 (?)	
1984[d]			2000 (?)
1985[d]			? (4300)
1986[d,f]			nearly 8000
1987[d,f]			3000
1988[d,f]			nearly 4500
1989[d,f]			5000
1990[g,h]			5000
1991[h,i]			4000+
1992[h,j]			2500 (2000+)
1993[h,k]			3400

[a]On 10 April 1918, prior to nest initiation, Willett (1919) estimated about 2000 gulls (about 90% California, 10% Ring-billed) were present on the "usual breeding grounds on islands" in Clear Lake.

[b]On 11 and 12 July 1933, H. M. Worcester (in Lincoln 1933) found California Gulls close to fledging on an island in Clear Lake from which the water had receded three miles.

[c]Nesting use by gulls, mostly the Ring-billed, up over recent years.

[d]From refuge's Annual Narrative Reports or files; data quality Category 3 (see Methods, Shuford and Ryan 2000).

[e]Peak population and production slightly lower in 1977 than in 1976 because of human intrusion in colonies.

[f]One to two, of several, mixed gull colonies on islands near the Clear Lake dam.

[g]An aerial survey on 20 June revealed 2000 gull nests on an island north of the Clear Lake peninsula (1630 young on 27 June ground survey) and 3000 nests on an island near the Clear Lake dam.

[h]Data quality Category 2 (see Methods, Shuford and Ryan 2000), from L. A. Moreno-Matiella (in litt.) and/or refuge's Annual Narrative Reports.

[i]About 4000 gull nests on an island at the north end of the Clear Lake peninsula were later abandoned when a landbridge was exposed, allowing predator access. A count by foot on 30 June found 450 adult gulls on Bird Island and 270 adults on Rocky Island; the former was connected to shore in early June and produced no young, the latter held 265 young on 24 July.

[j]Surveys by boat estimated 2000 gull nests on Rocky Island on 1 May and 500 nests on Bird Island on 10 June. Surveys by foot found 2000 young on Rocky Island on 13 July. Exposed landbridges connected both islands to shore, and an electric fence was erected in late April or early May to protect various colonial waterbirds on Rocky Island.

[k]Of the total, 1000 gull nests were on Rocky Island, 1500 on the island north of the peninsula, 400 on Bird Island, and 500 on islands in the west lobe.

annually at five to seven sites (nine sites total) in this region. In most years, Butte Valley WA, Clear Lake NWR, Big Sage Reservoir, and Honey Lake WA together held over 98% of the state's breeding Ring-billed Gulls; Lake Shastina was the only other site occupied annually. In 1997, Goose Lake held about 9% of the statewide breeding population. This site, however, was occupied irregularly, and at least in some years the gulls there may represent birds splitting off from the nearby colony at Big Sage Reservoir. Of other sites occupied since the 1970s, only Tule Lake NWR remained unoccupied throughout the survey period. Although not present in 1997 (Appendix 1), a colony of roughly 250 pairs was active at Lake Davis, Plumas County, in at least 2006–2008 (G. Sibbald in litt.). A report of Ring-billed Gulls breeding at Modoc NWR, Modoc County (Small 1994), appears to be erroneous (Shuford and Ryan 2000).

Limited historical data (Conover 1983) make it difficult to assess population trends for this species in California (Shuford and Ryan 2000). While the creation of islands in reservoirs, expansion of irrigation agriculture, and augmentation of food supplies on the wintering grounds may have led to increasing gull populations (Conover 1983), this surely has been offset to an unknown degree by the loss of over 90% of California's historic wetlands (Dahl 1990).

Ecological Requirements

Like most larids, Ring-billed Gulls nest on the ground. In northeastern California, these gulls breed mainly on islands and, rarely, on peninsulas at natural lakes, reservoirs, managed wetlands, and saline or alkaline lakes, between about 2700 to 5800 ft (823–1768 m) above sea level (Shuford and Ryan 2000, G. Sibbald pers. obs.). Island substrates may be earthen, rocky, or, infrequently, composed of broken down tule mats; the gulls nest in the open or among rocks, tall weeds, or shrubs. Ring-billed Gulls often breed together with California Gulls and/or with other colonial breeders, such as pelicans, cormorants, herons and egrets, and terns. Nests typically are loosely built from dead plant material, collected near

Table 9 Number of Nests (and Young) of California and Ring-billed Gulls at Tule Lake National Wildlife Refuge, 1931 to 1990[a]

Year	California	Ring-billed
1931[b]		"numerous…apparently nesting"
1938[c]	nesting	nesting
1940[d]	nesting	nesting
1947[e,f]	?	?
1952[f,g]	240 (430)	390 (980)
1953[f,h]	380 (720)	430 (1240)
1954[f,h]	172 (460)	203 (630)
1955[f,h]	101 (197)	30 (84)
1962[f]	160 (300)	
1964[f]		5(8)
1990[i]		? (11)

[a]Data quality Category 3 for all years, except 1990 with Category 2 (see Methods, Shuford and Ryan 2000).

[b]From Moffitt (1942).

[c]California and Ring-billed gulls nesting on islands in Sump 2 (now called 1-B).

[d]E. N. Harrison (WFVZ egg data slip) collected at least seven egg sets of the Ring-billed and three sets of the California from a small island in the south part of Tule Lake, Siskiyou County, on 16 May.

[e]Gulls, species unspecified, were nesting on islands in the (lower) Sump 1-B.

[f]From refuge's Annual Narrative Reports or files.

[g]Gulls nesting in the (lower) Sump 1-B on six of eight small islands (seven in Siskiyou Co., one in Modoc Co.), and all but one rocky one were in the process of being destroyed by wave action.

[h]From at least 1952, erosion proceeded; by 1956 gull nesting was prevented by high water, and the only island exposed in the (lower) Sump 1-B was occupied exclusively by cormorants.

[i]On 19 July 1990, L. A. Moreno (pers. comm.) found 35 adult and 11 young Ring-billed Gulls on a small rocky island near the south shore of the (lower) Sump 1-B of Tule Lake, Modoc County. D. Shuford et al. (pers. obs.) did not find any nesting gulls on this island during visits in May–June 1994 to 1997 and 1999.

the colony, including twigs and sticks, grasses, leaves, and the like; some nests are little more than a scrape (Ryder 1993).

All of the state's Ring-billed Gull colonies are at or near extensive freshwater wetlands or large valleys with irrigated fields (primarily alfalfa), which are the principal areas used for foraging while breeding. Birds also feed at lakes and reservoirs, dumps, parks, parking lots, and over a variety of habitats for aerial insects.

Like most gulls, Ring-billed Gulls are opportunistic foragers; no data are available on the distances they forage away from nesting colonies (Ryder 1993). The summer diet of western birds, foraging mostly in agricultural lands, includes small rodents, insects, grains (wheat, oats), earthworms, birds, and garbage (Ryder 1993); fish and arthropods dominates the diet of eastern birds foraging in aquatic habitats. At Honey Lake, California, Ring-billed Gulls' diet is dominated by insects (cicadas, grasshoppers, whirligig beetles), meadow mice (*Microtus* spp.), garbage, fish, and earthworms (Anderson 1965). At that site, Ring-billed Gulls feed more on insects and meadow mice and less on fish and garbage than do California Gulls. In Alberta, the diet of Ring-billed Gulls varied between birds in the north feeding mainly in aquatic habitats (more fish) and those in the south feeding mainly in agricultural fields (more rodents; Vermeer 1970). In agricultural areas, however, Ring-billed Gulls eat more grain and mice and less birds and waterfowl, and are less likely to scavenge, than are California Gulls. In Alberta and Manitoba, the Ring-billed Gull diet shifts from major reliance on grain or earthworms early in the season to insects later on; use of garbage increases as the season progresses in Alberta and vice versa in Manitoba (Vermeer 1970, Welham 1987). Also, annual variation (Vermeer 1970) and slight sexual differences in diet (Welham 1987) have been noted.

Threats

The main threat to breeding gulls is the periodic scarcity of isolated nesting islands free of ground predators (Shuford and Ryan 2000). Ring-billed Gulls nesting in northeastern California are particularly vulnerable during droughts. For example, in 1994 low water levels appeared responsible for the lack of nesting islands at two sites and formation of landbridges at six sites, thereby allowing access by ground predators, particularly coyotes; resulting predation appeared to reduce nesting success at three sites (Shuford and Ryan 2000). It is possible, however, that sometimes birds displaced by drought may nest at nearby sites, which may have occurred in the Klamath Basin in 2003 and 2004. In those years, a large gull colony that typically forms at Meiss Lake, Butte Valley WA, was inactive because water levels were too low to maintain isolation of nesting islands; another colony at Clear Lake NWR was diminished from more usual levels by a reduction in island nesting area (Shuford et al. 2004, 2006; D. Shuford pers. obs.). At the same time, a very large Ring-billed Gull colony was present nearby in the Oregon portion of the Klamath Basin at Swan Lake, where there is limited prior evidence of this gull breeding.

The effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland habitat for waterbirds, including gulls. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR and Clear Lake NWR, exacerbating the effects of droughts. As noted elsewhere, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a

Table 10 Numbers of Nesting California and Ring-billed Gulls at Honey Lake Wildlife Area, 1940 to 1993[a]

Year	California	Ring-billed	Unidentified
1940[b]		150+ nests	
1941[c]		75+ nests	
1950[d]	present	present	750 nests
1953[e]	26 nests	717 nests	
1956[f]	~500 adults	~2000 adults	
1963[g]	~1025 nests	~1025 nests	
1964[h]	nests present	~2000 adults	
1976[i]	40 young, 710 adults	700 young, 1800 adults	
1977[j]		40 nests, 80 adults	
1977[k]	5 nests, 0 young, 15 adults	16 nests, 0 young, 100 adults	
1979[l]	4 adults	8000 adults	
1980[m]			350 adults
1980[n]	500 adults	3000 adults	
1981[o]			600 adults
1981[p]	500 adults	1000+ adults	
1984[q]			2200+ adults
1984[r]			1600 adults
1985[s]	80 nests	40 nests	
1990[t]	1400 nests, 3012 adults	1928 nests, 3120 adults	
1991–1992[u]	inactive	inactive	
1993[u]	active	active	

[a]Data quality Category 2, except Category 3 in 1940, 1941, and 1976 and Category 1 in 1953 and 1990 (see Methods, Shuford and Ryan 2000).

[b]Moffitt (1942) reported secondhand sources indicating Ring-billed Gulls have nested at Hartson Reservoir since at least about 1920. Moffitt visited the Hartson colony on 3 May 1940 (early in the egg laying period) and found gulls nesting on at least two islands, one of which he estimated held 150 Ring-billed Gull nests.

[c]On 14 May 1941, Moffitt (1942) found Ring-billed Gulls nesting on three islands in Hartson, one of which held about 75 nests. That year he collected at least 8 sets of Ring-billed Gull eggs at Hartson Reservoir (CAS, WFVZ). Based on these incomplete surveys in 1940 and 1941, Moffitt estimated the population totaled "250 or more pairs."

[d]When Hartson Reservoir was very low in 1950, Johnston and Foster (1954) counted about 750 gull nests on a small duck pond near the refuge headquarters; although the Ring-billed predominated, they suspected the California also was breeding.

[e]Nest counts on 17 May 1953 were 717 for the Ring-billed and 26 for the California on one island in Hartson Reservoir (Johnston and Foster 1954).

[f]Based on visits to Hartson Reservoir on 26 May and 2 June, W. M. Anderson (MPCR files) estimated numbers of adult gulls and noted both eggs and downy young.

[g]Anderson (1965), while studying the effects of nesting gulls on waterfowl production, surveyed Hartson Reservoir in 1963, when it was filled nearly to capacity. On 22 and 23 May he counted 2050 gull nests on several islands and estimated that numbers of California and Ring-billed gulls were about equal.

[h]From 15–17 May, L. R. Howsley, R. Quigley, and K. E. Vorce collected at least 9 sets of Ring-billed Gull eggs from a colony of "1000 pairs" nesting on small islands in Hartson Reservoir; they also collected at least 2 sets of California Gull eggs from a small island with "only about 10 pairs on this island" (WFVZ).

[i]From visit by R. Stallcup et al. to Hartson Reservoir on 16 July (MPCR files, R. Stallcup pers. comm.).

[j]Conover (1983) reported that S. A. Laymon estimated 160 Ring-billed and 10 California gulls were breeding at Hartson in 1977. Laymon's field notes for a 11 June 1977 visit, however, mention an estimate of 40 nests and 80 adults of the Ring-billed and none of the California (S. A. Laymon pers. comm.).

[k]From a 23 June visit, during an extreme drought, on which Winkler (1982, in litt.) found gulls nesting on two former islands connected to the shoreline and dead adults and many destroyed eggs strewn about both colonies; his next visit on 19 July found the colony apparently abandoned, and no young were produced.

[l]Based on a 10 June visit to Hartson Reservoir (S. A. Laymon pers. comm.).

[m]Based on a 17 May visit to Hartson Reservoir (D. A. Airola pers. comm.).

[n]Based on a 15 June visit to Hartson Reservoir (S. A. Laymon pers. comm.).

[o]Based on a 2 May visit to Hartson Reservoir (D. A. Airola pers. comm.).

[p]Based on a 13 June visit to Hartson Reservoir (S. A. Laymon pers. comm.).

[q]Based on a 5 May visit to Hartson Reservoir (D. A. Airola pers. comm.).

[r]A 29 May aerial survey found gulls nesting on four islands in Hartson Reservoir (B. E. Deuel in litt.).

[s]Based on a 15–17 June visit to Hartson Reservoir (S. A. Laymon pers. comm.).

[t]Based on direct nests counts on smaller islands and extrapolations from nests counts on transects across larger islands on 14 May (J. R. Jehl Jr. and C. Holmes in Honey Lake WA files).

[u]From C. Holmes (pers. comm.).

tentative settlement to major water disputes in the basin, which remains to be implemented.

Management and Research Recommendations

- Focus on long-term protection of suitable foraging habitats and on maintaining water levels that isolate colonies from ground predators. Although periodic droughts are a natural phenomenon to which gulls are adapted, water diversions for human uses may exacerbate their effects.
- Limit human disturbance at nesting sites. Despite the remote location of many colonies, human visitation is a potential threat to nesting Ring-billed Gulls. Seasonal closure of nesting islands used by California Gulls has proven effective at Mono Lake (D. Shuford pers. obs.), but such restrictions or interpretive signing will likely be effective only where adequate personnel are available for enforcement or interpretation. Consider on a case-by-case basis whether such efforts might be counterproductive in drawing undue attention to nesting colonies.
- Enhance protection of gull colonies via comprehensive conservation plans that address the needs of all colonial waterbirds that nest together on islands.
- Investigate foraging patterns of gulls from Klamath Basin colonies to determine the relative importance to their diet of prey from wetlands versus irrigated agriculture and how a tightening water supply might affect these foraging habitats.

Monitoring Needs

Breeding birds in the state should be monitored at least once every 5–10 years, during typical climatic and habitat conditions, using methods responsive to the shifting of breeding locations. Surveys should be timed to obtain peak nest counts (usually mid-May) and should use methods, varying according to local conditions, that will provide the most accurate and consistent counts. Entry into colonies should be avoided if this will cause predation by gulls on nests of other species or will otherwise affect other colonial waterbirds nesting on the same or nearby islands.

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CALIFORNIA GULL (*Larus californicus*)

General Range and Abundance

California Gulls breed at scattered locations in the interior of North America, primarily from the south-central taiga of Canada south through the Great Plains to southern Colorado and west and south through the Columbia Plateaus and Great Basin Desert to east-central California (Winkler 1996); breeding outposts to the west and south, respectively, are San Francisco Bay on the coast (Shuford and Ryan 2000) and the Salton Sea in southeastern California (Molina 2000). The continental and worldwide breeding population is roughly 210,000 pairs (Winkler 1996). This gull winters primarily along the Pacific Coast and slope from southern British Columbia (sparingly) south to southern Baja California, the Gulf of California, and, less commonly, to the south-central Pacific coast of mainland Mexico (Winkler 1996). Coastal wintering birds shift southward as the season progresses in response to changing oceanographic currents that reduce food supplies to the north (Shuford et al. 1989, Winkler 1996). Large numbers also winter in the Central Valley, coastal lowlands, and Salton Sea of California. Small numbers winter elsewhere west of the Cascade-Sierra axis, in the lower Colorado River valley, coastal lowlands of Mexico, and, sparingly and locally, within the breeding range in the northern United States. Many nonbreeding birds remain in the wintering range in summer, and small numbers occur throughout the breeding range, concentrating to some extent near nesting colonies.

Conservation Concern

The California Gull has no formal rangewide conservation status, but the North American Waterbird Conservation Plan considered it of "moderate" conservation concern (Kushlan et al. 2002). In California, it formerly was considered a Bird Species of Special Concern (Remsen 1978, CDFG 1992), but this status is no longer warranted (Shuford and Gardali 2008). A recent decision to restore the Mono Lake ecosystem by raising water levels will protect nesting islands at the state's largest colony (Shuford and Ryan 2000), the main focus of original concern (Remsen 1978).

Seasonal Status in California

California Gulls occur year round in the state, but their seasonal role varies substantially by region; the breeding season extends from mid-April to early August (D. Shuford pers. obs.). In the northern mountain valleys, Klamath Basin, Modoc Plateau, and Great Basin Desert, greatest numbers occur from March to October or November with most, but not all, birds retreating for the winter (Cogswell 1977, McCaskie et al. 1979, Gaines 1992). In winter, birds from throughout the North American breeding range congregate primarily in marine and marine-coastal habitats and coastal and interior lowlands the length of the state, where numbers begin to swell in July, reach peaks in late fall to early winter, then dwindle to summer lows by mid-May (Cogswell 1977, McCaskie et al. 1979, Garrett and Dunn 1981, Patten et al. 2003); on the coast, at least, peak winter numbers occur earlier to the north than to the south (Shuford et al. 1989). In summer, most nonbreeding subadults concentrate in the wintering range; fewer occur within the breeding range (D. Shuford pers. obs.).

Breeding Range and Abundance in California

Historic locations of confirmed breeding include Clear Lake, Modoc County; Eagle Lake, Lassen County; Mono Lake, Mono County; a shifting station in the middle stretches of the Sacramento River in the Sutter Basin near Reigo, Sutter County; and Woodward Reservoir, Stanislaus County (Grinnell and Miller 1944, Shuford and Ryan 2000). A report of former nesting at Lake Tahoe, Eldorado County (Dawson 1923), was considered unverified by Grinnell and Miller (1944). Orr and Moffitt (1971), however, provided a description of a single nest found by M. S. Ray on a sandspit at Al Tahoe (Rowlands), South Lake Tahoe, in 1925.

From the 1970s to 1990s, interior colonies had been active, at least intermittently, at Lake Shastina, Butte Valley WA (Meiss Lake), Lower Klamath NWR, and Tule Lake NWR, Siskiyou County; Clear Lake NWR, Goose Lake, Big Sage Reservoir, and Middle Alkali Lake, Modoc County; Honey Lake WA (Dakin Unit, usually Hartson Reservoir or adjacent ponds) and Eagle Lake, Lassen County; Lake Almanor, Plumas County; Mono Lake, Mono County; and the Salton Sea, Riverside and Imperial counties (Shuford and Ryan 2000). The sites with the most extensive historical records are the three Klamath Basin National Wildlife Refuges (Tables 7–9) and Honey Lake WA (Table 10). An increase in the number of known interior colonies from 5 in the late 1970s to early 1980s (Conover 1983) to 12 by 1997 primarily reflects greater observer coverage in the 1990s, as the Salton Sea is the only site that clearly was first colonized in the latter period (Shuford and Ryan 2000). In 1980, California Gulls first began nesting on the coast in San Francisco Bay (Jones 1986), where by 2000 they had expanded to breed at a total of nine sites, seven in the south bay and two in the central bay (Shuford and Ryan 2000).

Accurate estimates of the statewide breeding population are available from surveys from 1994 to 1997. In those years, annual totals ranged from 33,125 to 39,678 breeding pairs combined for 8–9 sites (12 total) in the interior and 5–6 subcolonies (7 total) within San Francisco Bay on the coast (Shuford and Ryan 2000; Table 6, Figure 4). In that period, numbers at the Mono Lake colony comprised 70% to 80% of the statewide total, colonies in the northeastern portion of the state 9% to 16%, and the San Francisco Bay colonies 11% to 14%. The newly formed Salton Sea colony held <0.1% of the statewide total in 1996 and 1997. In addition to Mono Lake, the only other interior colonies holding over 500 pairs were Butte Valley WA, Clear Lake NWR, and Honey Lake WA, and the only other colonies occupied each year were Lake Shastina, Lower Klamath NWR, and Big Sage Reservoir. Of other sites occupied as recently as the early 1990s, only Tule Lake NWR and Lake Almanor remained unoccupied throughout the four years of surveys.

Although no statewide surveys have been conducted since 1997, new colonies have since been documented at several sites. California Gulls have attempted to breed annually at Owens Lake, Inyo County, since 2004, but they do not appear to have raised any young (PRBO unpubl. data, Debbie House pers. comm.); rapid nest losses from high predation rates has made it difficult to estimate the number of nesting gulls. A small colony (perhaps 100± pairs) has been active at Laurel Pond south of the town of Mammoth Lakes, Mono County, since at least 2007 (perhaps earlier, Kristie Nelson pers. comm.). Although no nesting gulls were detected on an aerial survey of Lake Davis, Plumas County, in 1997 (Appendix 1), a colony of roughly 250 pairs of California Gulls was breeding there, with roughly equal numbers of Ring-billed Gulls, in at least 2006–2008 (G. Sibbald in litt.). Given Lake Davis is about 28 mi (45 km) from the long-standing Honey Lake colony, it would be valuable to assess whether gulls may use the former site intermittently when conditions are poor at Honey Lake. Probably reflecting continued expansion from San Francisco Bay, California Gulls began nesting offshore on South Farallon Island in 2008, but apparently with little success; estimates of the number of active nests declined from about 244 in mid-June to 25 in mid-July (Russ Bradley/PRBO unpubl. data).

Although most historical estimates of colony size are too rough for use in population trend assessment, numbers of breeding California Gulls appear to have increased substantially in California in recent decades. This upward trend has been driven largely by patterns at two key sites. At Mono Lake, the population increased in the early to mid 20th century (Winkler and Shuford 1988) but subsequently has generally stabilized despite considerable annual fluctuation since accurate counts were first taken in 1983 (Table 11). At San Francisco Bay, numbers have increase dramatically from colonization in 1980 to the present (Shuford and Ryan 2000, Strong et al. 2004, SFBBO unpubl. data). At the Salton Sea, an initial 2 breeding pairs in 1996 increased to 22 pairs in 1997, then leveled off at 39 to 44 pairs from 1998 to 2001 (Molina 2004). Recent trends at other colonies in the state are mixed or unclear, and many vary considerably in size with changing availability of island nesting habitat in response to climatic fluctuation (Shuford and Ryan 2000; Shuford et al. 2004, 2006). Still, the proportion of gulls nesting on the coast has increased substantially relative to that in the interior. The nesting population of California Gulls in south San Francisco Bay (excluding two colonies in the central bay) has continued to expand exponentially to an estimated 23,406 pairs in 2008 (San Francisco Bay Bird Observatory unpubl. data). Although the Mono Lake colony has long been noted as the largest colony of this species in the state, it is now being challenged for that distinction by the aggregation in San Francisco Bay.

At Mono Lake, recent annual variation in the size of the colony appears to be driven largely by the density of brine shrimp and mean temperature near the time of egg-laying and, to a lesser degree, by the potential number of four-year-old gulls returning to breed for the first time and winter coastal conditions associated with the Pacific Decadal Oscillation (Wrege et al. 2006). Still, large-scale environmental fluctuations outside the Mono Basin from El Niño–Southern Oscillation events appear to have a strong indirect effect on California Gull numbers at Mono Lake, as voluminous spring inflows from extremely high El Niño snowpacks in the Sierra Nevada disrupt the lake's normal mixing regime and thereby depress algal production and shrimp numbers for several years (Jellison and Melack 1993a, b).

Ecological Requirements

Like most larids, California Gulls nest on the ground. In northeastern California, these gulls breed mainly on islands and (rarely) peninsulas at natural lakes, reservoirs, managed wetlands, and saline or alkaline lakes, primarily between 2800 to 5800 ft (853–1768 m) above sea level (Shuford and Ryan 2000). Island substrates may be earthen, rocky, or, infrequently, composed of broken down tule mats; gulls nest in the open or among rocks, tall weeds, or shrubs. California Gulls often breed together with Ring-billed Gulls and/or with other colonial breeders, such as pelicans, cormorants, herons and egrets, and terns. Nests are loosely built mainly from dried plant material (twigs, sticks, grasses) found near the colony, but also may contain bones, feathers, wings, mummified carcasses of the previous year's young, and a wide variety of human cast offs, such as string, plastic, tin foil, or other debris (D. Shuford pers. obs.). Nests range from no more than a bare scrape to substantial bulky structures; some of the latter were present at Hartson Reservoir at Honey Lake WA in 1995, when some gulls had built their nests higher to avoid inundation by rising waters.

With the exception of the very large colony at hypersaline Mono Lake [currently 6382 ft (1945 m)], most of the state's California Gull colonies are at or near extensive freshwater wetlands or large valleys with irrigated fields (primarily alfalfa). In San Francisco Bay, California Gulls breed at sea level, primarily on earthen islands and levees in salt ponds; the small colony at the Salton Sea is on a nearshore sandy and rocky island of this large saline water body, which is 227 ft. *below* sea level.

The species is a highly opportunistic forager, and the main foods eaten depend on colony location (Winkler 1996); little is known of home range size, but Baird (1976 in Winkler 1996) found birds in Montana foraging an average of 17.4 km (max. 61 km) from their colony. Typical diet items include small mammals, fish, eggs and young of birds (including conspecifics), garbage, and a variety of invertebrates, such as grasshoppers, mayflies, damselflies, earthworms, brine shrimp (*Artemia* spp.), cicadas, etc.; these gulls also eat ripe cherries, large pieces of vegetables as garbage, and green plant material such as sprouted grain.

At Honey Lake, Anderson (1965) reported the primary animal foods were fish (mostly carp, *Cyprinus carpio*), meadow mice, insects, and rabbits; vegetable matter was mostly garbage and grass. At Mono Lake, the abundant populations of brine shrimp (*Artemia monica*) and alkali flies (*Ephydra hians*) typically dominate this gull's diet during the chick rearing period, though year-to-year variation in prey dominance can be substantial, with cicadas (*Okanagana cruentifera*), infrequently, among the top two prey items (Winkler 1983, Hite et al. 2004). The variation in relative importance of brine shrimp versus alkali flies may reflect variation in predominant weather conditions, particularly wind, that affect the respective availability of these two prey (Hite et al. 2004). As elsewhere, California Gulls at Mono Lake exploit a wide variety of other prey, with long-legged flies (*Hydrophorus plumbeus*) and garbage (including fish, taken away from Mono Lake) being among the most important beyond those discussed above. Studies at Mono Lake have

Table 11 Numbers of California Gull Nests at Mono Lake on Individual Negit Islets and Negit Island (PRBO) and on All of the Paoha Islets and Paoha Island (from J. R. Jehl Jr.), 1983 to 2000

Negit Islets	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Twain	3808	7372	9309	11,985	12,422	11,057	10,573	15,045	10,883	15,896	15,431	15,792	11,035	12,690	13,140	9488	10,728	11,772
Little Tahiti	5260	7051	6572	5763	4261	3692	2983	4218	3205	3810	3616	4505	4021	4570	4092	3846	5108	5168
Little Norway	2218	1956	1407	810	360	254	269	432	355	473	428	533	493	766	794	606	732	887
Steamboat	997	1016	721	722	467	359	314	704	671	862	958	1217	981	459	505	405	381	477
Java	143	396	195	400	439	458	543	789	586	1040	399	199	4	70	41	65	149	480
Spot	505	358	296	311	248	247	231	309	311	335	356	449	422	399	341	191	27	29
Tie	511	231	196	150	84	87	95	167	160	220	210	320	264	267	194	81	5	16
Krakatoa	319	272	178	173	185	197	174	283	181	209	146	175	116	57	33	16	76	120
Hat	146	109	73	56	14	18	10	19	10	21	21	14	19	41	58	47	43	29
La Paz	105	58	43	30	22	21	23	46	49	70	77	57	55	44	30	17	0	0
Geographic	140	0	0	0	0	0	2	4	10	68	84	69	51	0	0	0	0	0
Muir	170	0	0	0	0	1	10	61	84	139	131	116	87	4	0	0	0	0
Saddle	175	46	41	29	14	13	10	18	8	14	10	11	21	31	13	1	2	1
Midget	5	3	3	4	4	2	3	3	2	2	3	2	2	2	3	0	3	2
Siren	51	0	1	0	0	0	1	7	7	19	20	14	16	10	0	0	0	0
Comma	2	1	1	1	0	0	0	0	1	1	1	0	0	1	0	0	0	0
Castle Rocks	2	3	4	3	4	6	5	4	5	5	3	3	3	4	4	3	3	1
Pancake	0	0	0	7	570	1216	1395	651	0	0	0	0	0	0	1	13	1136	2098
Java Rocks	0	0	0	0	4	3	0	4	2	13	15	9	5	1	0	0	0	0
No name	0	0	0	0	0	0	0	1	0	3	3	3	1	0	0	0	0	0
Totals																		
Negit Islets:	14,557	18,872	19,040	20,444	19,098	17,631	16,641	22,765	16,530	23,200	21,912	23,488	17,596	19,416	19,249	14,779	18,393	21,080
Totals																		
Paoha Islets:	8001	3546	3151	3596	3208	2833	2682	5145	4442	9283	8498	8182	7331	4334	5707	2383	1435	2959
Negit Island:	—	—	92	636	1502	2037	2765	2827	788	4	12	0	0	0	0	0	14	103
Paoha Island[a]	—	—	2	102	0	0	0	0	0	1	0	0	0	0	1	304	423	519
Totals																		
Mono Lake:	22,558	22,418	22,285	24,778	23,808	22,501	22,088	30,737	21,760	32,488	30,422	31,670	24,927	23,750	24,957	17,466	20,265	24,661

[a]Numbers of nests intermittently attributed to Paoha Island are from a peninsula of that island (immediately adjacent to the Paoha Islets), which in various years is either partially or completely (e.g., 1998–2000) isolated as a small islet by the rising lake.

documented considerable sexual, temporal, seasonal, and among-nest variation in diet (Jehl and Mahoney 1983, Hite et al. 2004). The diet of recently fledged young is dominated by brine flies, taken at a much higher rate than expected based on their abundance; this apparent preference appears to reflect ease of capture and greater nutritional value relative to brine shrimp (Elphick and Rubega 1995). In San Francisco Bay, about 40% of the diet is garbage; other important prey items include midges (*Chironomus* spp.), brine shrimp, fishes, brine flies (*Ephydra cinerea*), and other insects (Jones 1986, Dierks 1990). Dierks (1990) reported prey fed to chicks varied by chick age and by time of day, the later influenced to some degree by tidal and wind patterns. The diet of adults in Alberta varied seasonally—from no favored food in May to more insects in June to more refuse in July (Vermeer 1970). The diet of the California Gull there contains more amphibians and waterfowl eggs and young and larger rodents than that of the Ring-billed Gull (see account); the former species scavenges more than the latter.

Threats

The main threat to breeding gulls is the periodic scarcity of isolated nesting islands free of ground predators (Shuford and Ryan 2000). California Gulls in northeastern California are particularly vulnerable during periods of drought. For example, in 1994 low water levels appeared responsible for the lack of nesting islands at two sites and formation of landbridges at six sites, thereby allowing access by ground predators, particularly coyotes; resulting predation appeared to reduce nesting success at three sites (Shuford and Ryan 2000). It is possible, however, that sometimes birds displaced by drought may nest at nearby sites, which may have occurred in the Klamath Basin in 2003 and 2004. In those years, a large Ring-billed and California gull colony that typically forms at Meiss Lake, Butte Valley WA, was inactive because water levels were too low to maintain isolation of nesting islands; another at Clear Lake NWR was diminished from more usual levels by a reduction in island nesting area (Shuford et al. 2004, 2006; D. Shuford pers. obs.). At the same time, a very large gull colony was present nearby in the Klamath Basin at Swan Lake, Oregon, where there is limited evidence of prior gull breeding.

The effects of a reordering of water priorities in the Klamath Basin in 1995, however, have threatened to reduce or degrade wetland habitat for waterbirds, including gulls. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR and Clear Lake NWR, exacerbating the effects of droughts.

As noted for other species, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented.

At Mono Lake, meromixis—a persistent chemical stratification caused by a rapid influx of large amounts of fresh water on top of the lake's hypersaline waters (intensified by decades of water diversions)—has reduced primary productivity for two recent six-year periods, 1983 to 1988 and 1997 to 2002 (Jellison and Melack 1993a, Jellison et al. 1998, R. Jellison pers. comm.). Although gull productivity has been low in many meromictic years (PRBO unpubl. data), this phenomenon does not presently appear to pose a long-term threat to Mono Lake's gull colony.

In south San Francisco Bay, introduced Red Foxes (*Vulpes vulpes*) have caused partial or complete abandonment of several gull colonies, which are either permanently attached to the mainland or become landbridged when waters recede early in the nesting season (Shuford and Ryan 2000). In 1989, the Don Edwards San Francisco Bay NWR purchased the Knapp property, the site of the bay's largest gull colony, from Cargill Salt Division, and the pond remained an active salt evaporator until 1993; since then the refuge has not actively managed the pond or pumped any water into it. The refuge is considering flooding this pond in the near future to restore the area to tidal wetlands, which likely would displace nesting gulls. More broadly, the South Bay Salt Pond Restoration Project is considering options for controlling the gull population in San Francisco Bay to reduce impacts to other nesting waterbirds, which may deepen if the gull population continues to increase and restoration forces gulls and other waterbirds into even closer association (Shuford 2008).

Management and Research Recommendations

- Focus on long-term protection of suitable foraging habitats and on maintaining water levels that isolate colonies from ground predators. This is necessary because water diversions for human uses may exacerbate the effects of periodic droughts that otherwise are a natural phenomenon to which gulls are well adapted.
- Limit human disturbance at nesting sites. Despite the remote location of many colonies, human visitation is a potential threat to nesting gulls. Seasonal closure of nesting islands has proven effective at Mono Lake (D. Shuford pers. obs.), but such restrictions or interpretive signing will likely be effective only where adequate personnel are available for enforcement or interpretation. Consider on a case-by-case basis whether such efforts might be counterproductive in drawing undue attention to nesting colonies.
- Enhance protection of gull colonies via comprehensive conservation plans that address the needs of all colonial waterbirds that nest together on islands.
- Investigate foraging patterns of gulls from Klamath Basin

colonies to determine the relative importance to their diet of prey from wetlands versus irrigated agriculture and how a tightening water supply might affect these foraging habitats.

- Continue studies of the foraging ecology of gulls at Mono Lake to better determine how prey availability affects reproductive success, what climatic or limnological factors affect prey availability, and what management, if any, is needed to ensure adequate prey.

Monitoring Needs

The state's breeding population should be monitored at least once every 5–10 years, during typical climatic and habitat conditions, using methods responsive to the shifting of breeding locations. Surveys should be timed to obtain peak nest counts (usually mid- to late May in interior) and should use methods, varying according to local conditions, that will provide the most accurate and consistent counts. Entry into colonies should be avoided if this will cause predation by gulls on nests of other species or will otherwise affect other colonial waterbirds nesting on the same or nearby islands. It also would be valuable to continue long-term monitoring of population size and reproductive success at key colonies, such as those at Mono Lake and San Francisco Bay.

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CASPIAN TERN (*Hydroprogne caspia*)

General Range and Abundance

The Caspian Tern is a (nearly) cosmopolitan, monotypic species that occurs widely in the Old and New worlds (AOU 1998, Cuthbert and Wires 1999). In North America in the late 1980s to 1998, an estimated 32,000 to 34,000 breeding pairs were split among five distinct populations: Pacific Coast (w. Alaska south to Baja California Sur)/western (interior) region (45%), Central Canada (28%), Gulf Coast (7%; Texas to Florida), Atlantic Coast (<1%), and Great Lakes (19%; Wires and Cuthbert 2000). In the Americas, this tern winters on the Pacific Coast, mainly from southern California (sparingly in interior) south through Baja California, the Gulf of California, and west Mexico to Guatemala (locally Nicaragua to Panama); on the Atlantic Coast from southern North Carolina south around Florida; and on the Gulf Coast of the United States, the east coast of Mexico, and south to at least northern Honduras. It also winters inland in the United States, usually in smaller numbers, in the Florida Peninsula (most widely) and on the coastal plain of Georgia, Alabama, Louisiana, and Texas, and in Mexico in the Central Volcanic Belt (bridging the Pacific and Gulf coasts) and on the Atlantic Slope (south to Tabasco) (Cuthbert and Wires 1999, Shuford and Craig 2002). It also winters locally (rare) in the West Indies and the Atlantic coasts of Panama and South America.

Conservation Concern

Although not listed at the national level in the United States, Canada, or Mexico, the Caspian Tern is listed as threatened or endangered in 3 states or provinces and is considered of special concern in 10 more, 4 of which (British Columbia, Montana, Wyoming, Utah) are in western North America (Shuford and Craig 2002). The North American Waterbird Plan considered this species to be of "low" conservation concern at the continental scale (Kushlan et al. 2002).

The Caspian Tern recently has been increasing over most of the continent, including the Pacific Coast and California. Still, concentration of large numbers of terns at a few colonies leaves populations vulnerable to stochastic events and fisheries conflicts (Wires and Cuthbert 2000, Roby et al. 2002, Shuford and Craig 2002, Suryan et al. 2004). Because of the extreme concentration of terns in the Columbia River estuary of Oregon, USFWS (2002) considered the species to be of conservation concern in BCR 5 (Northern Pacific Rainforest) (Shuford and Craig 2002, T. Zimmerman pers. comm.). USFWS (2005), in cooperation with the Corps of Engineers and NOAA Fisheries, has proposed a management plan to reduce fisheries conflicts in the Columbia River estuary by managing habitat to redistribute a portion of the tern colony on East Sand Island to up to seven sites in the Pacific Coast/Western region (including three in California in San Francisco Bay) identified on the basis of an initial assessment of known and potential nesting sites within that region (Seto et al. 2003). Tule Lake NWR and Lower Klamath NWR have subsequently been added to the list of sites in California (D. Mauser pers. comm.). The distribution of nesting terns more evenly over a greater number of sites should also reduce the vulnerability of a large part of the regional population to stochastic events such as storms and disease.

Seasonal Status in California

The Caspian Tern occurs in California primarily as a migrant and summer resident from late March through early November (McCaskie et al. 1979, Garrett and Dunn 1981). Small numbers of this species currently winter regularly on the southern coast north to Morro Bay, with a few in Humboldt Bay on the north coast; it is casual inland during winter in central and southern California, except at the Salton Sea where it occurs regularly (Shuford and Craig 2002). The breeding season in the state extends from April through August, rarely into September (Cogswell 1977), with the period of colony occupancy varying by latitude, elevation, and local water conditions.

Breeding Range and Abundance in California

The early history of the distribution and abundance of the Caspian Tern is fragmentary for both California's interior and coastal colonies (Shuford and Craig 2002). Hence, these historical data are of limited value for assessment of population trends or distributional shifts knowing more extensive data in recent decades have documented rapid changes in these parameters over short periods (Gill and Mewaldt 1983, Wires and Cuthbert 2000, Shuford and Craig 2002, Suryan et al. 2004). Still, some patterns are evident, particularly that of a link between declines in the interior and corresponding increases on the coast.

Up to the mid-1940s, colonies in California were located primarily in the interior of the state, where known only from Tule Lake (1899, "apparently breeding"), Modoc County; Sutter Basin (1910–1916), Sutter County; Woodward Reservoir (1925, 1936), Stanislaus County; Buena Vista Lake (1920–1923), Kern County; and the Salton Sea (1927–1940+), Imperial County (Grinnell and Miller 1944, Gill and Mewaldt 1983; Appendix 7). The only coastal colony in California early in 20th century was established in south San Francisco Bay in Alameda County (1922, eggs collected in general area in 1916; Grinnell and Miller 1944). Those authors concluded the species appeared to have increased slowly since the era of the "feather trade" prior to 1900. Pre-1940s data on the size of colonies in the interior of California are very limited. Bailey (1902) observed a feeding flock of about 500 Caspian Terns along the shores of Tule Lake in July 1899 but did not visit the nesting island(s) or estimate the number of breeding pairs. H. A. Snow and colleagues visited the nesting site of a "large colony" in the Sutter Basin from 1910 to 1915, from which they collected at least 131 egg sets (100 on 25 May 1915 alone; Appendix 7). About 30 pairs attempted to nest at Buena Vista Lake in 1923 and about 25–40 pairs bred at the Salton Sea in the late 1920s to 1940s; a small to moderate-sized colony is suggested by the 15–17 egg sets collected at Woodward Reservoir in 1925 and 1932 (Appendix 7). It is likely that other unknown colonies were active during this period.

Subsequently, colonies have been active in the interior at Meiss Lake, Butte Valley WA (1979, 1997–present) and Lower Klamath NWR (1955, 1970–1979) Siskiyou County; Tule Lake NWR (1952–1962), Siskiyou and Modoc counties; Clear Lake NWR (1952–present), Goose Lake (1976–present), and Big Sage Reservoir (1976–present), Modoc County; Honey Lake WA (1956–present), Lassen County; Mono Lake (1963–present), Mono County; Tulare Basin (various sites; 1982–present), Kings County; Lake Elsinore (1995, 1999), Riverside County; Salton Sea, Imperial County (1927–1957[59?], 1992–present) (Gill and Mewaldt 1983; Shuford and Craig 2002; Tables 12 and 13, Appendix 7). Coastal colonies have been active at scattered sites from Humboldt Bay south to San Diego Bay.

Population estimates at most interior sites have been sporadic and of unknown quality. Biologists have estimated numbers of nesting pairs of Caspian Terns at refuges in the Klamath Basin since at least 1952 (Table 12). Lower Klamath NWR or Tule Lake NWR hosted small colonies (up to 80 pairs, average <30) sporadically from the early 1950s to mid-1970s. Clear Lake NWR has been occupied almost continuously since at least 1952. Numbers of nesting pairs were below 160 in most years through the 1970s but have been mostly in the 200–300 range since 1977.

Broad-scale surveys from 1997 to 1999 estimated about 794–1762 pairs were nesting annually at 6–8 sites (12 total) in the interior of California (Table 13). In 2000 and 2001, about 610 and 867 pairs nested inland in the state at 7 and 6 sites, respectively; sites active in these years, but not the previous four, were at Mono Lake (Figure 5) and (an isolated pair) in the Tulare Basin (Shuford and Craig 2002). Totals were greatly influenced by numbers at the Salton Sea, where, after 30 pairs recolonized that site in 1992, the population increased to about 1500 pairs in 1996 then declined to 211 pairs by 1999 and 29 pairs by 2002 (Molina 2001, 2004; K. Molina in litt.).

The fate of interior colonies is intertwined with that of coastal sites. Gill and Mewaldt (1983) reported the Pacific Coast (WA, OR, ID, CA, NV, Baja) population had increased by >70% from the 1960s to the late 1970s, when it totaled about 6000 pairs, in 24 colonies at 20 sites, concentrated in Washington (51%) and California (45%). At that time, terns no longer nested at 18 historic breeding sites (all interior). They estimated the California population in the late 1970s to be about 2654–2684 pairs at 11 sites (21% of population at

Table 12 Numbers of Nesting Caspian Terns at Tule Lake, Lower Klamath, and Clear Lake National Wildlife Refuges, 1952 to 1996[a]

	Tule Lake		Lower Klamath		Clear Lake	
Year	Nests	Young[b]	Nests	Young[b]	Nests	Young[b]
1952	80	140	0	0	40	100
1953	14	30	—	—	0	0
1954	0	0	0	0	37	86
1955	3	6	15	11	86	223
1956	0	0	—	—	60	125
1957	—	—	—	—	108	200
1958	—	—	—	—	30	60
1961	—	—	—	—	30	50
1962	19	20	—	—	160	110
1963	—	—	—	—	100	200
1964	—	—	—	—	43	60
1965	—	—	—	—	40	50
1966	—	—	—	—	32	50
1967	—	—	—	—	83	100
1968	—	—	—	—	150	130
1969	—	—	—	—	400	350
1970	—	—	20	20	48	50
1971	—	—	—	—	60	70
1972	—	—	27	50	132	80
1973	—	—	—	60	—	206
1976	—	—	20	25	—	—
1977	—	—	—	—	—	135
1979	—	—	—	—	250	—
1983	—	—	—	—	180[c]	—
1984	—	—	—	—	170	—
1985	—	—	—	—	—	280
1986	—	—	—	—	—	160
1987	—	—	—	—	250	—
1988	—	—	—	—	260	—
1989	—	—	—	—	300	—
1990	0	0	—	—	200	—
1991	0	0	—	—	260	—
1993	—	—	—	—	250	—
1994	—	—	—	—	20	—
1995	—	—	—	—	72 adults	—
1996	—	—	—	—	220	60

[a]Data from the files and Annual Narrative Reports of the Klamath Basin National Wildlife Refuges unless otherwise indicated. Data quality generally Category 3, as in very few instances are descriptions of methods and dates of surveys available. —, no data available.

[b]Estimated number of young fledged.

[c]Smith et al. (1984) reported 75 pairs of terns nesting on one island at Clear Lake on 28 June 1983.

7 inland sites, 79% at 4 coastal sites). Finally, they concluded that since the turn of the century the Pacific Coast population had shifted from breeding at numerous small colonies associated with freshwater marshes to nesting primarily in large colonies on human-created habitats along the coast. From 1979–1981, the coast accounted for only 43% of the colonies but 83% of the entire Pacific Coast population. Suryan et al. (2004) reported that from 1979–1981 to 1997–2000 the Pacific Coast population had more than doubled to 12,900 pairs. Along with this increase the overall population became heavily concentrated in Oregon (69% of total), in particular at the Columbia River estuary (65%). Still, with 42% of colonies and 82% of the population on the coast in 1997–2000, proportional distribution between the coast and interior remained almost identical to that in the prior period. From 1997 to 2000, the California nesting population declined from about 3602 pairs (51% at 4 coastal sites, 49% at 6 inland sites) to about 2583 pairs (76% at 5 coastal sites, 24% at 7 inland sites) (Shuford and Craig 2002). This decline in overall numbers, and increasing concentration of terns on the coast, primarily reflected changes at the Salton Sea, as noted above.

Ecological Requirements

Caspian Terns nest in colonies and, rarely, as single pairs, usually near or adjacent to other colonial nesting waterbirds (gulls, skimmers, other terns, cormorants, pelicans) and semicolonial and solitary nesting shorebirds (Cuthbert and Wires 1999). Nesting sites typically are on sandy, earthen, or rocky islands, though locally they may be on floating tule-mat islands (formerly in Klamath Basin) or, rarely, peninsulas (Bent 1921, Cuthbert and Wires 1999, D. Shuford pers. obs.). Nest sites often are on the highest point of an island (usually >2–3 m above water) to avoid flooding, but proximity to other terns may override elevation in the selection process (Cuthbert and Wires 1999). Terns characteristically place nests in open, sparsely vegetated areas, though also among or adjacent to driftwood, partly buried logs, rocks, or tall annual weeds (Bent 1921, Cuthbert and Wires 1999, California egg set data, D. Shuford pers. obs.). Nest substrates vary from sand, sand-gravel, spongy marshy soil, or dead or decaying vegetation to hard soil, limestone, or bedrock. Of experimental nest substrates in Ontario, terns preferred sand over pea-gravel and crushed stone and all of these over pre-existing hard packed ground (Quinn and Sirdevan 1998). Nests typically are depressions or hollows in bare soil or ones lined (or built up elaborately) with debris, such as shells, crayfish chelipeds, dried grasses and weed stems, wood, chips of salt crust, or pebbles (Bent 1921, Cuthbert and Wires 1999, California egg set data slips). Adult terns may raise rim heights of nests by >3 cm in areas subject to immediate flooding and may move small chicks >100 m to alternate scrapes if the original nest is disturbed (Cuthbert and Wires 1999).

Caspian Terns feed almost entirely on small fish, although they also occasionally take crayfish and insects (Cuthbert and Wires 1999). They are generalist foragers that tend to prey on the most available fish near their colonies (Roby et al. 2002). Terns forage primarily by plunge-diving into relatively shallow estuarine, inshore marine, and freshwater habitats; birds also occasionally rob other terns and small gulls in flight, eat carrion and scavenge dead fishes from net catches, and forage on beaches, apparently for invertebrates. Inland foraging habitats include freshwater lakes, reservoirs, marshes, rivers,

Table 13 Numbers of Caspian Terns on Surveys of the Interior of California, 1997 to 1999[a]

		Survey date			Number of adults			Number of nests			Estimated pairs		
Site	Colony code	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Siskiyou County													
Butte Valley WA (Meiss Lake)	326-271-001	14 July	10 June	15 June	41	—	—	15 yg	16	27	25[b]	16	27
Modoc County													
Clear Lake NWR	327-182-001	14 May	27 May	22 June	290	110	299	39	—	118	180[b]	68[b]	118
Goose Lake	327-074-001	18 May	—	20 June	230	—	~500	57	—	—	143[b]	—	310[b]
Big Sage Reservoir	327-056-001	15 May	—	21 June	100	—	13	5+	—	0	62[b]	—	0
Lassen County													
Dakin Unit (Hartson Reservoir), Honey Lake WA[c]	354-034-003	8 June	—	19 June	262	—	176	152	—	87+	152	—	87+
Kings County													
Lemoore NAS sewage ponds	455-928-001	—	28 May	25 June	—	33	—	—	10	0	—	20[b]	0
South Evaporation Basin, Westlake Farms	478-988-001	various	14 May	various	—	—	—	0	3	0	0	3	0
Tulare lakebed, ~14 km E of Kettleman City	478-987-001	dry	29 June	dry	—	33	—	—	3+	—	0	20[b]	0
South Wilbur Flood Area, Tulare Lake Drainage District	478-976-001	various	10 July	9 June	—	—	184	0	70	27	0	70	27[b]
South Evaporation Basin, Tulare Lake Drainage District	478-976-004	various	13 July	various	—	—	—	0	40	0	0	40	0
Riverside County													
Lake Elsinore	525-763-001	—	—	8 June	—	—	17	—	—	14	—	—	14
Imperial County													
South End Salton Sea													
Mullet Island	526-525-001	12 May	—	—	—	—	—	—	0	0	70	0	0
Rock Hill, Salton Sea NWR	526-525-003	31 May	29 May	24 June	—	—	—	—	800	211	800	800	211
Obsidian Butte	526-526-001	15 May	—	—	—	—	—	—	0	0	330	0	0
Total pairs											1762+	—	794

[a]Coverage most complete in 1999, when all known colony sites were surveyed; surveys focused on northeastern California in 1997, the Central Valley in 1998. The small colony at Mono Lake, Mono County, was inactive 1997–1999, but active in 2000 (8 nests on Negit Islets, subcolony 406-911-001). Use caution in interpreting data because of (1) variation in timing of counts (e.g., some in northeastern California taken in mid-May, which is ideal for counting nests of Ring-billed and California gulls but suboptimal for Caspian Terns) and (2) logistical constraints (vegetation obscuring nests, threat of gull predation on tern nests) sometimes precluded accurate counts. —, no data available.

[b]When nest counts were unavailable for the optimal time period (mid-June to north, earlier to south), counts or estimates of breeding adults were multiplied by 0.62 to approximately estimate numbers of breeding pairs on the basis of the average ratio of nests to adults at sites on the California coast (0.625, Carter et al. 1992, p. I-45) and the California interior (0.61, D. Shuford unpubl. data).

[c]A survey on 18 June 2000 found 82 nests and 98 adults on islands in Dakin Unit, Pond 5A (subcolony 354-033-001), just east of Hartson Reservoir (D. Shuford pers. obs.).

sloughs, and irrigation canals. Some terns at a San Francisco Bay colony flew regularly 18 mi (29 km), and occasionally up to 37 mi (62 km), to forage at freshwater reservoirs (Gill 1976). Terns may vary their foraging strategies by eschewing shared foraging patterns and fidelity to specific foraging areas (Ontario, freshwater); adjusting fishing areas to spawning places and fish migrations (Finland, coastal); and (individuals or pairs) specializing on particular foraging locations (California, coastal nesters foraging at freshwater reservoirs) (Gill 1976, Cuthbert and Wires 1999). Fishing success rates (number captures/total dives) reported range from 15% to 42% (Cuthbert and Wires 1999).

The diet (% frequency occurrence, n = 10 stomachs) of Caspian Terns at Elkhorn Slough, Monterey County, in July was 80% shiner perch (*Cymatogaster aggregata*) and 20% northern anchovy (*Engraulis mordax*); Caspian Terns took mostly adults, whereas Forster's Terns mostly juveniles of these two fish species (Baltz et al. 1979). The major food items of Caspian Terns at a south San Francisco Bay colony were predominantly estuarine species including jack smelt (*Atherinopis californiensis*, 33%), shiner perch (19%), and staghorn sculpin (*Leptocottus armatus*, 19%) (n = 605 samples, Gill 1976); also taken were 12 rainbow trout (*Salmo gairdneri*), from nearby reservoirs, and single specimens of 5 other freshwater fish species. Marine species, particularly northern anchovy and Pacific sardine (*Sardinops sagax*), were the most frequent in the diet of Caspian Terns breeding at Bolsa Chica Ecological Reserve, Orange County (Loeffler 1996 in Cuthbert and Wires 1999); topsmelt (*Atherinopis affinis*) was the prey item most often found at nests at San Diego Bay (Ohlendorf et al. 1985). No quantitative information has been published on the diet of Caspian Terns in the interior of California.

Threats

In the interior of California, the greatest threat to Caspian Terns historically has been the loss of suitable nesting and foraging habitat. Today the greatest threat is a lack of high quality water at wetlands. Within about one to two decades, salinity at the Salton Sea is predicted to reach concentrations that will severely affect populations of invertebrates and fish and, by extension, those of the sea's fish-eating birds (Tetra Tech 2000), such as the Caspian Tern. The recent rapid changes in numbers of Caspian Terns nesting at the Salton Sea and comparable changes in the sea's fish populations (Molina 2004, Molina and Sturm 2004) may perhaps already reflect a response of fish to increasing salinity or other stressful or deteriorating ecological conditions. Although contaminants at the Salton Sea have not been shown to cause large-scale die-offs or other major problems, there is still ongoing concern for the potential risk to waterbirds of reproductive impairment or immunotoxicity from selenium, boron, and DDE (e.g., Setmire et al. 1990, 1993; Bruehler and de Peyster 1999).

The effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland nesting and foraging habitat for waterbirds, including terns. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR and Clear Lake NWR, exacerbating the effects of droughts. As reported for other species, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented. Caspian Terns should specifically benefit, as noted above, from efforts to create nesting islands for them at Tule Lake NWR and Lower Klamath NWR.

Management and Research Recommendations

- Focus on restoring, enhancing, and providing long-term protection for suitable wetlands and on maintaining isolation of nesting islands from humans and ground predators.
- In the Tulare Basin, consider enhancing tern habitat primarily in years of exceptional runoff, when it will do the most good, thereby exploiting the tendency of waterbirds to exhibit boom and bust cycles of productivity. Create some nesting habitat available on an annual basis and maintain additional incipient habitat that when flooded in wet periods will provide suitable nesting islands.
- In northeastern California and the Salton Sea, create nesting islands where none exist in lakes, reservoirs, or large managed wetland impoundments.
- Conduct research on the basic foraging and nesting ecology of Caspian Terns at inland colonies in California.
- Using color-banded or radio-tagged birds, investigate movements of terns with changing conditions and the degree of interchange between inland and coastal colonies.
- Study population demography to identify which breeding sites do, and do not, produce enough young to maintain the local population and to what degree this varies over time. Also, identify the life history stages at which populations are most limited.
- Investigate whether tern prey found in areas with extensive agricultural runoff, such as the San Joaquin Valley and Salton Sea, concentrate contaminants that might leave terns at risk of reproductive failure.

Monitoring Needs

As long as USFWS continues to coordinate annual monitoring of colonies throughout the Pacific Coast region, it would be valuable to continue to estimate the size of the state's breeding population by surveying all or most known and potential colony sites in California (both inland and coastal) each year. If it proves impractical to conduct annual surveys indefinitely, it would be desirable to design a monitoring scheme for Caspian Terns that samples only a select number of colonies annually or that surveys all colonies at a set interval of years (e.g., once every 3–5 years). Surveys should be timed to obtain peak nest counts (usually mid-June in the interior away from the Salton Sea) and should use methods, varying according to local conditions, that will provide the most accurate and consistent counts. Entry into colonies should be avoided if this will cause predation by gulls on tern nests or otherwise affect other colonial waterbirds nesting on the same or nearby islands. It would be valuable to monitor reproductive success annually at a subset of inland colonies and to periodically assess contaminant levels at sites where risk of exposure seems high.

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BLACK TERN (*Chlidonias niger*)

General Range and Abundance

The Black Tern is comprised of two subspecies, *C. n. niger* in the Old World and *C. n. surinamensis* in the New World. In North America, it breeds widely across central and southern Canada and the northern United States, reaching its southwestern breeding limit in California's Central Valley (AOU 1998, Shuford 1999). It generally is patchily distributed on the fringes of its breeding range, with largest concentrations in zones of highly productive wetlands, particularly in the Prairies (Dunn and Agro 1995, Peterjohn and Sauer 1997). The size of the continental breeding population is poorly known. Shuford (1999) judged the U.S. population as "reasonably in the low hundreds of thousands," with that in Canada possibly larger. Kushlan et al. (2002) estimated the continental population as 100,000–500,000 breeders. The Black Tern migrates broadly across North and Middle America to reach wintering grounds mainly in marine and marine-coastal areas of Middle and northern South America (Shuford 1999). This tern also occurs in these habitats in summer outside the breeding range, mainly from the Gulf Coast south to northern South America and at the Salton Sea in southern California (Dunn and Agro 1995).

Conservation Concern

Concern has been expressed for the Black Tern in North America because its population declined continentwide (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 indicate this taxon declined significantly surveywide at an average rate of –1.6% annually (–41.3% overall) from 1966 to 1999 (Sauer et al. 2000); the updated trend of –2.1% from 1966 to 2007, however, was not significant (Sauer et al. 2008). Although USFWS (2002) currently does not consider the Black Tern of conservation concern at the national level, it has expressed concern for some regional populations in the eastern United States; in Canada, the species has no official status despite recommendations for listing as "threatened" by Gerson (1988) and "vulnerable" by Alvo and Dunn (1996). The North American Waterbird Conservation Plan considered this tern to be of "moderate" conservation concern (Kushlan et al. 2002). It is extirpated from 2 states, listed as threatened or endangered in 6 states, and designated of conservation concern in 18 other states or provinces (Shuford 1999). In California, the Black Tern is considered a Bird Species of Special Concern (Shuford and Gardali 2008).

Seasonal Status in California

The Black Tern occurs in California primarily as a migrant and summer resident from mid-April to mid-October (McCaskie et al. 1979, Garrett and Dunn 1981); arrival is later (early May) and departure earlier (by early to late Sep) in northeastern California (Gould 1974; Summers 1993; Shuford et al. 2004, 2006). The breeding season extends from early May to early August (Appendices 8 and 9).

Breeding Range and Abundance in California

Grinnell and Miller (1944) described the Black Tern as a "locally common" breeder that nested in two distinct areas: the Modoc Plateau region and mountain valleys of northeastern California, and the lowlands of the Central Valley. Apparent nesting at Merritt Lake, Monterey County (Silliman 1915), likely represents an extralimital attempt, as the species has not bred elsewhere on the coastal slope of California.

The outline of the breeding range today remains largely unchanged in northeastern California, except where the species is extirpated to the south at Lake Tahoe (Shuford et al. 2001). By contrast, the range has changed substantially in the Central Valley. Black Terns are extirpated from the Sacramento–San Joaquin River Delta, and in the San Joaquin Valley, formerly a center of abundance, they now breed mostly in two small areas of rice fields in the San Joaquin Basin. The species is quasi-extirpated in the Tulare Basin, where it nests irregularly and locally in ephemeral habitats mainly in extremely wet years. Statewide surveys in 1997 and 1998 estimated 4153 breeding pairs of Black Terns in California, 47% in northeastern California and 53% in the Central Valley (Shuford et al. 2001; Tables 14–16; Figure 6).

Table 14 Numbers of Adult Black Terns, Nests, and Estimated Pairs from Surveys of Wetlands in Northeastern California in 1997

			Number of adults[a]		Number of nests[b]		
Site	Colony code	Survey date	Disturbed	Undisturbed	Total	Partial	Estimated pairs[c]
Siskiyou County							
Butte Valley WA (Unit 7C)	326-271-002	14 July	22	—	—	2	11[2]
Butte Valley National Grasslands	326-271-003	14 July	0	2	—	1	2[3]
Grass Lake[d]	326-262-001	12 July	—	28	—	2+	22[3]
Orr Lake	327-168-001	30 May	—	8	—	—	6[3]
		24 & 26 June	—	6	—	—	—
Dry Lake	326-251-001	12 July	—	4	—	2	3[3]
Lower Klamath NWR[e]							
Unit 4D	327-186-003	18 June	—	18	12+	—	12[1]
Unit 4E	327-186-004	18 June	~73	65	—	3	37[2]
Barnum Flat Reservoir	327-134-001	1 July	—	68	—	2+	54[3]
Subtotal							147
Modoc County[f]							
Dry Lake	327-163-001	20 June	—	12	—	—	9[3]
Fourmile Valley	327-088-001	27 May	38	27	27	—	27[1]
Wild Horse Valley	327-088-002	28 May	6	8	3	—	3[1]
Buchanan Flat	327-087-001	26–27 May	36	29	21	—	21[1]
Weed Valley	327-087-002	3 June	—	203	—	6	160[3]
Baseball Reservoir	327-087-003	26 May	47	47	42	—	42[1]
Dry Valley Reservoir	327-077-001	25 May	58	—	30	—	30[1]
Hager Basin North	327-077-002	24 May	22	13	14	—	14[1]
Hager Basin South	327-077-003	24 May	51	21	18	—	18[1]
Telephone Flat Reservoir	327-076-002	31 May	23	—	7	—	7[1]
South Mountain Reservoir	327-076-001	31 May–1 June	6	—	2	—	2[1]
Pease Flat[g]	327-085-001	21 May	—	1	0	—	—
		17 July	—	~60	—	—	47[3]
		18 July	—	19	—	2+	—
Mud Lake	327-075-001	22 May	26	8–10	16	—	16[1]
Crowder Mountain Reservoir	327-075-002	1 June	—	41+	40	—	40[1]
Whitney Reservoir	327-152-001	20 June	10	—	—	—	5[2]
Hackamore Reservoir	327-152-002	20 June	20	—	—	4	10[2]
Spaulding Reservoir	327-152-003	21 June	40	—	—	10	20[2]
Beeler Reservoir	327-151-001	22 June	26	—	—	10	13[2]
Pinkys Pond	327-151-002	22 June	14	—	—	3	7[2]
Widow Valley	327-058-001	22 June	—	82	—	1	64[3]
Bucher Swamp	327-058-002	22 June	—	122	—	5	96[3]
Six Shooter Tank	327-058-003	23 June	18	12	—	1	9[2]
Deadhorse Flat Reservoir	327-068-002	23 June	—	45	—	1	35[3]
Surveyors Valley	327-068-003	23 June	—	35	—	1	28[3]
Boles Meadow (marsh)	327-067-001	7 June	—	211	—	15	166[3]
Fletcher Creek Reservoir	327-077-004	16–17 June	—	48	31	—	31[1]
Jacks Swamp	327-057-002	5 June	—	64	26	—	26[1]
Dead Horse Reservoir	327-065-001	29 May	—	7+	11	—	11[1]
Jesse Valley	327-023-001	26 June	—	13	—	4	10[3]
Whitehorse Flat Reservoir	327-134-002	1 July	—	37	—	4+	29[3]
Egg Lake	327-133-001	30 June–1 July	—	343	—	1+	270[3]
Taylor Creek wetlands	327-132-001	30 June	—	128	—	2	101[3]
Subtotal							1367
Lassen County							
Muck Valley	327-112-001	2 July	—	53	—	5	42[3]
Hoover Flat Reservoir	354-181-001	3 July	—	7	—	—	6[3]

(continued)

Table 14 *(continued)*

Site	Colony code	Survey date	Number of adults[a]		Number of nests[b]		Estimated pairs[c]
			Disturbed	Undisturbed	Total	Partial	
Moll Reservoir	327-017-001	27 June	34	20	—	3+	17[2]
		16 July	13	—	—	—	—
Oxendine Spring	327-016-002	27 June	9	5	—	—	5[2]
		16 July	—	0	—	—	—
Ash Valley (main)	327-016-001	27 June	—	66	—	—	52[3]
Ash Valley (southeast)	327-016-003	19 July	—	9	—	—	7[3]
Red Rock Lakes complex	327-012-002	26–27 June	—	72	—	2+	57[3]
Boot Lake	327-012-001	25–26 June	—	15	—	8	12[3]
Poison Lake[h]	354-162-002	5 July	76	43	—	2	38[2]
Dry Lake, Grass Valley	354-162-001	10 June	—	6	—	—	5[3]
		5 July	—	0	—	—	—
Straylor Lake	354-171-001	26 May	—	11	—	—	9[3]
		11 July	—	1	—	—	—
Long Lake	354-171-002	26 May	—	6	—	—	5[3]
		11 July	—	0	—	—	—
Ashurst Lake	354-068-001	26 May	—	7	—	—	?
		13 June	—	2	—	—	2[3]
		10 July	—	2	—	—	—
Gordon Lake	354-078-001	9 June	—	12	—	—	9[3]
		10 July	—	10	—	—	—
Pine Creek wetlands	354-058-001	10 June	—	9	—	—	7[3]
		10 July	—	5	—	—	—
McCoy waterpit	354-067-001	9 June	—	12	—	—	9[3]
		10 July	—	0	—	—	—
Eagle Lake[i]							
Spaulding	354-067-003	8 July	—	92	—	2+	73[3]
North Basin	354-066-004	9 July	—	22	—	—	17[3]
Troxel	354-066-003	9 July	—	28	—	1+	22[3]
Willow Creek WA	354-055-001	10 June	—	13	—	—	10[3]
Horse Lake	354-065-001	8 July	15	15	—	1+	8[2]
Mountain Meadows Reservoir (meadows)	354-038-001	7 July	22	20	—	—	11[2]
Honey Lake N, private	354-033-002	15 June	5	5	—	1	3[2]
Subtotal							426
Total							1940[j,k]

[a]Numbers of adults from either disturbed or undisturbed counts (see Methods). —, no data available.

[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 yields 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 (colony 327-068-004), which was mostly dry and devoid of waterbirds when visited 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. Of the 160 adults, 10 were at Spaulding, 29 at the Mouth of Pine Creek (subcolony 354-067-002), 105 at North Basin, 8 at Troxel, and 8 at Lederer Marsh; adults were repeatedly carrying food to specific sites, presumably where they fed young, in marshes at Troxel and Lederer Marsh (subcolony 354-066-002).

[j]In addition, an estimate of 9 nesting pairs in marshes west of the north end of Harriet Lane (subcolony 380-063-001) in Sierra Valley, Plumas County, was made on the basis of a count of 17 adults, 1 subadult, and 1 nest there on 13 June 1998 (D. Shuford, J. McCormick pers. obs.).

[k]Also, from at least 15–19 June 1999, 5–15 Black Terns were seen in marshes of Sierra Valley, Sierra County, west of Hwy 89 at Rice Hill (subcolony 380-064-001; D. Shuford, J. McCormick pers. obs.).

Table 15 Estimated Numbers of Black Terns Breeding in the Sacramento Valley from Roadside Surveys of Rice Fields, 29 May to 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	1411.1	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. —, no data available for calculation of density.

[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 County in 1998, coverage since the 1970s 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.

Northeastern California

Historic locations of confirmed breeding 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, egg set data). The southeastern breeding limit was at Lake Tahoe, where terns nested primarily at Rowlands Marsh near the mouth of the Upper Truckee River (Orr and Moffitt 1971). That colony held over 100 pairs.

Habitat loss and degradation via development and lowering of water levels eliminated breeding Black Terns at Lake Tahoe (Orr and Moffitt 1971, Cogswell 1977, D. 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 (Shuford et al. 2001). The known elevational limit of breeding is at 6560 ft (2000 m) at Boot Lake, Lassen County, in the Warner Mountains. Attribution of nesting to Shasta Valley, Siskiyou County (Zeiner et al. 1990, Small 1994), west of the known breeding range, lacks documentation. Extensive wetland loss, particularly in the Klamath Basin, may have been partially offset on the Modoc Plateau by historic creation of shallow-water reservoirs for livestock grazing and recent enhancement for waterfowl (T. Ratcliff and G. Studinski pers. comm.).

In 1997, about 1940 pairs of Black Terns nested at 60 widely scattered sites in northeastern California; about 70.5%, 22.0%, and 7.6% of the terns were in Modoc, Lassen, and Siskiyou counties, respectively (Shuford et al. 2001, Table 14). The 10 sites with >50 pairs, together comprising 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, Red Rock Lakes complex, and Eagle Lake, Lassen County. State and federal refuges held <4% of the population, U.S. Forest Service and private lands most of the rest.

Central Valley

Grinnell and Miller (1944) reported nesting 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. The Black Tern formerly was described as very numerous in the San Joaquin Valley (Ray 1906, Chapman 1908, Tyler 1913, van Rossem 1933). One of few early quantitative estimates was of a colony of "about 200 pairs" at Buena Vista Lake in June 1921 (A. J. van Rossem egg data slip, WFVZ #2470).

Black Terns were severely affected by the great historic loss of Central Valley wetlands and the massive alteration of the natural hydrologic regime. Formerly hundreds of thousands of hectares in both the Sacramento and San Joaquin valleys were subject to inundation from annual or periodic overflow (The Bay Institute 1998). It is unclear how much of this

Table 16 Numbers of Adult Black Terns, Nests, and Estimated Pairs from Breeding Sites in the San Joaquin Valley in 1998

Site	Colony code	Survey date	Number of adults[a]	Number of nests[b]		Estimated pairs[c]
				Total	Partial	
Merced County						
Rice fields SW of Merced	430-035-001	22 June	30	—	—	24[2]
		3 July	25	—	2	—
West Bear Creek Unit (Raccoon Marsh), San Luis NWR	430-037-001	22 June	4	2	—	2[1]
Merced NWR (Cinnamon Slough)	430-025-001	23 June	4	2	—	2[1]
Fresno County						
Rice fields S of Dos Palos, Merced Co.	454-086-001	22–23 June	58	—	5	46[2]
James Bypass S of James Rd.	454-062-001	1 July	2	1	—	1[1]
Kings County						
S of Hacienda Ranch Flood Basin #1	478-976-002	19 June	69	—	7	54[2]
S of Hacienda Ranch Flood Basin #2	478-976-003	19 June	28+	—	3	22[2]
		13 July	—	—	3–4	—
Tulare County						
Vicinity jct. Hwy 43 and Virginia Ave.	478-984-002	25 June	35+	—	2	28[2]
3 km W of Road 40, ~5 km S of Alpaugh	478-975-002	23 June	21	—	1	16[2]
W of Road 40, ~6 km S of Alpaugh	478-974-001	22 June	32	—	3	25[2]
Kern County						
Kern Fan Element Water Bank (Pond W-2)	478-933-002	20 June	7	—	1	6[2]
Total						226

[a]Numbers of adults from counts of undisturbed birds (see Methods). —, no data available.

[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.

habitat remained through summer, but prolonged snowmelt floods (Apr–June) in the San Joaquin Valley, particularly in the Tulare Basin, likely left that region with the most ephemeral habitat for breeding terns. Water management infrastructure now reduces the frequency of floods five to ten fold and likewise limits their duration (The Bay Institute 1998). Still, today in the closed Tulare Basin in extreme winters flood waters are diverted into shallow storage basins or run unchecked into fields, leaving potential breeding habitat.

Grinnell and Miller (1944) noted a partial shift of breeding terns to rice fields, but it is unclear how widespread or numerous they were in this habitat, which in 1943 totaled 96,000 ha in California (see Shuford et al. 2001). Extensive wetland loss in the Sacramento Valley was offset by expansion of rice to the current annual level of 160,000 to 200,000 ha, which, though of uncertain equivalency, may far exceed the average historic extent of shallow-water wetlands available there in spring and summer (Shuford et al. 2001). By contrast, wetlands lost in the San Joaquin Valley have been replaced to only a tiny degree by rice, which has declined there slowly since the mid-1950s. Terns formerly bred in rice fields as far south as Kern County but no longer breed in that habitat south of northern Fresno County.

Cogswell (1977) concluded that tern numbers declined initially from wetland loss, increased with expansion of rice culture, 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. Numbers of Black Terns recorded on surveys of pheasant broods in Butte County, 1976 to 1992 (J. Snowden in litt.), did not show a significant temporal trend but appeared to track the county's rice acreage (Shuford et al. 2001). Numbers of Black Terns on the only BBS route (no. 148) in California on which they are fairly numerous (median = 8, min.-max. = 0-54, n = 30 yrs), in Glenn and Colusa counties, appeared to increase from 1972 to 2003 while showing substantial variability (Sauer et al. 2004).

In 1998, following an El Niño winter, an estimated 2213 pairs bred in the Central Valley, of which 1987±594 (±SE) were in Sacramento Valley rice fields; overall about 89.8%

were in the Sacramento Valley, 10.2% in the San Joaquin Valley (Shuford et al. 2001, Tables 15 and 16). Although birds were spread widely in rice, largest numbers there were in the northern Colusa Basin. In the San Joaquin Valley, about 75 pairs bred at five sites in the San Joaquin Basin (70 pairs at two rice areas) and 151 pairs at six sites in the Tulare Basin. Refuges or reserves held <1% of Central Valley terns, private lands the rest. The current tenuous status of the species 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. The latter area, however, perhaps may always have been an important, though poorly documented, breeding area.

Migratory Stopovers

Tule Lake NWR, Siskiyou and Modoc counties, is a very important postbreeding or migratory stopover for Black Terns in late summer, when they appear to be attracted to large numbers of damselflies (D. Mauser in Shuford et al. 2004, 2006). From 1949 to 1977, estimated peak counts of Black Terns at Tule Lake from July to early September ranged from 2000 to 19,000 individuals (n = 17 yrs, median 5000; Shuford et al. 2001). Estimates of tern numbers there in July–August 1997, ranged from 1000 to 6000 birds, and the peak count in 2003 was 4621 (Shuford et al. 2001, 2004). In five years from 1958 to 1972, peak counts at Lower Klamath NWR in August exceeded 1000 (maximum 9000; Shuford et al. 2001), but large numbers are no longer reported there at that season (Klamath Basin NWR files). The only other major stopover site 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. 2003), but the only census, 13–16 August 1999, tallied 4011 individuals (Shuford et al. 2000, 2002). Small (1994) implied numbers have declined at the Salton Sea since 1987, but there is no evidence of this (M. Patten in litt.); numbers of migrants have declined historically on the southern California coast (Garrett and Dunn 1981).

Ecological Requirements

Information on ecological requirements of the Black Tern in California are restricted mostly to general accounts of habitat and nest site use as described below by region. Diet studies are lacking in California, but elsewhere breeding Black Terns are mainly insectivorous. Fish, however, make up a large part of the diet in some habitats and regions (Dunn and Agro 1995) and may dominate the diet by mass and provide an important source of calcium (Beintema 1997).

Black Terns nest semicolonially in favorable areas of marshes (Dunn and Agro 1995). Ideal nest sites provide protection from wind or waves, cover for chicks, and, presumably, camouflage to incubating adults without greatly hindering their access to the nest site or reducing their visibility of approaching predators (Shuford 1999). Nests are small cuplike gatherings of vegetation usually built on floating substrates of matted or decaying marsh vegetation, detached root masses, logs and boards, muskrat feeding platforms or clippings, algae or peat mats, lily pads, dried cowpies, and old nests of grebes, coots, and Forster's Terns. These substrates are usually anchored to, or lodged in, emergent vegetation or dense beds of submerged rooted aquatics. Nonfloating nest substrates (within a marsh matrix) include muskrat lodges, raised mud patches, marshy hummocks, rooted flattened vegetation, and upturned tree roots with attached vegetation.

In northeastern California, most of the Black Tern's breeding marshes are dominated by low (<1 m) emergents, typically spikerush or *Juncus* spp. (Gould 1974, Shuford et al. 2001), and vegetative cover (vs. open water) usually is >80% (Shuford et al. 2001). Taller emergents, such as *Scirpus* spp. (see Shaw 1998), infrequently dominate breeding areas. At Lower Klamath NWR, terns sometimes nest in shallowly flooded units lacking much live emergent vegetation but dominated instead by residual barley stubble and algae mats (Shuford et al. 2001). At Boot Lake, Lassen County, in the Warner Mountains at 6560 ft (2000 m), breeding habitat is dominated by a floating yellow pond-lily (*Nuphar luteum* ssp. *polysepalum*). At Rowlands Marsh, Lake Tahoe, terns formerly nested in pond lily, water smartweed (*Polygonum amphibium* var. *stipulaceum*), or "marsh grass" (Orr and Moffitt 1971). Most floating nests are over water about 25 to 80 cm deep and supported by emergent vegetation, abandoned nests of grebes or Forster's Terns, floating boards or logs, floating cowpies, muskrat rafts, reed or algal debris, or small earthen hummocks (Orr and Moffitt 1971, Gould 1974, Shaw 1998, Shuford 1999).

In the Central Valley, habitat use has shifted greatly historically. Black Terns in this region formerly nested in ephemeral, early successional habitats created by natural overflow of rivers and lakes (Mailliard 1904, Tyler 1913, van Rossem 1933) or by flood irrigation of pasturelands (Chapman 1908). Today few of the Central Valley's terns breed in marshes or overflow habitats. Valleywide in 1998, 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 (Shuford et al. 2001). All breeding evidence in the Sacramento Valley was from rice, though one colony in Glenn County was in sedges in the corner of a field rather than in the rice itself. In 2002, at least two pairs of Black Terns were breeding in a brood pond on a duck club in Colusa County dominated by spikerush and interspersed with numerous small pockets of open water (C. Isola in litt.). Also in 2002, 4–5 nests were initiated, but later failed, at a large wetland unit at Sacramento NWR being managed as permanent water (M. Wolder in litt.). This was the first known nesting attempt on any federal refuge in the Sacramento Valley since at least the early 1980s (J. Silveira pers. comm.), though Black Terns bred at Sacramento NWR in 1958 (Appendix 9), when rice was regularly grown on the refuge. Of 226 pairs in the San Joaquin Valley in 1998, 66.8% were in flooded agricultural fields with residual crops or weeds, 31.0% in rice, and 2.2% in emergent wetlands of low stature (Shuford et al. 2001). In the Sacramento Valley, Lee (1984) reported nests in rice fields built on top of dirt mounds, about 10 cm high, unintentionally created during field preparation. Water depths at nests ranged from 5 to 15 cm before farmers raised water levels in July.

Threats

In northeastern California, the effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland nesting and foraging habitat for waterbirds, including terns. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR, exacerbating the effects of droughts. Although breeding habitat for Black Terns may be affected by water shortages, foraging habitat for these terns at Tule Lake, where they stage in large numbers in summer and early fall, will retain some priority for summer water for remnant populations of the endangered Lost River and shortnose suckers. As noted for other species, however, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented.

Concern has been expressed over the potential impacts of increasing human recreation on waterbirds at Eagle Lake (Gould 1974, Shaw 1998). This is not likely, however, to be a widespread regional problem given the shallow, densely vegetated marshes preferred by the terns are not suitable for fishing and boating.

In the Central Valley, Black Terns currently are vulnerable to lack of protection on private lands and potential changes in water allocation priorities to accommodate California's burgeoning human population. Large shifts from rice to other less water-consumptive crops likely would greatly affect terns. Agricultural practices that rapidly draw down water levels in rice fields have exposed tern nests to rat predation only to later destroy renesting attempts when fields were reflooded above initial levels (Lee 1984). Three egg yolks collected from a 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 there. Dunn and Agro (1995) and Weseloh et al. (1997) reviewed the impacts of contaminants in tern eggs but found no evidence of impaired reproduction. They concluded direct chemical toxicity is generally not a problem with these terns, but pesticides may reduce favored insect foods. Loss of insect diversity or biomass might lead to chick starvation.

Management and Research Recommendations

- Focus on restoring, enhancing, and providing long-term protection for suitable wetlands and on maintaining isolation of colonies from humans and ground predators.
- Protect habitats at key stopover areas, such as Tule Lake NWR and the Salton Sea.
- Conduct research on the foraging and nesting ecology of Black Terns in California, on movements of banded birds with changing water conditions, and on population demography to identify which breeding sites do, or do not, produce enough young to maintain the local population and to what degree this varies over time.
- Priorities in Northeastern California should be to:
- Try to establish spikerush-dominated marshes, the species' main breeding habitat in the region, on refuges that currently hold few breeding Black Terns.
- Secure an maintain an adequate long-term water supply for refuges in the Klamath Basin to enable effective management for the region's breeding terns.
- Priorities in the Central Valley should be to:
- Consider enhancing tern habitat primarily in years of exceptional runoff, when it will do the most good, thereby exploiting the tendency of waterbirds to exhibit boom and bust cycles of productivity. In such years, try to increase limited breeding on newly restored wetlands on refuges near Los Banos by spreading water over larger areas within the Eastside Bypass near Los Banos and the James Bypass/Fresno Slough south of Mendota WA or by drawing water from upstream, circulating it through refuge ponds, and draining it back into the bypass downstream. Maintain a slow but steady flow to reduce the chances of botulism.
- When possible, flood fields containing residual vegetation or crop stubble for use as breeding habitat. Explore retiring fields with marginal crop yields and putting them in a conservation bank to be flooded when water is available. Weigh such flooding against possible mortality of waterbirds from botulism disease outbreaks, which might be reduced by rotating fields to be flooded and choosing areas with no prior evidence of disease.
- Expand research to address concerns about the potential effects of agricultural pesticides and crop cultivation practices on Black Terns (Lee 1984).
- Conduct studies to assess whether the value of rice fields to Black Terns equals that of ephemeral overflow habitat or natural marshes.

Monitoring Needs

The state's breeding population should be monitored every 3–5 years, during typical climatic and habitat conditions, using methods responsive to the shifting of breeding locations. In northeastern California, Black Terns should be surveyed in mid-June by counts of undisturbed adults taken from peripheral or within-wetland sites 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. In the Central Valley, these terns should be monitored by a set of standardized roadside transects in rice fields in the Sacramento Valley run in early June.

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FORSTER'S TERN (*Sterna forsteri*)

General Range and Abundance

The Forster's Tern is the only tern species restricted almost entirely to North America throughout the year. It breeds at scattered locations from coast to coast and from south-central Canada south to northern Baja California Norte and the Gulf Coast of Tamaulipas, Mexico (McNicholl et al. 2001). The largest fairly contiguous breeding areas are in an arc across the Prairies of southern Canada and the northern United States and in the Intermountain West of northeastern California, southeastern Oregon, northern Nevada, southern Idaho, and northern Utah. Recent published estimates of breeding populations within specific geographic area are: Canada (2133–4216 pairs); the Great Lakes (3025 pairs); the U.S. Atlantic (5766 pairs), Pacific (8095 pairs), and Gulf (23,096 pairs) coasts; and Baja California, Mexico (30–35 pairs) (references in McNicholl et al. 2001). By contrast, Kushlan et al. (2002) estimated the continental population at 47,000–51,500 *breeders* (not pairs).

This species winters along the Pacific Coast from northern California (principally San Francisco Bay area) south through Baja California and west Mexico to El Salvador; on the Atlantic Coast from southern New Jersey south through Florida; along the Gulf Coast of the United States and Mexico south to the Yucatán; and from Honduras south (rarely) to Costa Rica and Panama (McNicholl et al. 2001). It winters in the interior of the United States in southern California and portions of the Gulf Coast states and Florida, and in Mexico in Baja California, on the Atlantic and Pacific slopes, and the central interior. In summer, nonbreeding immatures are found throughout the winter range.

Conservation Concern

The North American Waterbird Conservation Plan considered this species to be of "moderate" conservation concern (Kushlan et al. 2002). It is not on any federal list in the United States or Mexico and is assigned indeterminate status by the Committee on the Status of Endangered Wildlife in Canada (McNicholl et al. 2001). In the United States, this tern is listed as endangered in Illinois and Wisconsin and a species of concern in Michigan and Minnesota. For the period 1966–2007, Breeding Bird Survey (BBS) data showed a decline of –0.8 per year for California and increases of 0.7 per year for both the United States and surveywide, but all are insignificant and deficient (Sauer et al. 2008); also, BBS methods generally are inadequate for surveying colonial waterbirds and undersample marshes (Bystrak 1981, Robbins et al. 1986).

Seasonal Status in California

The Forster's Tern occurs year round in California but its seasonal status varies substantially by region. The breeding season extends from May through early September (Cogswell 1977, Gould 1974, Appendix 10); at individual sites, the timing of nest initiation can vary considerably among years or subcolonies (Gould 1974, Shaw 1998). Birds occur primarily from April through September in the northern and central interior (Gould 1974; Summers 1993; Shuford et al. 2004, 2006), and year round on the coast (Humboldt Bay southward), in the Sacramento–San Joaquin River Delta, and (locally) in the southern interior (McCaskie et al. 1979, Garrett and Dunn 1981, Harris 2005, CBC data). This species also occurs widely during migration and may summer nearly anywhere in the normal migrant and winter ranges.

Breeding Range and Abundance in California

Grinnell and Miller (1944) described the Forster's Tern as breeding sparsely in California on the northeastern plateau and locally in the Central Valley. Their indication of breeding in "northern Monterey County" refers to egg sets collected in 1932 and 1933 at the Salinas River mouth (then at Moss Landing) and vicinity (MVZ collection). Locations of confirmed breeding in northeastern California pre-1945 are Tule Lake, Siskiyou/Modoc counties; Alturas and Laguna at Willow [Creek] Ranch, Modoc County; Grasshopper Meadows and Eagle Lake, Lassen County; Lake Tahoe, El Dorado County; and Bridgeport (Sweetwater) Reservoir, Mono County (Grinnell and Miller 1944; Appendix 10). Such sites in the Central Valley include near Reigo, Sutter County; vicinity of Sacramento (Co.?); Los Banos and near Dos Palos, Merced County; sites in Madera and Fresno counties; Gearnsey's Slough and Tulare Lake, Kings County; and Buena Vista Lake, Kern County.

Historical estimates of the size of breeding colonies of the Forster's Tern in California are few. At Eagle Lake, J. Moffitt (in Grinnell et al. 1930) reported "nearly 100 pairs" were breeding near Spaulding's (Spaulding Tract) in June 1925. The 125–150 individuals at Rowlands Marsh, Lake Tahoe, in May 1927 were considered to represent usual summer numbers for that locale; 40 nests were found there on 5 June 1927, and 6 others elsewhere in the marsh that summer (Orr and Moffitt 1971). In the San Joaquin Valley, estimates of large colonies include "about 100 pairs" in Madera County, 12 mi east of Firebaugh (Fresno. Co.) on 13 June 1925 (J. G. Tyler, egg data slip, WFVZ); "about 200 pairs" at Los Banos on 10 June 1925 (D. B. Bull and W. E. Unglish, egg data slip, MVZ); and Buena Vista Lake records of 500–600 pairs in early July 1920 (A. van Rossem, egg data slips, WFVZ) and about 100 pairs on 23 May 1923 (J. G. Tyler field notes).

Today the Forster's Tern still breeds in the interior, widely in northeastern California and very locally in the Central Valley, and has colonized the coast from San Francisco Bay southward, the Salton Sea, and one site on the coastal slope of Orange County. In northeastern California, extensive wetland loss, particularly in the Klamath Basin, may have been partially offset on the Modoc Plateau by historic creation of shallow-water reservoirs for livestock grazing and recent enhancement for waterfowl (T. Ratcliff and G. Studinski pers. comm.). Forster's Terns were severely affected by the great historic loss of Central Valley wetlands and the massive alteration of the natural hydrologic regime, as described in detail above in the Black Tern account. Although the latter species has adapted to breeding in cultivated rice in the Central Valley, the Forster's Tern has not. Currently, the Forster's Tern is extirpated as a breeder in the Sacramento Valley and breeds very locally in the San Joaquin Valley, mainly in very wet years. In such years, breeding terns tend to concentrate in the closed Tulare Basin, where potential breeding habitat is formed as winter flood waters are diverted into shallow storage basins or run unchecked into fields. Post-1945 estimates of the breeding abundance of this tern are mostly anecdotal (Appendix 10), though biologists have estimated numbers at the Klamath Basin National Wildlife Refuges since at least 1952 (Table 17) and at Eagle Lake several times since 1970 (Appendix 10).

Surveys in 1997–1998 found about 2357 pairs nesting at 34 sites in the interior (Figure 7), with about 77% in northeastern California and 23% in the San Joaquin Valley (Shuford 1998, Shuford et al. 1999, Tables 18 and 19). In 1997, an estimated 1800 pairs were nesting at 20 sites in northeastern California; a colony at South Lake Tahoe, not checked in 1997, held 16 pairs in 1998 (Table 18). Goose Lake and Boles Meadow combined held about 50% of the regional total. Six other sites—each with >50 pairs (Butte Valley WA, Lower Klamath NWR, and the [upper] Sump 1-A of Tule Lake NWR, Siskiyou County; Fairchild Swamp, Modoc County; and Eagle Lake and Grasshopper Valley, Lassen County)—held an additional 41%. Surveys in 1998, following an El Niño winter, estimated 541 pairs of Forster's Terns breeding at 10 locations in the San Joaquin Valley (Shuford et al. 1999, Table 19). Of these, about 75 pairs (13.9%) were at one site (Turlock Lake, Stanislaus County) in the San Joaquin Basin and 466 (86.1%) were at nine sites in the Tulare Basin.

Extirpation of the Forster's Tern from the Sacramento Valley and its current tenuous status in the San Joaquin Valley documents a major population decline in the Central Valley over the last 100 years. This has been offset to an unknown degree primarily by substantial colonization of the California coast. Coastal colonies have been active since at least 1948 in San Francisco Bay (Sibley 1953; 1000–2500 pairs in South Bay from 1970s to 1990s, Ryan 2000), from 1932 to 1949 at the Salinas River mouth, Monterey County (MVZ collection, H. Cogswell in Carter et al. 1992), since 1962 in San Diego Bay, San Diego County (Gallup 1963; up to "2000 birds" in 1980, Sowls et al. 1980); from at least 1952 to 1980 at Elkhorn Slough/Moss Landing salt ponds, Monterey County (Sibley 1953, Sowls et al. 1980); and since 1986 at Upper Newport Bay (AB 40:1255) and 1987 at Bolsa Chica, Orange County (AB 41:1488; increasing to over 200 pairs, C. Collins in Ryan 2000).

Also, small populations have been established in the interior of southern California at the Salton Sea, Riverside and Imperial counties (Molina 2004) and about 16 mi (26 km) from the coast at the Burris Sand Pit (reservoir) adjacent to the Santa Anna River between Anaheim and Orange, Orange County, since 1999 (about 12–15 pairs in 1999, 24 in 2000; D. Willick in litt.). Nesting was first documented at the

Table 17 Numbers of Nesting Forster's Terns at Tule Lake, Lower Klamath, and Clear Lake National Wildlife Refuges, 1952 to 1995[a]

	Tule Lake		Lower Klamath		Clear Lake	
Year	Nests	Young[b]	Nests	Young[b]	Nests	Young[b]
1952	300	800	0	0	—	—
1953	300	800	—	—	—	—
1954	—	640	23	60	—	—
1956	350	900	30	80	—	—
1957	650	700	100	200	28	60
1958	—	—	—	—	20	40
1963	100	250	—	—	—	—
1964	100	200	—	—	—	—
1965	100	200	50	100	30	160
1966	180	200	70	30	100	150
1967	350	400	—	—	—	—
1968	250	300	100	50	—	—
1969	280	375	220	300	—	—
1970	160	200	—	—	30	60
1971	—	—	—	—	67	70
1972	480	400	44	120	219	230
1973	—	320	—	—	—	142
1976	—	—	26	20	—	—
1977	—	80	—	—	—	40
1979	120	200	—	40	—	—
1990	0	0	—	—	—	—
1991	0	0	250	—	—	—
1995	8	—	—	—	—	—

[a]Data from the files and Annual Narrative Reports of the Klamath Basin National Wildlife Refuges unless otherwise indicated. Data quality generally Category 3, as in very few instances are descriptions of methods and dates of surveys available. Nesting occurred at least in some other years, e.g. in 1985 a "new" nesting colony was observed in Unit 12A of Lower Klamath NWR. —, no data available.

[b]Estimated number of young fledged.

Salton Sea at the mouth of the New River, Imperial County, in 1970 (2 nests, AFN 24:717; Appendix 10), though apparently "a few nested in 1939" (L. Goldman in Molina 2004). About 20 pairs were nesting at the mouth of the New River in 1972 (McCaskie et al. 1974). The maximum nesting population of Forster's Terns estimated for the Salton Sea was 200 pairs at the north end in 1978 (Garrett and Dunn 1981, AB 32:1208–1209). The species currently breeds mainly, and irregularly, at the south end of the Salton Sea (Molina 2004). Nesting was documented there in 1992 (about 20 pairs), 1993 (15–20 pairs), and 1994 (15–20 pairs) and was suspected at an inaccessible site in 1995 and 1996. Comprehensive surveys of the Salton Sea in 1999 did not detect nesting by this species (Shuford et al. 2000, 2002).

Ecological Requirements

Forster's Terns nest colonially in freshwater, brackish, and saltwater marshes, including the marshy borders of lakes, islands, or streams (McNicholl et al. 2001). At inland sites, breeding terns are found more often in the open, deeper portions of marshes, generally in wetlands with considerable open water and large stands of island-like vegetation or mats of floating vegetation. In Iowa, Brown and Dinsmore (1986) found this species breeding only in marshes >20 ha. In freshwater marshes, nests are usually within or adjacent to clumps of vegetation, often next to or close to open water, and may be on muskrat (*Ondatra zibethicus*) lodges, mats of floating vegetation, abandoned grebe nests, or artificial nest platforms (McNicholl et al. 2001). Inland these terns also nest on the ground (in or near scattered vegetation) on islands within marshes, saline or freshwater lakes or reservoirs, and large rivers (Hall 1988,1989; Shuford 1998, Shuford et al. 1999).

Along the Atlantic and Gulf coasts, these terns breed mainly on wrack deposits covering saline or brackish marsh vegetation on near-shore islands and less often on floating mats of vegetation in mainland marshes; terns also occasionally nest on sand or shell beaches with wrack deposits and nearby vegetative cover (Martin and Zwank 1987). Wrack and vegetation provide nest support and cover for chicks. Predator-free islands favored are typically small (>0.1 to <20 ha), low-lying (<0.5 m max. elevation, i.e., periodically flooded), and isolated (1–3 km, water depth >0.5 m) from the mainland or large (>20 ha) islands. At Atlantic Coast salt marshes, the characteristics of nest sites (vegetation height, distance to open water, orientation relative to prevailing winds) tempered the effects of tidal flooding (Storey 1987). In coastal California, most terns nest on dredge spoil islands and degraded, insular levees in current or former salt ponds but also in slough channels and diked marshes (Gill 1972, Dakin 2000, Ryan 2000). Terns nesting on dredge spoil islands in south San Francisco Bay select sites with vegetative cover when available and sites within 0.4 m of a moderately steep area of substrate providing cover or restricting visibility from above; birds apparently use topography and vegetation as cover from predation and extreme weather (blowing froth from high winds, Dakin 2000). At the Salton Sea, these terns have nested on the inner aspect of a perimeter levee and on hummocks of vegetation on shallowly flooded mudflats near the shoreline, where nests were inundated by wind-driven waves (Molina 2004).

Of an estimated 1816 pairs of Forster's Terns in northeastern California in 1997–1998, about 52% nested on low-lying, sparsely vegetated or barren islands at 4 sites; about 42% on the edges of or in openings within marsh vegetation (generally of moderate height, i.e., >1 m) at 15 sites; and 6% apparently both on islands and in marshes at 2 sites (Shuford 1998, unpubl. data). Terns at Goose Lake frequently nested on accumulations of wave-cast wrack, supplemented by Canada Goose feathers, on islands with monotypic stands of low saltgrass (*Distichlis spicata*), and at Honey Lake WA some terns nested on floating mats of marsh vegetation cut by muskrats. At Eagle Lake, Forster's Terns sometimes nest in association with *Aechmophorus* grebe colonies (Gould 1974, Shaw 1998). Tern nests were in *Juncus*, *Scirpus*, and *Polygonum* beds, over water 61–127 cm deep, in areas protected from prevailing winds and accompanying wave action.

Table 18 Numbers of Adult Forster's Terns, Nests, and Estimated Pairs at Sites in Northeastern California in 1997[a]

Site	Colony code	Survey date	Number of adults[b]		Number of nests[c]		Estimated pairs[e]
			Disturbed	Undisturbed	Total	Partial[d]	
Siskiyou County							
Prather Ranch north[f]	326-271-004	15 July	—	11	—	FL	8[3]
Butte Valley WA (Meiss Lake)	326-271-001	13 July	—	140	—	FL, M	98[3]
Lower Klamath NWR							
Unit 3A	327-186-001	19 June	—	41	—	2	29[3]
Unit 4D	327-186-003	18 June	—	—	18	—	18[1]
Unit 4E	327-186-004	18 June	—	—	46	—	46[1]
Unit 11B	327-186-005	18 June	—	—	63	—	63[1]
Tule Lake NWR (upper) Sump 1-A	327-185-001	20 June	—	324	—	18	226[3]
Subtotal							488
Shasta County							
Horr Pond	327-114-001	4 July	—	5+	—	CF, N	4[3]
Modoc County							
Egg Lake	327-133-001	1 July	—	32	—	1+	22[3]
Boles Meadow (islands)	327-068-001	7 June	~700	—	443	—	443[1]
Fairchild Swamp	327-057-001	4 June	—	166+	—	3	116[3]
Raker and Thomas Reservoir	327-065-002	30 May	20	—	8	—	8[1]
Goose Lake	327-074-001	18–19 May	916+	—	—	259	458[2]
Subtotal							1047
Lassen County							
Ash Creek WA, Lassen and Modoc cos.	327-121-001	all summer	—	~20	—	—	~14[2]
Mountain Meadows Reservoir (main)	354-038-002	7 July	—	55	—	CF, M	38[3]
Eagle Lake[g]		8–9 July	—	123	—	—	86[3]
Grasshopper Valley	354-076-001	10 July	—	77	—	—	54[3]
Horse Lake	354-065-001	8 July	—	27	—	1+	19[3]
Red Rock Lakes complex	327-012-002	27 June	—	5	—	1+	4[3]

(continued)

Of an estimated 541 pairs in the Central Valley in 1998, following an El Niño winter, 75% nested on former nest mounds of coots or on island fragments of levees at five areas of flooded agricultural fields with residual crops or weeds, 14% on an island in a large open-water reservoir, 10% on the edges of limited emergent marsh or on former grebe or coot nest mounds at two small open-water reservoirs, 0.7% on an island in a compensation wetland, and 0.2% on a levee between cells of an agricultural evaporation basin (Shuford et al. 1999, unpubl. data).

Nest substrates vary from unlined or sparsely lined scrapes in earth or sand to the vegetation of stranded wrack lines, floating rafts, algae mats, grebe or coot nests, and tops of muskrat platforms (McNicholl et al. 2001, D. Shuford pers. obs.). Nests may range from little more than a cup with no clear rim to elaborate structures built of marsh plants; in San Francisco Bay, small pieces of driftwood, shells, dried fish, bones, and feathers are often used for scrape construction (Gill 1972).

Forster's Terns typically forage by plunge-diving, often from hovering flight, into the shallow waters (or upper surface) of marshes, lakes, reservoirs, streams, salt ponds, estuaries, and inshore marine areas (Salt and Willard 1971, Baltz et al.1979, McNicholl et al. 2001). In coastal California, these terns forage in shallow water (<1 m) of intake salt ponds and flooded estuarine mudflats, catching fish 1–10 cm in length at depths up to 30 cm (Salt and Willard 1971, Baltz et al.1979). The overall diet is primarily small fishes and some arthropods (McNicholl et al. 2001). The dominant fishes (% total individuals) in the diet of Forster's Terns (n = 15 stomachs) at Elkhorn Slough, Monterey County, in July were shiner perch (44%; *Cymatogaster aggregata*), northern anchovy (36%, *Engraulis mordax*), and arrow goby (12%, *Clevelandia ios*) (Baltz et al. 1979). The Forster's Tern took smaller fish, mostly juveniles of shiner perch and anchovies, whereas the Caspian Tern took larger fish, mostly adults of these species. At San Francisco Bay, the mean size of fish caught by the Forster's steadily declined from spring to fall, perhaps reflecting the

Table 18 *(continued)*

Site	Colony code	Survey date	Number of adults[b] Disturbed	Undisturbed	Number of nests[c] Total	Partial[d]	Estimated pairs[e]
Leavitt Lake	354-035-001	8 June	48	39	31	—	31[1]
Fleming Unit (Pond 15), Honey Lake WA[h]	354-033-003	15 June	14	10	7	—	7[1]
Honey Lake North, private	354-033-002	15 June	3	—	2	—	2[1]
Subtotal							255
Plumas County							
Sierra Valley (S of steel bridge)	380-073-001	25 May	—	8+	—	NB	6[2]
El Dorado County							
Pope Marsh, South Lake Tahoe	405-081-001	14 June	—	29+	16+	—	16[1]
Total							1816

[a]All counts taken in 1997 except at Pope Marsh, South Lake Tahoe, where taken in 1998. —, no data available.

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

[c]Number of nests from either total or partial counts (see Methods). Nests counted on the basis of observations of eggs, small chicks, or adults sitting in incubation posture on obvious nests, except at Egg Lake, Horse Lake, and Red Rocks Lake complex, where counts made on the basis of observations of adults carrying fish repeatedly to apparent nest sites hidden in the marsh.

[d]In some cases no actual nests were located but evidence observed indicated a strong probability that nesting was in progress: CF, adult carrying fish, presumably to feed females during courtship or dependent young at the nest; FL, fledged young probably restricted to vicinity of nesting areas; M, adults mobbing observer indicating nest(s) or young nearby; N, adults at apparent nest site but view obscured by vegetation; NB, nest building.

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

[f]Possibly may represent birds that moved from nearby nesting colony at Butte Valley WA.

[g]Of 123 Forster's Terns counted from 8–9 July 1997, 14 were along the southwest shore from south of Pelican Point south to cove near Eagle Lake Resort, 90 at Spaulding (subcolony 354-067-003), 4 in Delta Bay, 1 in Buck Bay, 11 in North Basin, 2 at Troxel, and 1 in Duck Island Bay. Of 63 undisturbed adult Forster's Terns counted on 23 June 1999 (estimated to represent 44 pairs), 13 were at Spaulding, 4 at the Mouth of Pine Creek, 4 in Buck Bay, 8 in the northernmost cove just S of jct. Hwy. 139 and Eagle Lake Rd., 27 in North Basin (subcolony 354-066-004), 5 at Troxel (subcolony 354-066-003), and 2 in Duck Island Bay; adults were seen repeatedly carrying food to sites, presumably where they fed young, in marshes at North Basin and Troxel.

[h]Adults were sitting on a total of 28 nests on three small islands in Dakin Unit, Pond 6G (subcolony 354-034-002), Honey Lake WA on 19 June 1999 (D. Shuford pers. obs.).

passage (growth) of an age-class of fish through the size range at which they were vulnerable to tern predation (Salt and Willard 1971, Baltz et al. 1979). No quantitative information has been published on the diet of Forster's Terns in the interior of California.

Threats

In the interior of California, the greatest threat to the Forster's Tern historically has been the loss of suitable nesting and foraging habitat. Today the greatest threat is a lack of high quality water at wetlands. The effects of a reordering of water priorities in the Klamath Basin in 1995 have threatened to reduce or degrade wetland nesting and foraging habitat for waterbirds, including terns. Shortages of water or inappropriate timing of delivery to wetlands on Lower Klamath NWR, particularly in summer and fall, have been occurring with increasing frequency (USBR 1998, D. Mauser pers. obs.). In addition, water quality is often poor because of high background nutrient concentrations coupled with a loss of much of the natural filtering function of riparian and wetland habitats within the watershed. Water shortages in particular may potentially affect various colonial waterbird colonies at Lower Klamath NWR, exacerbating the effects of droughts. Fortunately, nesting and foraging habitat for Forster's Terns at Tule Lake will retain some priority for summer water for remnant populations of the endangered Lost River sucker and shortnose suckers. As noted for other species, however, the long-term risk of inadequate water supplies for wildlife appears to have been reduced in 2008 when key stakeholders reached a tentative settlement to major water disputes in the basin, which remains to be implemented.

Table 19 Numbers of Adult Forster's Terns, Nests, and Estimated Pairs at Breeding Sites in the San Joaquin Valley in 1998

Site	Colony code	Survey date	Number of adults[a]	Number of nests[b]		Estimated pairs[c]
				Total	Partial	
Stanislaus County[d]						
Turlock Lake	430-055-001	3 July	~150	—	~50+	75[2]
		11 July	100–150	—	—	50–75[2]
		1 Aug	~55 ad., 30 juv.	—	—	—
Kings County						
Corcoran Irrigation District Reservoir #1	455-925-002	25 June	101	—	38+	51[2]
Corcoran Irrigation District Reservoir #2	455-925-001	1 July	5	3	—	3[1]
Lost Hills Water District and Rainbow Ranch compensation wetland	455-918-001	19 May	—	3	—	3[1]
		26–27 May	8	4	—	4[1]
		3 June	—	4	—	4[1]
		9–10 June	8	4	—	4[1]
S of Hacienda Ranch Flood Basin #1	478-976-002	19 June	237	134	—	134[1]
S of Hacienda Ranch Flood Basin #2	478-976-003	19 June	61	—	13	—
		13 July	—	74	—	74[1]
South Evaporation Basin, Tulare Lake Drainage District	478-976-004	10 May	—	1	—	1[1]
		17 May	—	0	—	—
Tulare County						
Alpaugh Irrigation District Reservoir lands	478-984-001	25 June	76	—	13	38[2]
~2 km W of Road 40, ~6 km S of Alpaugh	478-975-003	22 June	255	—	80	128[2]
Kern County						
Kern Fan Element Water Bank (Pond W-5)	478-933-001	20 June	66	—	28+	33[2]
Total						541

[a]Numbers of adults from undisturbed counts (see Methods). —, no data available.

[b]Number of nests from either total or partial counts (see Methods). Nest counts based on observations of small chicks or of adults sitting in incubation posture on obvious nests.

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

[d]About 15 pairs bred at Woodward Reservoir (colony 430-077-001), Stanislaus County, in 1999 on the basis of observations of 12 nests with eggs and 6 mobile chicks on 12 July (J. Gain, J. Turner pers. comm.).

Although the nesting population of this species is quite small at the Salton Sea, salinity there is predicted within about one to two decades to reach concentrations that will severely affect populations of invertebrates and fish and, by extension, those of the sea's fish-eating birds (Tetra Tech 2000), such as terns.

Despite a lack of studies of contaminants in Forster's Terns in the 1960s and 1970s when their effects were greatest in other fish-eating birds, subsequently organochlorines, heavy metals, and selenium have been measured in their eggs (references in McNicholl et al. 2001). Although reproductive effects on Forster's Terns have been documented elsewhere, this was not the case in the only California study of this species in 1982 at Bair Island in San Francisco Bay, where DDE, PCBs, *trans*-nonachlor, and mercury occurred at elevated levels in the eggs of this and other terns and ardieds (Ohlendorf et al. 1988). Although contaminants at the Salton Sea have not been shown to cause large-scale die-offs or other major problems, there is still ongoing concern for the potential risk to waterbirds of reproductive impairment or immunotoxicity from selenium, boron, and DDE (e.g., Setmire et al. 1990, 1993; Bruehler and de Peyster 1999).

Although many Forster's Terns nest at remote locations in the interior, others are susceptible to disturbance at nest sites (particularly on islands) in lakes and reservoirs heavily used for human recreation (Gould 1974, D. Shuford pers. obs.).

Forster's Terns nesting at evaporation ponds and alternative wetlands in the San Joaquin Valley, surrounded by a sea of agriculture, have very high rates of predation (J. Seay pers. comm.).

Management and Research Recommendations

The biology and ecology of the Forster's Tern has been poorly studied relative to other tern species (McNicholl et al. 2001), particularly in California. Similarly, little active management currently is being conducted for this species in the state. For additional details on research and management needs of this species, beyond those described below, the reader should consult Mossman's (1989) recovery plan for the Wisconsin population and McNicholl and other's (2001) review of this tern's biology. Recommendation for California are to:

- Focus on restoring, enhancing, and providing long-term protection for suitable wetlands and on maintaining isolation of colonies from humans and ground predators. At sites with high human use, restrict boat access or lower speed limits near colonies and prohibit landing on islands occupied by nesting terns.
- Conduct research on the foraging and nesting ecology of the Forster's Tern in California, on movements of banded birds with changing water conditions, and on population demography and limiting factors to identify which breeding sites do, and do not, produce enough young to maintain the local population and to what degree this varies over time. Compare breeding biology of marsh-nesting and island-nesting colonies and between inland and marine populations. Investigate whether banded birds move between inland and coastal breeding sites.
- Identify characteristics of islands and marshes used for breeding in northeastern California and create additional ones at various wetlands, wildlife refuges, and reservoirs.
- Consider enhancing tern habitat in the Central Valley primarily in years of exceptional runoff, when it will do the most good, thereby exploiting the tendency of waterbirds to exhibit boom and bust cycles of productivity. In such years, try to increase limited breeding on agricultural evaporation ponds, alternative wetlands, and agricultural lands in the Tulare Basin.
- When possible, flood fields containing residual vegetation or crop stubble for use as breeding habitat. Explore retiring fields with marginal crop yields and putting them in a conservation bank to be flooded when water is available. Weigh such flooding against possible mortality of waterbirds from botulism disease outbreaks, which might be reduced by rotating fields to be flooded and choosing areas with no prior evidence of disease.

Monitoring Needs

A statewide survey of the breeding population should be conducted about every 10 years, during typical climatic and habitat conditions, to document potential range shifts and calibrate long-term monitoring data. Monitoring should be conducted annually by trained observers taking comprehensive nest counts at a representative number of colonies in both northeastern California and on the coast; if possible monitoring also should be conducted at the few regular breeding sites in the San Joaquin Valley. Methods should incorporate and standardize ongoing monitoring protocols at some coastal sites and should suit local conditions, account for the difficulty of reaching some sites, and be responsive to the shifting of breeding locations and annual or local variability in the timing of nest initiation.

It also would be valuable to periodically monitor contaminant levels in tern eggs, both from coastal and inland populations, and the levels of human disturbance at colonies at lakes with high human use, such as Eagle Lake.

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ADDITIONAL INLAND BREEDERS

Although not surveyed during the present study, there are six other species of pelicans or larids (gulls, terns, skimmers) that have bred very locally or irregularly inland in California: the Brown Pelican, Laughing Gull, Franklin's Gull (*Leucophaeus pipixcan*), Least Tern (*Sternula antillarum*), Gull-billed Tern, and Black Skimmer. All but the Franklin's Gull, which breeds exclusively inland (Burger and Gochfeld 1994), are primarily coastal breeders in western North America; the Least Tern, however, breeds regularly inland (mainly along rivers) in mid-continent but not west of the Rockies (Thompson et al. 1997). For these coastal breeders, the saline Salton Sea, a mere 110 mi (180 km) inland from the Gulf of California, Mexico, is the only site where the Brown Pelican, Laughing Gull, and Gull-billed Tern have nested in the interior of California; the Laughing Gull has nested nowhere else in California. The Black Skimmer's only regular inland breeding site in California is also at the Salton Sea, though on one occasion it bred in the Tulare Basin of the southern San Joaquin Valley. The latter area currently hosts a very small population of the Least Tern. The following paragraphs briefly describe the historic and recent breeding status of these species in the interior of California; readers should look elsewhere for comparable status information for the California coast for the Brown Pelican, Least Tern, Gull-billed Tern, and Black Skimmer.

Brown Pelican (*Pelecanus occidentalis*)

At least three pairs of Brown Pelicans bred successfully on elevated mats of common reed at the Alamo River delta at the south end of the Salton Sea, Imperial County, in 1996; pelicans constructed three to five nests nearby on a rocky islet off Obsidian Butte in 1997 but no eggs were documented (Sturm 1998, Molina and Sturm 2004).

The California Brown Pelican (*P. o. californicus*) is currently listed as both federally and state endangered, and the North American Waterbird Conservation Plan considers it to be of "moderate" conservation concern (Kushlan et al. 2002).

Laughing Gull (*Leucophaeus atricilla*)

This species was first documented nesting in California in 1928, when two nests were located during an incomplete census of a set of sandy islets at the southwest corner of the Salton Sea, Imperial County, where Gull-billed Terns were first discovered nesting the previous year (Miller and van Rossem 1929). Although data on their status were incomplete, Laughing Gulls apparently nested annually at the south end of the Salton Sea until at least 1957 and possibly intermittently until 1965 (Remsen 1978). Sporadic reports indicated that up to 5 to 10 pairs of gulls bred in at least some years (Molina 2000a). The next record of documented breeding at the Salton Sea was of a single nest at Johnson Street at the north end, Riverside County, in 1994 (Molina 2000a); one, three, and five pairs bred on islets in an impoundment at Rock Hill on the Salton Sea NWR at the south end in 1999, 2000, and 2001, respectively (Molina 2004).

The North American Waterbird Conservation Plan considers the conservation status of the Laughing Gull to be "not currently at risk" (Kushlan et al. 2002).

Franklin's Gull (*Leucophaeus pipixcan*)

This species was first documented breeding in California in 1990 at Lower Klamath NWR, Siskiyou County, in the Klamath Basin (Summers 1993, Burger and Gochfeld 1994), and small numbers have been present there in summer in most years since. The Franklin's Gull was very rarely seen in the Klamath Basin in the 1970s and early 1980s (R. Ekstrom in litt.) but has since increased both as a migrant and breeder. Through the early 1990s annual high counts of migrants were in the single digits, typically <5; high counts of migrants and/or breeders often eclipsed double digits from 1995 to 2003, reaching peaks of 51 at Lower Klamath NWR on 8 July 2000 and 53 at Tule Lake NWR on 5 May 2002 (R. Ekstrom in Shuford et al. 2004, 2006). Reports of unprecedented numbers of Franklin's Gulls indicated that many hundreds of them migrated through, or to, the Klamath Basin in 2003 (Shuford et al. 2004, 2006). The highest seasonal counts, of many reported that year, were 260 on 10 May at Tule Lake NWR during spring migration, 154 on 12–13 June at Lower Klamath NWR during the breeding season, and 128 on 14 August at Lower Klamath NWR during fall staging or migration. Of the 154 at Lower Klamath in mid-June, 55 were in the vicinity of a large ibis and egret colony in a hardstem bulrush (*Scirpus acutus*) marsh in Unit 13A, where the gulls were also apparently nesting; although the rest of the Franklin's Gulls at Lower Klamath at that time were not observed in suitable nesting habitat (e.g., 75 with a large roost of Ring-billed and California gulls in a newly sprouted grain field), it seems very likely given the date that most of these birds were nesting either within the colony at 13A or in marshes elsewhere at Lower Klamath. Many fewer Franklin's Gulls were observed in the Klamath Basin in 2004 than in 2003 (D. Shuford pers. obs.).

Franklin's Gulls may have bred at Honey Lake WA, Lassen County, in 1996 (C. Elphick in litt.). Observations included 3, 1, and about 10–20 birds on the Dakin Unit on 7, 8, and 9 June, respectively, and 18 on the Fleming Unit on 8 June.

The North American Waterbird Conservation Plan considers the Franklin's Gull to be of "moderate" conservation concern (Kushlan et al. 2002).

Least Tern (*Sternula antillarum*)

On the basis of its proximity to marine source populations, its saline environment, and the prior establishment there of nesting by other coastal species described above, the Salton Sea would have been a logical place for Least Terns to first have nested inland in California, particularly as this tern is a rare spring and summer visitor there (Patten et al. 2003). Instead, nesting was first confirmed in the interior of the state in the Kings County portion of the Tulare Basin of the southern San Joaquin Valley. After breeding-season observations in Kings County of a single individual at the Tulare Lake Drainage District (TLDD) North Evaporation Basin just northwest of Corcoran on 8 July 1995 (R. Hansen in litt.) and two birds at the Naval Air Station Lemoore sewage ponds on 10 July 1997 (J. Seay in litt.), the Least Tern was documented nesting in 1998 at the Westlake Farms South Evaporation Basin (FN 52:499, J. Seay in litt.). Through 2003, 1–3 pairs attempted to nest annually at these agricultural evaporation ponds; although one tern was seen in 2004, no nesting attempt was made that year (J. Seay in litt.). Nearby at TLDD's Hacienda Evaporation Basin, Kings County, one pair of Least Terns attempted to breed in 2003 and two pairs in 2004 (R. Hansen in litt.). Except for a nest on the powdery soil of an internal levee between ponds in 1998, when all ponds held water, all other nests at both sites have been on the salt-encrusted bottoms of dry ponds.

The California Least Tern (*S. a. browni*) is currently listed as both state and federally endangered, and the North American Waterbird Conservation Plan considers this species to be of "high" conservation concern (Kushlan et al. 2002).

Gull-billed Tern (*Gelochelidon nilotica*)

This tern was first documented breeding in California in 1927, when a colony estimated at 500 pairs was on three of a series of sandy islands at the southwestern end of the Salton Sea, Imperial County; this colony apparently had been active for several (perhaps six) years (Pemberton 1927). The colony was also active in 1927, and in 1937, when it apparently "was less than 200 [pairs?] in number"; April estimates were about 450 individuals in 1940, 150 (near Westmorland) in 1942, and 500 in 1949 (Grinnell and Miller 1944, AFN 3:224). Subsequently, numbers of breeding terns declined as nesting islands were flooded by rising water levels (Garrett and Dunn 1981), which increased substantially from the mid-1930s to mid-1950s and more gradually through about 1980 (Schroeder et al. 2002). Counts or estimates of tern pairs were 75 in 1957, 40–50 in 1959, and only a few through most of the 1960s (Remsen 1978). About 20 pairs nested at the mouth of the New River in 1972 (McCaskie et al. 1974); 17 pairs nested at the Salton Sea in 1976 and perhaps twice that number in 1977 (Remsen 1978). Numbers have increased since (e.g., 75 pairs with nests in 1986; AB 40:1255, G. McCaskie in litt.). Through at least the mid-1980s, apparently all nesting was at the south end of the Salton Sea, extending north on the west side to just south of Salton City (Garrett and Dunn 1981, AB 40:1255). From 1992–2001, the nesting population at the Salton Sea averaged 119 pairs (n = 10 yrs, range = 72–155, SE = 8; Molina 2004). During this period, the terns nested at a total of two sites at the north end (Colfax and Johnson streets, no longer suitable) and five sites at the south end (Obsidian Butte, Morton Bay, Mullet Is., Rock Hill, Unit 1). These sites include nearshore islets or eroded levees, an offshore island, islets in impoundments, and barnacle-beach shoreline. The reader should consult Molina (2008a) for additional information on the Gull-billed Tern's status, ecological requirements, threats, and management, research, and monitoring needs in California.

USFWS (2002) considers this species to be of conservation concern at the national level and at the regional levels that encompass the California population. California birds belong to the subspecies *vanrossemi*, with a total population estimated at fewer than 700 breeding pairs (Molina 2000b). The North American Waterbird Conservation Plan considers this species to be of "high" conservation concern (Kushlan et al. 2002). In California, the Gull-billed Tern is considered a Bird Species of Special Concern (Shuford and Gardali 2008).

Black Skimmer (*Rynchops niger*)

The Black Skimmer was first documented breeding in California in 1972, when five nests were observed at the south end of the Salton Sea (mouth of the New River, small island opposite Mullet Is.; McCaskie et al. 1974). Skimmers apparently have bred annually at the Salton Sea since, except from 1980 to 1984 and in 1989 (Collins and Garrett 1996, Molina 1996). Numbers rose rapidly to 100 pairs in 1977 and

1978 and again, after reinitiation of breeding in 1985, to 500 pairs by 1987, but generally have been variable since. From 1992–2001, the population averaged 360 pairs (n = 10 yrs, range = 100–487, SE = 38, Molina 2004). Although they have nested at other more ephemeral or poorly defined sites, during this period they nested at a total of nine sites: two at the north end (Colfax and Johnson streets), seven at or near the south end (Elmore Ranch, Obsidian Butte, Morton Bay, Mullet Is., Ramer Lake, Rock Hill, Unit 1) (Molina 1996, 2004). Nesting sites are of the same types described above for the Gull-billed Tern. Elsewhere in the interior of California, the skimmer has bred only at the Tulare Lake Drainage District South (agricultural) Evaporation Basin, Kern and Kings counties. In 1986, a single pair nested successfully in association with a large Caspian Tern colony on an island just inside the Kings County portion of the basin (AB 40:1251, R. Hansen pers. comm.). The reader should consult Molina (2008b) for additional information on the Black Skimmer's status, ecological requirements, threats, and management, research, and monitoring needs in California.

USFWS (2002) considers the Black Skimmer to be of conservation concern at the national level and at regional levels that encompass the California population. The North American Waterbird Conservation Plan considers this species to be of "high" conservation concern (Kushlan et al. 2002). In California, the Black Skimmer is considered a Bird Species of Special Concern (Shuford and Gardali 2008).

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Caspian Terns (*Hydroprogne caspia*) and Ring-billed Gulls (*Larus delewarensis*) nesting within or adjacent to relatively tall annual growth on an island near the southeastern shoreline of Goose Lake, Modoc County, California, 20 June 1999.

CHAPTER 3

Digital Atlas of Colonies of Seven Species of Inland-breeding Waterbirds in California

W. David Shuford, Chris Rintoul, Diana Stralberg, and Viola Toniolo

The digital CD-ROM atlas of the colony locations for the seven species in the interior of California, found in a sleeve at the back of this document, is what makes this a catalogue by providing regional interactive maps that enable the user to zoom in on topo maps to locate individual colony (or subcolony) sites and to retrieve information about them. As noted above, the digital atlas is also available online at www.dfg.ca.gov/wildlife/nongame/waterbirdcatalogue/.

The CD version of the digital atlas may be viewed in a web browser such as Netscape, Internet Explorer, or Safari. To start browsing the atlas, open the file "index.html" in the root of this CD. This will bring you to the atlas homepage, where you can access the interactive maps of colonies for three regions of California. Also, included are links to statewide range maps and tables of species' abundance during statewide surveys, which are copies of those found in the text of the catalogue.

Nesting gulls on low-lying islands in Meiss Lake, Butte Valley Wildlife Area, Siskiyou County, California, against the backdrop of snow-covered Mount Shasta, 24 June 1999.

California Gulls (*Larus californicus*) nesting on islands, originally built for nesting Canada Geese (*Branta canadensis*), in Unit 6A of Lower Klamath National Wildlife Refuge, Siskiyou County, California, 18 May 1994. In some years, these islands are occupied by nesting Ring-billed Gulls (*Larus delewarensis*).

Appendices

Forster's Tern (*Sterna forsteri*) nest with two recently hatched chicks and an egg in a marsh at Fairchild Swamp, Devil's Garden Ranger District, Modoc National Forest, Modoc County, California, 4 June 1997.

Nesting habitat for Forster's Terns (*Sterna forsteri*) at Fairchild Swamp, Devil's Garden Ranger District, Modoc National Forest, Modoc County, California, 4 June 1997.

Appendices include (1) details of survey coverage, by category and year for the period 1997–1999, mainly for sites found to lack colonies of the seven key species (Appendices 1-4), and (2) historical sight and egg-set records of confirmed breeding, from the late 1880s to the turn of the 21st century, for five of the key species (Appendices 5-10). Literature citations found in any of the appendices are listed above in the species account of the relevant species.

APPENDIX 1. Sites in northeastern California surveyed by airplane for selected species of breeding waterbirds on 12 and 13 May 1997.

Aerial photographic surveys were made at known American White Pelican and Double-crested Cormorant colonies, and visual searches were made for additional colonies of these and other species, particularly the Ring-billed Gull, California Gull, and Caspian Tern.

12 May 1997

Trinity County: Trinity Lake.

Shasta County: Whiskeytown Lake and Lake McCloud.

Siskiyou County: Lake Siskiyou, Lake Shastina, various small lakes in Shasta Valley, Irongate Reservoir, Copco Lake, Butte Valley WA, Lower Klamath NWR, and Tule Lake NWR (part).

Modoc County: Tule Lake NWR (part), Clear Lake, and Goose Lake.

13 May 1997

Plumas County: Butt Valley Reservoir, Round Valley Reservoir, Antelope Lake, Frenchman's Lake, and Lake Davis.

Lassen County: Eagle Lake, West Valley Reservoir (part), and Moon Lake.

Modoc County: West Valley Reservoir (part), Middle Alkali Lake, Dorris Reservoir, Upper Cummings Reservoir, unknown wetland (west of Wood Flat Reservoir), Wood Flat Reservoir, Pretty Juniper Reservoir, Raker and Thomas Reservoir, Dead Horse Reservoir, McGinty Reservoir, Crowder Flat Reservoir, South Mountain Reservoir, unnamed reservoir north of Telephone Flat Reservoir, Dry Valley Reservoir, Jones Reservoir, Baseball Reservoir, Dorris Brothers Reservoir, Reservoir C, Reservoir M, Reservoir A, Reservoir N, Fairchild Swamp, Duncan Reservoir, Williams Reservoir, Six Shooter Reservoir, Reservoir F, Beeler Reservoir, Spaulding Reservoir, Mud Lake, Hackmore Reservoir, Whitney Reservoir, and Lower Roberts Reservoir.

Shasta County: Horr Pond/Big Lake/McArthur Swamp/Hollenbeck Swamp complex.

APPENDIX 2. Sites in northeastern California surveyed in 1997 at which no breeding Black Terns were found (see Table 14 for Black Tern breeding sites).

Sites listed by county in chronological order by survey date. Numbers, if any, accompanying survey dates in parentheses represent the number of Black Terns foraging in or passing over a wetland but apparently not breeding at the site. Nonbreeding status assigned on the basis of noting a lack of seemingly suitable nesting habitat or surveying seemingly suitable habitat and finding no nests or agitated terns.

Siskiyou County: Tule Lake NWR (upper) Sump 1-A (20 June, 15 flybys), Adobe Flat Reservoir (4 July), Wiley wetlands (T39N, R4E, S3) (4 July), Dead Steer Flat (12 July), Antelope Sink (12 July), various wetlands off Dorris-Brownell Rd. and Sheep Creek Rd. (13 July), Mud Lake (T45N, R2W, S16) (13 July), lake south of Juniper Knoll Rd. (T46N, R1W, S16) (13 July), Prather Ranch south (T45N, R2W, S5) (15 July), Prather Ranch north (T46N, R2W, S34) (15 July), Sky Mountain Game Bird Club (T47N, R2W, S10&11) (15 July), and Claes Nilsson wetland (T47N, R1E, S18&19) (15 July).

Modoc County: Everly Reservoir (20 May), Householder Reservoir (21 May), Enquist Reservoir (21 May), Black Reservoir (21 May, 18 July), Sibley Lake (21 May), Oregon Rim Reservoir (21 May), Green Springs Reservoir (22 May), Drift Fence Stock Tank (22 May), Rimrock Valley Reservoir (22 May, 6 carrying food in direction of nearby Mud Lake), Green Tank Reservoir (22 May, 36, of which many flying off toward nearby Mud Lake; 18 July), Lower Roberts Reservoir (23 and 24 May), Lower Cummings Reservoir (24 May), Kelly Reservoir (24 May), Ingall Swamp (24 and 30 May), Hager Basin Reservoir (24 May), Janes Reservoir (25 May), Diamond Reservoir (25 May, 11, presumed breeders from Baseball Reservoir on foraging trip), Duncan Reservoir (26 May, 5; 22 June), Reservoir F (26 May, 7; 4 June, numerous flybys), Fourmile Reservoir (27 May), unnamed wetland (T47N, R9E, S10) ~2.5 mi south of Warm Springs (28 May), Logan Spring (29 May), Layton Spring (29 May), Lauer Reservoir (29 May), Pretty Tree Reservoir (29 May), Raker and Thomas Reservoir (29–30 May), Emigrant Spring (30 May), Wood Flat Reservoir (30 May), Upper Cummings Reservoir (30 May), Indian Valley Reservoir (30 May), Dorris Brothers Reservoir (30 May), Bailey Tank (31 May), Deer Hill Reservoir (31 May), Mosquito Lake (1 June, 1 July), reservoir east end of Widow Valley (1 June, 2 July), Antelope Reservoir (2 June), Jacks Butte Tank (2 June), Mapes Reservoir (2 June), Wild Horse Reservoir (3 June, 1 flyby), Graves Valley (3 June), Williams Valley (3 June), Reservoir C (3 June, 1 flyby), Antelope Plains (2 and 4 June), unnamed reservoir (T44N, R10E, S8) south of jct. roads to Boles Meadow and Fairchild Swamp (4 June, 3), Fairchild Swamp (4 June; 5 June, 1 flyby), Dobe Swale Reservoir (6 June, 25), Ash Creek WA (Modoc/Lassen cos.) (~15 June, 2 flybys; none on multiple other summer dates), Avanzino Reservoir (16 June, 3), Reservoir G (16 June), Wilson Valley (21 June), Grohs Brothers wetland (T48N, R9E, S20) (21 June), Kowloski Reservoir and meadow (21 June), unnamed reservoir (T47N, R6E, S2) along Rd. 108 (21 June), Double Head Lake (21 June), Lone Pine Lake (21 June), westernmost of two lakes east of Double Head Lake (21 June), Pothole Valley (21 June), Pinnacle Lake (21 June), Mud Lake near Spaulding Reservoir (21 June), Lost Valley (22

June), Hidden Basin Tank (22 June), Pond 139 east of Pinkys Pond (22 June), Reservoir N (23 June, 6), Reservoir M (23 June), Cowhead Lake (24 June), Big Mud Lake (24 June), Fee Reservoir (24 June), Lake Annie (25 June), Cambron Lake (25 June), Snake Lake (25 June), Sworinger Reservoir (part; 25 June), unnamed reservoir (T38N, R17E, S6) east of Sworinger Reservoir (25 June),West Valley Reservoir (part; 26 June), Pit River Valley near Likely (27 June), Lyneta Ranch wildrice paddies north of Likely (27 June), Little Egg Lake (30 June and 1 July, min. 3 to max. 17, presumed breeders from Egg Lake on foraging trip), Joinen Reservoir (30 June), Upper Roberts Reservoir (30 June), Taylor Reservoir (2 July), Hines Reservoir (2 July), ranch pond north of road to south end of Goose Lake west of Davis Creek (17 July, 6 flybys), and Modoc NWR (multiple summer dates).

Shasta County: Crystal Lake (6 June), Baum Lake (6 June), Horr Pond/Big Lake/McArthur Swamp/Hollenbeck Swamp complex (8 June, 2 and 4 July), Green Place Reservoir (2 July), Hopeless Flat wetland (T37N, R3E, corner S15,16,21,22) (4 July), Cornaz Lake (4 July), Bald Mountain Reservoir (4 July), Grassy Lake (4 July), Logan Lake (5 July), Summit Lake (5 July), and Shasta Valley WA (multiple summer dates).

Lassen County: Leavitt Lake (17 May, 8 June), Feather Lake (17 May, 30 June, 5 July), Hog Flat Reservoir (17 May, 10 July), McCoy Reservoir (17 May, 10 July), Grasshopper Valley (17 May, 10 July), Corders Reservoir (26 May, 12 June), Jack's Lake (26 May, 5; 11 July), Smith Reservoir (26 May, 3; 16 July), Said Valley Reservoir (8 June), Mud Lake (T31N, R9E, S29&32) (8 June), Lake Norvell (8 June), Mahogany Lake (8 June), Colman Lake (8 June), Long Lake just south of Hwy. 44 (8 June), Papoose Meadows (8 June, 9 July), Summit Lake (9 June), Bullard Lake (9 June), Gordon Valley (9 June), Halls Flat (10 June), Half Cabin Reservoir (10 June), Swains Hole (10 June), Mosquito Flat (13 June), Harvey Valley (13 June), Ashurst Well (13 June), Dakin Unit Honey Lake WA (14 June), Fleming Unit Honey Lake WA (15 June), Mud Flat (15 June), Sworinger Reservoir (part; 25 June), Newland Reservoir (25 June), Newland Springs (25 June), Blue Door Flat (26 June), Mud Lake (T39N, R13E, S24) (26 June), West Valley Reservoir (part; 26 June), wetland west of Madeline at jct. County Rd. 527 x Longhorn Rd. (27 June), Fleming Sheep Camp/Holbrook Reservoir (27 June), unnamed wetland (T36N, R9E, S1) west of Daisy Dean Spring (3 July), Dillon Lake (3 July), Silva Flat Reservoir (3 July), Snider Waterhole (3 July), Snider Lake (3 July), Dry Lake (T37N, R8E, S34) (3 July), Clover Valley (5 July), Craemer Reservoir (8 July), Little Cleghorn Reservoir (10 July), Cleghorn Reservoir (10 July), Twin Lakes (11 July), Blue Water (11 July), Pat Morris Spring (11 July), two unnamed lakes (T34N, R9E, S18) (11 July), Big Jack's Lake (11 July, 6 ad. and 4 juv.), Little Jack's Lake (11 July), Schroder Lake (11 July), Bear Valley Reservoir (11 July), Bear Lake (11 July), Little Valley (11 July), Beaver Creek wetlands (11 July), unnamed reservoir (T37N, R12E, S7 & S18) ~1.25 mi south of Fleming Sheep Camp (19 July), and Jay Dow wetlands south end Honey Lake (multiple summer dates).

Tehama County: Wilson Lake (6 July).

Plumas County: Sierra Valley (11 June), Lake Davis (11 June, 4), Lake Almanor (6 July), Round Valley Reservoir (6 July), Stump Ranch (6 July), Willow Lake (6 July), and Fleischmann Lake (6 July).

Sierra County: Kyburz Marsh (19 July).

Nevada/Placer Counties: Martis Creek Lake (20 July).

APPENDIX 3. Sites in the Central Valley surveyed on the ground in 1998 at which no breeding terns or cormorants were found.

Sites listed by county in chronological order by survey date (See Methods for areas surveyed by air or boat). Sites surveyed where either terns or cormorants were found breeding are listed in text or tables.

Tehama: heronry at Mooney Island on west side of Sacramento River (26 May) and heronry on west side of Sacramento River viewed from east end of Clark Ave. (26 and 28 May).

Glenn County: Sacramento NWR (part; multiple dates May–July) and Willow Creek WMA (part; 25 June).

Butte County: Sacramento River NWR's Llano Seco Rancho wetlands (multiple dates May–July), Butte Sink WMA (part; 24 June), Thermalito Forebay (6 July), and Thermalito Afterbay (6 July).

Colusa County: Sacramento NWR (part; multiple dates May–July), Delevan NWR (multiple dates May–July), Colusa NWR (multiple dates May–July), Kalfsbeek pond just south of Arbuckle on Mumma Rd. (multiple dates May–July), Moss pond off Gridley-Colusa Hwy. just north of Gray Lodge WA (multiple dates May–July),VBS pond just north of Arbuckle on Miller Rd. (just off Hahn Rd.; multiple dates May–July), Sycamore Slough at Sachreiter Rd. (9 June), Willow Creek WMA (part; 25 June), Lurline WMA (part; 25 June), and Butte Sink WMA (part; 24 June).

Sutter County: Butte Sink NWR (multiple dates May–July), Sutter NWR (multiple dates May–July), Gray's Bend (part; 16 May), Gilsizer Slough at Sutter Bypass (16 May), Abbott Lake (16 May), Natomas Drain (part; 16 May), and Butte Sink WMA (part; 24 June).

Yuba County: various wetlands on Beale Air Force Base (multiple dates Apr–June) and Old Plumas Lake (16 May).

Yolo County: Yolo Bypass WA (multiple dates May–July), Liberty and Prospect islands (part; various dates May–July), Howard Beeman pond on Rd. 95 near jct. with Rd. 27 (multiple dates May–July), Conaway Ranch (multiple dates June and July), Gray's Bend (part; 16 May), heronry at Elkhorn Slough/Elkhorn Regional Park viewed from east side of Sacramento River (18 May), Lake Solano on Putah Creek (part; 26 May), and Woodland Wastewater Ponds (1 June).

Solano County: shoreline of Sacramento River from Rio Vista to Collinsville (various dates May–July), Liberty and Prospect islands (part; various dates May–July), Lake Solano on Putah Creek (part; 26 May), and heronry on Decker Island (2 June).

Sacramento County: Sherman, Andrus, and Brannan islands (various dates May–July); wetlands of Cosumnes River Preserve (various dates May–July); Natomas Drain (part; 16 May); and American River at Arden Bar (29 May).

San Joaquin County: Lodi sewer ponds 1 mi south of Hwy. 12 just west of I-5 (various dates May–July); Union, Fabian, Robert's, Jones, Terminous, King, Empire, Bishop, Staten, Bouldin, and Victoria islands (various dates May–July); 50-acre wetland just south of Hwy. 12 near San Joaquin–Calaveras county line (6, 12, and 25 May); heronry on Mokelumne River at base of Comanche Dam (17 May); heronry along Bear Creek midway between Atkins Rd. and Disch Rd. south of Hwy. 12 near Clemments and Lockeford (17 May); heronry at Venice Tip (22 or 23 May); Kings Island heronry viewed from north side of Clifton Court Forebay (27 May); heronry on midchannel island in Middle River just south of East Bay Utility District Aqueduct and A.T. and S.F. Railroad (27 May); all rice fields, ponds, vernal pools, and riparian areas visible from roads in area bounded on west by Hwy. 99, on north by Hwy. 4, on east by San Joaquin–Stanislaus county line, and on south by River Rd. (4 dates, 1–26 June); and all standing water areas visible from roads in area bounded on west by J5/Jack Tone Rd., on north by Hwy. 26, on east by Waverly Rd. and Wimer Rd., and on the south by Hwy. 4 (also riparian areas along Calaveras River in northeast corner of area described; all on 3 July).

Stanislaus County: Modesto sewer ponds (various dates May–July); Woodward Reservoir (30 May, 4 July); and rice fields from just northeast of Modesto to northwest of Woodward Reservoir, including areas along Claribel, Claus, Rice, Victory, Cometa, Henry, Carter, and Twenty-eight-mile roads and a number of nearby minor roads (part in San Joaquin Co.; 4 July).

Merced County: all refuges and units of San Luis NWR Complex (multiple dates May–July); San Joaquin River from Hwy. 140 south to about 1 mi south of San Luis NWR (various dates May–July); Los Banos WA, Volta WA, Mud Slough WA, O'Neil Forebay WA, and Salt Slough WA (various dates May–July); East Side Bypass from Sandy Mush Rd. south to Washington Rd. (13 July); and China Island WA and adjacent San Joaquin River (14 July).

Fresno County: Britz Farms Evaporation Basin (multiple dates May–July), Gragnani Farms wetland site (multiple dates May–July), Mendota WA (various dates May–July), James Bypass/Fish Slough/Fresno Slough from south side of Mendota WA south to Mt. Whitney Ave. (2 July), Fresno Slough from south of town of San Joaquin north to south end of Mendota WA (2 July), and Fresno-Clovis Metropolitan Sewage Facility (9 July).

Kings County: Meyers Ranch Evaporation Basin (multiple dates May–July), Jack Stone Land Company Evaporation Basin (multiple dates May–July), Westlake Farms North Evaporation Basin (multiple dates May–July), Westlake Farms demonstration wetland project (multiple dates May–July), Westlake Farms mitigation wetlands (multiple dates May–July), Summit Lake at Lemoore NAS (multiple dates May–June), abandoned but flooded Liberty Farms Evaporation Basin (29 June), vast extent of flooded farmland in old Tulare lakebed (29 June), flooded fields along Blakeley Canal from South Central Levee west to Westlake Farms South Evaporation Basin (30 June), flooded fields west of South Central Levee from Utica Ave. to just north of Tule River (30 June), Melga Reservoir (30 June), and Hanford sewer ponds east of 11th Ave. between Houston Ave. and Iona Ave. (30 June).

Tulare County: old evaporation basins (Bowman, Morris, Martin farms) and flooded sinks and ponds along Homeland Canal from Rd. 40 southwesterly to Tulare-Kings county line (25 June), ponds just northeast of jct. Ave. 144 and Rd. 72 (30 June), ponds just northwest of jct. Ave. 144 and Rd. 128 (30 June), ponds southwest of jct. Rd. 52 and Ave. 264 (30 June), and ponds north side of J30/Ave. 280 between Rd. 44 and Rd. 56 (30 June).

Kern County: Kern NWR (various dates May–July), Lost Hills Water District Evaporation Basin (multiple dates May–July), Rainbow Ranch Evaporation Basin (multiple dates May–July), old Buena Vista lakebed (21 June), flooded fields along Garces Hwy. between Corcoran Rd. and Hwy. 43 (23 June), Goose Lake bottoms wetlands of Buttonwillow Land and Cattle Company and Semitropic Water Storage District (24 June), flooded fields along Utica Ave. (24 June), flooded fields and sinks just north of Poso Creek just east of Corcoran Rd. (29 June), abandoned Carmel Ranch Evaporation Basin (29 June), flooded fields east side of Corcoran Rd. ~7.5 mi south of Utica Ave. (29 June), Arvin Edison Water Storage District's Sycamore and Tejon settling ponds (1 July), and ponds just east of Hwy. 43 and north of Brimhall Rd. (1 July).

APPENDIX 4. Sites throughout California surveyed in 1999 by aerial, kayak, boat, or ground methods.

13 May 1999—aerial surveys.

Siskiyou County: Meiss Lake, Butte Valley WA; Sheepy Lake, Lower Klamath NWR; and Tule Lake NWR (upper) Sump 1-A.

Siskiyou/Modoc County: Tule Lake NWR (lower) Sump 1-B.

Modoc County: Clear Lake NWR, Goose Lake, and Big Sage Reservoir.

Lassen County: Eagle Lake, Grasshopper Valley, and Hartson Reservoir on Dakin Unit, Honey Lake WA.

Plumas County: Lake Almanor.

13 May 1999—ground surveys (after aerial flight).

Glenn County: Stony Gorge Reservoir.

14 May 1999—aerial survey of wetlands and riparian stands along rivers in portions of Sacramento–San Joaquin River Delta and northern San Joaquin Valley and of reservoirs in foothills of adjoining Coast Ranges and Sierra Nevada.

Solano County: Decker Island, Van Sickle Island, and Chipps Island.

Sacramento County: Sherman Island, Sherman Island WA, Donlon Island, Kimball Island, and West Island.

Contra Costa County: Browns Island, Winter Island, Bradford Island, Webb Tract, Frank's Tract, and Quimby Island.

San Joaquin County: Venice Island, Venice Tip, Empire Tract, Mandeville Island, Medford Island, Bacon Island, Mildred Island, McDonald Island, and other small unnamed islands.

San Joaquin, Stanislaus, and Merced counties: San Joaquin River (riparian stands, oxbow lakes, etc.) from Hwy. 4 in Stockton south to Hwy. 40 crossing (by north end of federal, state, and private wetlands of Grasslands Ecological Area).

Merced County: O'Neill Forebay, San Luis Reservoir, Los Banos Creek Reservoir, and Merced River (riparian stands, oxbow lakes, etc.) from San Joaquin River to Lake McSwain (Mariposa Co.).

Mariposa County: Lake McSwain and north-south arm on west side of Lake McClure.

18 May 1999—aerial survey of wetlands, reservoirs, and riparian stands in portions of Sacramento–San Joaquin River Delta and northern and central San Joaquin Valley and of adjacent foothill reservoirs of Sierra Nevada.

Contra Costa County: Clifton Court Forebay.

San Joaquin County: Venice Tip, Orwood Tract, Woodward Island, Victoria Island, Victoria Tip, and miscellaneous small islands in vicinity of these. Also survey (west to east) Grant Line and Fabian and Bell canals and west back to Clifton Court Forebay via Old River.

Stanislaus County: Tuolumne River from below Don Pedro Reservoir west to San Joaquin River, Turlock Lake, and Modesto Reservoir.

Merced County: San Joaquin River (riparian stands, oxbow lakes, etc.) from Hwy. 140 south to Fresno County line south of Hwy. 152, Mariposa Bypass and East Side Bypass south to vicinity of Merced NWR, Burns Reservoir, Lake Yosemite, and Kelsey Reservoir.

Fresno and Madera counties: San Joaquin River from Merced County line south and easterly to and including Millerton Lake. Stop to photograph cormorant colony at CDFG's Milburn Unit east of Hwy. 99.

Fresno County: Pine Flat Reservoir and Kings River downstream of Pine Flat Reservoir to just shy of Hwy. 99.

Madera County: Hensley Reservoir, Madera Equalization Reservoir, and Eastman Lake.

Mariposa County: Owens Reservoir, Mariposa Reservoir, Bear Reservoir, and east arm of Lake McClure.

Tuolumne County: Don Pedro Reservoir.

19 May 1999—aerial survey of various reservoirs in Coast Ranges west of Sacramento Valley and of Sacramento River from Fremont Weir north/upstream to Redding.

Tehama and Glenn counties: Black Butte Lake.

Glenn County: Stoney Creek (from Black Butte Lake to East Park Reservoir) and Stoney Creek Reservoir.

Colusa County: East Park and Indian Valley reservoirs.

Lake County: Lake Pillsbury, Upper Blue Lake, Lower Blue Lake, and Clear Lake.

Mendocino County: Lake Mendocino.

Napa County: Lakes Berryessa and Hennessey.

Yolo, Sutter, Colusa, Glenn, Butte, Tehama, and Shasta counties: Sacramento River from Fremont Weir, Yolo County, to Hwy. 299 at Redding, Shasta County. From town of Colusa broke off to survey known cormorant colony in the Butte Sink.

19 May 1999—ground survey of cormorant nests in mixed heron-egret-cormorant colony at Beaver Lake near Tyndall Landing, Yolo County.

20 May 1999—aerial survey of northern San Joaquin Valley and reservoirs of adjacent Sierra Nevada foothills, reservoirs of Sierra foothills east of Delta and southern Sacramento Valley, and Feather River from Oroville Reservoir south to confluence with Sacramento River.

San Joaquin, Stanislaus, Calaveras, and Tuolumne counties: Stanislaus River from confluence with San Joaquin River up to Tulloch and New Mellones reservoirs.

San Joaquin County: Davis Lake.

Stanislaus County: Woodward Reservoir.

Calaveras and Tuolumne counties: Tulloch and New Mellones reservoirs.

Calaveras County: Salt Spring Valley and New Hogan reservoirs.

Amador, Calaveras, and San Joaquin counties: Pardee and Camanche reservoirs.

Amador County: Lake Amador.

Calaveras and San Joaquin counties: Calaveras River from New Hogan Reservoir down to vicinity of Hwy. 88.

Sacramento County: North Stone Lake, Stone Lakes NWR, and American River from Sacramento River to Folsom Lake.

Sacramento, Eldorado, and Placer counties: Folsom Lake.

Placer and Nevada counties: Lake Combie.

Nevada County: Lake of the Pines and Lake Wildwood.

Yuba and Nevada counties: Englebright Reservoir.

Yuba County: Collins Lake.

Butte, Yuba, Sutter, Yolo, and Sacramento counties: Feather River from Lake Oroville to confluence with Sacramento River, and Sacramento River from there down to Port of Sacramento.

28 May 1999—aerial survey of Salton Sea and various reservoirs in San Diego County and western Riverside County (part).

San Diego County: Lake Morena, Barrett Lake, Lower Otay Lake, Upper Otay Lake, Sweetwater Reservoir, Loveland Reservoir, El Capitan Lake, San Vicente Lake, Lake Hodges, Dixon Lake, Lake Wohlford, Lake Sutherland, Lake Cuyamaca, and Lake Henshaw.

Riverside County: Vail Lake and Lake Skinner.

1 June 1999—ground survey of (seasonally) inactive cormorant colony on Mullet Island, Salton Sea, Imperial County.

4 June 1999—boat survey by Joan Humphrey of known or former cormorant nesting sites at Clear Lake, Lake County.

3–6 June 1999—ground and kayak surveys of various reservoirs and other wetlands in San Diego and Riverside counties.

San Diego County: Lake Jennings (3 June, ground); Lower Otay Lake, Lake Murray, and Santee Lakes (all 4 June, all ground); Lower Otay Lake (5 June, kayak); and Lake Hodges (5 June, ground).

Riverside County: San Jacinto WA (6 June, ground).

7 June 1999—aerial survey of various reservoirs in (western) Riverside, San Bernardino, Los Angeles, Ventura, and Santa Barbara counties.

Riverside County: Lake Hemet, Canyon Lake, Lake Elsinore, Santiago Reservoir, Lake Matthews, Lake Perris, San Jacinto WA, and Mystic Lake.

San Bernardino County: Big Bear Lake, Lake Arrowhead, and Silverwood Lake.

Los Angeles County: Morris Reservoir, San Gabriel Reservoir, Boquet Reservoir, Castaic Lake, and Pyramid Lake.

Kern County: Castac Lake.

Ventura County: Lakes Casitas and Piru.

Santa Barbara County: Lake Cachuma, Gibraltar Reservoir, and Jameson Lake.

8 June 1999—ground and kayak surveys in western Riverside County.

Riverside County: Lake Elsinore (ground) and Mystic Lake (kayak).

9–10 June 1999—kayak and ground surveys of sites in Kings County.

Kings County: South Wilbur Flood Area (kayak), Corcoran Irrigation District (ID) Reservoir # 2 (ground), and Corcoran ID Reservoir #1 (ground) (all on 9 June 1999); and East Hacienda Ranch Flood Basin (10 June 1999, kayak).

19–24 June 1999—ground and kayak surveys of various sites in northeastern California.

Siskiyou County: Meiss Lake, Butte Valley WA (kayak); and Grass Lake (ground; both 24 June).

Modoc County: Goose Lake (kayak), Enquist Reservoir, Pease Flat, Householder Reservoir, and Everly Reservoir (all ground except as noted; all 20 June); Big Sage Reservoir (kayak), Reservoir C, unnamed reservoir in Round Valley, Fairchild Swamp, Lost Valley, and Duncan Reservoir (all ground except as noted; all 21 June); Clear Lake NWR (boat), Henski Reservoir/Spaulding Reservoir (ground), and Beeler Reservoir (ground; all 22 June).

Lassen County: Hartson Reservoir and vicinity at Dakin Unit, Honey Lake WA (ground), Leavitt Lake (ground), Eagle Lake (part; ground), and Grasshopper Valley (ground at distance) (all 19 June); Said Valley Reservoir (ground, 22 June); and Eagle and Poison lakes (ground, 23 June).

Sierra County: from Hwy. 89 between Sierraville and Loyalton survey Sierra Valley marsh for Black Terns (19 June, ground).

APPENDIX 5. Breeding records of the American White Pelican in California, 1877 to 2000, other than those listed or summarized in the text.

Siskiyou County: Meiss Lake, Butte Valley WA, 13 May 1999 (12 nests from aerial photos, D. Shuford), 16 June 2000 (15 nests, K. Novick in litt.); Lower Klamath Lake (CA or OR?), June–July 1895 (colonies scattered along for about 2 mi on tule-mat islands; 8 or 10 big rookeries [each with 400–600 birds] and 15 others [each with 50–200 birds], Finley [1907]; from these "data," Thompson [1933] stated an estimate of 6000–8000 "birds" seemed reasonable, and Boellstorff et al. [1988] graphed about 3200 "young produced" for [*sic*] 1907 [really 1895]; Boellstorff's [in USFWS 1984: p. 13] listing of 6475 *nests* for Lower Klamath in [*sic*] 1907 likely is in error and rather represents an estimation of *nesting adults* from Finley's [1907] description of the colony in 1895), 1–7 July 1906 (pelicans nesting on 15 tule-mat islands, Chapman 1908), 30 May 1915 (a visit to "some" of the pelicans "camps" found rows of hundreds of birds, Finley 1915).

Modoc County: Clear Lake, 10 April 1918 (1 egg set, G. Willett, WFVZ; 400–500 pairs [about 150 nests], Willett 1919), summer 1932 (5000 young pelicans hatched on Bird Island, H. M. Worcester in Thompson 1933), 11–12 July 1933 (water had receded from nesting island, leaving young 3 mi from water, Lincoln 1933), 17 May 1940 (5 egg sets, on large island; this was the largest of four colonies—about 2000 birds [unclear if 2000 birds total or 2000 birds in largest colony], egg data slips of E. N. Harrison, WFVZ); Goose Lake, prior to 1879 (pelicans found in summer in "immense numbers," Henshaw 1879), 25 June 1977 (about 300 unattended eggs found on island at south end of lake, which Winkler [1982] attributed to an aborted nesting attempt in either summer 1976 or 1977).

Siskiyou/Modoc County: Tule Lake, June–July 1895 (mixed pelican [size not described] and cormorant [250 nests] colony on sandy island, Finley 1907), early July 1899 (pelicans deserted nests and young at the first alarm, as had been entirely driven from peninsula [where thousands had been in the habit of breeding] and were feeding young on a few little rocky islands, Bailey 1902).

Lassen County: Hartson Reservoir, Honey Lake WA, early 1950s (reportedly laid eggs, A. Lapp in Tait et al. 1978), 5 June–14 July 1976 (roughly 950 young from 200–700+ nests; Tait et al. 1978, AB 30:997), 12 July 1978 (11 adults, 13 juveniles, nesting suspected; AB 32:1203, MPCR files), 14 May 1990 (7000 adults, 132 eggs, J. R. Jehl Jr. in Honey Lake WA files); Eagle Lake, 4 July 1877 (500–1000 pairs on sandy island, rough estimate of well over 1000 young [in all stages of growth], Henshaw 1879 in Grinnell et al. 1930; Thompson [1933] suggested that 1500 adults perhaps represented the size of the colony seen by Henshaw), Eagle Lake, Pelican Island (Point?), 28 June 1884 (resorts to breed in "great numbers," of two islands available pelicans had taken almost exclusive possession of one, cormorants the other, Townsend 1887), Eagle Lake, June–July 1905 (large colony said to be nesting [but not actually visited] on island at northeast end of lake; secondhand prior account of nestlings being clubbed to death because they had become so numerous, Sheldon 1907), Eagle Lake, Pelican Point, 18 May 1914 (3 egg sets, M. S. Ray, MVZ; 5 egg sets, colony of >400 nests, C. Littlejohn, M. S. Ray, WFVZ; Ray [1915] spoke of "vast ground colonies" of pelicans), 27 May 1921 (Ray [1921] commented that at the great pelican rookery every set of the scores of eggs had been destroyed by an "undetermined agency"), 21 June 1921 (of over 100 nests examined, none had eggs or live young; apparently after pelicans frightened from island by gunshots, gulls proceeded to peck holes in the eggs, Grinnell et al. 1930), summer 1928 (some young killed by persons resenting the competition for fishes, but still considered a successful nesting season, Grinnell et al. 1930), 13 June 1929 (about 200 adults on or near nesting island, two small groups of nests [some with eggs], and about 100 live young [just hatched to ¼ to ⅓ grown] and equal number dead, Grinnell et al. 1930), 17 July 1932 (350 pelicans on lake, had probably been 150 nests apparently destroyed by predatory animals, "Pelican Island" now part of mainland owing to 25-foot drop in elevation from diversion for irrigation, C. O. Fisher in Thompson 1933).

Lower Sacramento Valley: Heermann (1859) stated "some few pairs breed in Sacramento Valley," but provided no documentation for particular nesting sites. Various egg sets taken on 20 May 1906, and assigned to the following locales, likely were all from the same colony: (near Marysville [Yuba Co.], on levee bordering Sacramento River, 1 egg set, C. S. Thompson, SBCM; 6 egg sets, large colony breeding, egg data slips of H. A. Snow, WFVZ), (Tudor [Sutter Co.], on old levee ["Markuse Levy"] of Sacramento River about 4 mi out on overflow, 1 egg set, about 10,000 birds breeding, egg data slip of H. A. Snow, SBCM; 27 egg sets, H. A. Snow, WFVZ), ("Sacramento County," 1 egg set, H. V. La Jeunesse, MVZ). A data slip for a single egg set from "Sutter County" dated (erroneously?) 20 May 1905 (H. A. Snow, WFVZ) may also pertain to the 1906 colony. Lone Tree Island [after reclamation, by 1932, known as "Natomas Farms Co."], 3–5 mi northwest of Sacramento, 28 June 1910 (photo of "some" of the birds and nests [at least 100's of birds], Neale [1916, accompanying text indicates prior nesting]); text accompanying photos reproduced in Neale (1932) indicates "many thousands" of pelicans had been seen at this site and that the colony stretched over 12 miles at the time pictures were taken. Moffitt (1939) reported that a local resident stated pelicans nested on a sandbar at the edge of a lake westward of the site of Moffitt's observation of several pelicans on ponds along Butte Creek west of Marysville [Sutter] Buttes, Sutter County, on 13 June 1925.

Kings County: Tulare Lake, prior to 1884 (Gruber [1884] in Grinnell [1926] indicated Tulare Lake was among the breeding places of pelicans), summer 1907 (large loose flocks seen daily along north and west shores, 18–24 June and 6–8

July; secondhand account of observation about 25 June of a nest with eggs on small island near west shore, Goldman 1908), 1 May 1912 (secondhand account of visit by local to tiny nesting island with "thousands" of occupied nests; also mentions "local rumor" of a shifting colony there for a "great many years," Dawson 1923), 20 May 1939 (2 egg sets, large colony nesting on long narrow "island" levee cut of from mainland by a deep slough, about 1 mi from south end of lake, J. G. Tyler, WFVZ; 4000–5000 adults, over 500 pairs just beginning to nest [267 occupied nests containing 527 eggs, 5 young ⅓ to ½ grown, estimated 100–125 new nests not yet laid in], W. B. Minturn, J. G. Tyler field notes; in August, 500+ young not old enough to fly, Mr. Dow *fide* W. B. Minturn field notes), 5 May 1941 (1 egg set, large colony on levees, A. Andresen, WFVZ), 11 May 1941 (33 egg sets, L. T. Stevens, SBMNH; 7 egg sets, on small dike, about 75 pairs, L. T. Stevens, WFVZ), 8 June 1941 (24 egg sets, colony on old dike surrounded by water entirely destroyed by rising water on this date, E. N. Harrison, WFVZ), 1 June 1942 (breeding colony of 2000–3000 birds on island near south side of lake, W. B. Minturn field notes).

Kern County: "Kern County," 5 June 1918 (1 egg set, C. O. Reis, WFVZ); Buena Vista Lake, 20 May–16 June 1907 (colony of 250 nests on small sandy island in river mouth, another of about 500 nests of tules and marsh grass on lake shore, Linton 1908), 2 June 1907 (2 egg sets, on small island in river marsh, C. B. Linton, WFVZ), 8 June 1912 (roughly 300 nests [600 occupied nests about equally divided between pelicans and cormorants], plus about 100 eggs "scattered promiscuously" on ground, on Pelican Island, Lamb and Howell 1913; 2 egg sets, C. C. Lamb, SBCM, WFVZ), prior to 1914 (author indicates a colony of about 1000 birds, but on the visit he described [in nonbreeding season] actual observation was of unoccupied nesting island "heavily coated with guano," Baily 1914), 8 May 1917 (27 egg sets, J. Van Denburgh, I. W. McGuire; CAS, WFVZ), 10 May 1923 (5 egg sets, adult in colony could not complete a set because of the gulls raiding the eggs, by 10 June all attempts to nest had been given up, A. J. van Rossem, MVZ), 21 May 1923 (2 egg sets, on sand bar near mouth of river, J. G. Tyler, WFVZ), 14 June 1924 (6 egg sets, R. Ellis Jr., MVZ), 9 June 1928 (3 egg sets, A. H. Miller, MVZ), breeding season 1953 (about 550 young raised from 400 nests, AFN 8:41).

San Diego County: Lake Henshaw, 7 May 1925 (1 egg set, eggs laid on bare mud at margin of lake shore, a large colony started to nest here but birds scared away by the caretakers because they thought they were eating young trout that had been planted in the lake, J. S. & J. B. Dixon, MVZ). Nesting at this site is inconclusive (Willett 1933; Grinnell and Miller 1944; and Unitt 1984, 2004). Lacking documentation of actual nesting, it seems best to consider this a case of birds "dumping" eggs, which has occurred at other sites where pelicans have not formed breeding colonies (see species account above).

Imperial County: Salton Sea, 19 April 1908 (980 nests with eggs [many others in process of construction] and a minimum of 2000 adults all on Echo Island, also 3 nests with eggs on Pelican Island [2–3 years prior was *the* nesting grounds of pelicans], Grinnell 1908; 5 egg sets, C. H. Richardson Jr., J. Grinnell, MVZ), 11 May 1916 (1 egg set, J. Van Denburgh, CAS), 21 May 1927 (total of 450 nests with eggs on three small sandy islands [350, 50, 50 nests], Pemberton 1927; 6 egg sets, O.W. Howard, J. S. Rowley, J. R. Pemberton, WFVZ), 12–19 May 1928 (4 egg sets, on small island, several small colonies nesting, W.C. Hanna, SBCM, WFVZ), 9 June 1928 (3 egg sets, L. H. Miller, MVZ), 18 May 1929 (3 egg sets, large colony with nests containing eggs and young, W. C. Hanna, SBCM), summers 1928–1932 (about 50 pairs nesting in 1928, 1930, and 1932 and a "small number" in 1929, "Pelican Island" now a peninsula, Thompson [1933] via correspondence with L. H. Miller, G. Willett, and A. J. van Rossem), 27 May 1934 (2 egg sets, large colony on "3 Dune Island," J. B. Abbott, WFVZ; 2 egg sets, 234 nests counted on islands off Sea View, collector unspecified, WFVZ), 4 June 1934 (1 egg set, on sand island, A. Barr, WFVZ), 28 April 1945 (2 egg sets, J. H. Baumgardt, WFVZ), 12 April 1946 (3 egg sets, islands south end, Fred N. Gallup, WFVZ), 31 May 1947 (1 egg set, on [sand] island, H. W. Carriger, WFVZ), 9 June 1947 (3 egg sets, total of about 200 pairs breeding on three small islands, H. L. Heaton, E. E. Sechrist, SBCM, WFVZ), April 1949 (>300 nests recorded, AFN 3:224), 22 May 1949 (3 egg sets, one island with colony of about 200 pairs all with eggs, other island had a colony of about 100 birds all with young, E. E. Cardiff, SBCM), 4 June 1949 (2 egg sets, quite a colony on a small island about 400 yards off shore, many birds in the colony with young from newly hatched to several weeks old, E. A. Salter, E. M. Hall, WFVZ), breeding season 1956 (about 100 adults nested on small sandy island along south shore, for unknown reason nests and nestlings abandoned in early June, AFN 10:410), breeding season 1957 (about 80 adults present on nesting island did not incubate or produce young from the small numbers of eggs laid, AFN 11:429), breeding season 1959 (no nesting known from south end, AFN 13:399).

APPENDIX 6. Records of confirmed breeding of the Double-crested Cormorant in the interior of California, 1884 to 2001, other than those listed or summarized in the text.

Siskiyou County: Iron Gate Reservoir and Copco Lake, 29 May 1980 (150 cormorants indicated "probable nesting," AB 34:811); Trout Lake, Shasta Valley WA, nesting season 1992 (about 80 "breeding birds," B. Smith in Carter et al. 1995b); Meiss Lake, Butte Valley WA, 17 June 2000 (124 nests, J. Llewellyn *fide* K. Novick in litt.); Lower Klamath Lake (CA or OR?), 30 May 1915 ("village" of cormorants with "several hundred" half-grown young, Finley 1915).

Siskiyou/Modoc County: Tule Lake, summer 1895 (190 nests [with about 300 birds and half as many unhatched eggs] on one rocky island, 250 nests [with about 275 young and 200 eggs] on sandy island, Finley 1907), early July 1899 (nearly 100 large young lay under one group of trees, where vandals had shot them from their nests, Bailey 1902).

Modoc County: Clear Lake, 10 April 1918 ("about 100 pairs beginning to nest on one of the small islands," [many nests about completed, few with one or two eggs, no full clutches noted], Willett 1919); Goose Lake, aerial survey 4 June 1976 ("colony" present, B. E. Deuel in litt.), 25 June 1977 (east shore island with 65 young, most eggs hatched; estimated 25 pairs of adults, D. Winkler in litt.), 15 June 1979 ("20 nesting on big island at south end," B. E. Deuel in litt.), 5 June 1980 ("not as many… as last year," B. E. Deuel in litt.), June 1982 ("nesting," B. E. Deuel in litt.), 1 June 1983 (35 nests south end of lake, B. E. Deuel in MPCR files), 30 May 1984 (21 nests on one island, B. E. Deuel in MPCR files), 5 June 1985 (10 nests on peninsula, B. E. Deuel in MPCR files), 4 June 1986 (20–25 nests on peninsula, B. E. Deuel in MPCR files); Big Sage Reservoir, nesting season 1977 (2 pair "probably nested," D. Winkler in MPCR files), nesting season 1986 (<40 "breeding birds," G. Studinski in Carter et al. 1995b); Reservoir F, late 1970s (20–30 "breeding birds," G. Studinski in Carter et al. 1995b); Modoc NWR, nesting season 1977 (32 "breeding birds," Winkler 1982).

Shasta County: Big Lake/Ahjumawi Lava Springs State Park, 6 June 1974 (nesting colony, B. E. Deuel in litt.).

Lassen County: McCoy Flat Reservoir, nesting season 1970 (cormorants "nesting," G. Gould in litt.); Eagle Lake, 28 June 1884 ("large colony" on small rocky islet, Townsend 1887:192 in Grinnell et al. 1930), June–July 1905 ("large colony" breeding in dead pines on northwest side of lake and "few pairs" on pine stumps 100 ft offshore on east side of lake, Sheldon 1907), Pelican Point, 18 May 1914 (188 nests [51 on small island, 137 in dead trees in water nearby], C. Littlejohn, 5 egg sets, WFVZ), 17–18 May 1914 ("great tree colonies," Ray 1915), 18 May 1914 (1 egg set from nest in dead mahogany tree on small island, M. S. Ray, MVZ), 27 May 1921 (1 egg set from nest in dead tree on island near east shore, data slip M. S. Ray, MVZ), 21–22 June 1921 (approx. 91 nests on small island near east shore [56 in trees, 20+ in bushes, about 15 among rocks], Grinnell et al. 1930), west shore in dead yellow pines, 26 May 1925 ("as many as 10 pairs occupied one nest tree [of at least three]," Grinnell et al. 1930), Pelican Point, summer 1970 (7 nests, Gould 1974; colony inactive 1971), July 1970 (8 nests, AFN 24:712), summer 1974 (11 nests, Lederer 1976), summer 1974 (12 pairs nested, AB 28:944), summer 1977 (colony inactive, D. Winkler in Remsen 1978), summer 1991 and 1992 (60–70 pairs, J. Bogiatto in Shaw 1998), summer 1996 (26 nests, Shaw 1998), 14 June 1997 (41 nests; Shaw 1998, in litt.); Mountain Meadows Reservoir, 13 May 1964 (also present 1954) (colony of 150+ birds in snags on south side of reservoir; AFN 18:483, MPCR files); Hartson Reservoir, Honey Lake WA, summer 1966 (20 pairs, A. Lapp in Remsen 1978), summer 1976 (nesting in sagebrush, >300 birds on 5 June, 40 adults and at least 6 nestlings on 16 July; AB 30:996, MPCR files), 5 June 1976 (several active cormorant nests shown in close-up photo of pelican and cormorant colony, Tait et al. 1978), summer 1977 (colony inactive, A. Lapp in Remsen 1978), 3 June 1978 (20 pairs, S. Laymon in MPCR files), 16 May 1990 (45 nests with eggs [also 5–6 empty], J. Jehl Jr. in Honey Lake WA files); Said Valley Reservoir, 21 March 1972 (3 pairs nesting, R. Stallcup in MPCR files).

Plumas County: Butt Valley Reservoir, nesting seasons 1970 and 1971 (cormorants "nesting," G. Gould in litt.), nesting seasons 1976 and 1977 (24–25 nests, *fide* Dan Airola), nesting season 1981 (31 nests in 4 snags, G. W. Rotta in litt.), 2 June 1982 (46 nests in 3 snags, G. W. Rotta in litt.), nesting season 1983 (40 nests in 2 snags, G. W. Rotta in litt.), 4 May 1983 (32 nests in 2 snags, D. Airola in litt.), nesting season 1984 (40 nests in 2 snags, G. W. Rotta in litt.), 27 May 1984 (21 nests in 1 large nag, D. Airola in litt.), nesting season 1985 (colony active, numbers similar to last 2 years, G. W. Rotta in litt.), nesting season 1988 (14+ nests in 1 snag, G. W. Rotta in litt.), 25 May 1992 (about 18 nests in l snag, H. Green in MPCR files), 20 May 1994 (35+ nests in 2 snags, G. W. Rotta in litt.), 2 May 1996 (24 nests in 2 snags, 1 colony abandoned with drawdown of reservoir for maintenance, G. W. Rotta in litt.), 10 May 2001 (19 nests, adults incubating, in snag on upper part of reservoir [old nesting snag on lower portion of reservoir has fallen over], R. Jackman pers. comm.).

Mono County: Bridgeport Reservoir, 24 June 1974 (6 pairs with young; AB 28:944, MPCR files).

Lake County: Clear Lake, 29 April 1895 (one colony of about 120 nests [rookery "in use many years"] in oaks in "Big Valley" on south side of upper basin of lake; additional "immense rookery" [date observed?] occupying low pines in stretch of about one half mile long on south side of channel separating lower and upper basins of lake; Chamberlin 1895), 15 June 1928 (1 egg set collected from large "fir tree," F. J. Smith data slip, WFVZ), 30 May 1933 (upper Clear Lake, 1 egg set, MVZ); Indian Valley Reservoir, summer 1979 ("nesting," S. Laymon in MPCR files).

Sonoma County: Laguna de Santa Rosa, 14 May 2000 (seasonal peak of 38 nests, B. Evans *fide* J. Kelly); Petaluma wastewater treatment ponds, 4 June 2000 (seasonal peak of 6 nests, C. McAuliffe *fide* J. Kelly).

Butte County: Sacramento River at Llano Seco Rancho, 6 July 1989 (3 nests, J. Snowden pers. comm.).

Glenn/Colusa counties: Sacramento NWR, 30 Sep 1972 (25 nests, birds in and around them, J. Hornstein in MPCR files [presumably seen from tour loop, Glenn Co.; given the date, possible that these cormorants were just roosting in trees where herons or egrets nested earlier in season?]).

Sutter County: Sanborn Slough, near Butte Creek, 7 mi west of Pennington, "many years prior to about 1930," last found nesting 13 June 1925, colony deserted 4 May 1931 (>20 pairs bred in willows along slough, keeper of gun club systematically shooting birds as competitors for fish, Moffitt 1939); Sacramento River just below Kirkville, 21 May 1987 (1 nest, B. E. Deuel in MPCR files).

Sacramento County: vicinity of Sacramento (Co. ?), 20 Mar–17 Apr 1901 (4 egg sets, F. G. Coomes, CAS); North Stone Lake, 13 May 1982 (1 nest, B. Bailey, Stone Lake NWR files, CDFG files), nesting season 1988 (8 nests, M. Vennard in California Natural Diversity Database), 5 May 1989 (16+ active nests, T. Manolis in litt.), April 1990 (17 nests, Stone Lake NWR files), 1993 (51 nests, Stone Lake NWR files), 20–24 May 1994 (53 nests, Stone Lake NWR files), 14 Mar–28 Apr 1996 (82 nests, Stone Lake NWR files); Valensin Ranch, Cosumnes River Preserve, 1 June 1993 (15 nests, A. Engilis Jr. *fide* T. Manolis), 31 March 2001 (10 nests, J. Trochet in litt.); Pellandini Ranch, 25 May 1993 (25 nests, A. Engilis Jr. *fide* T. Manolis).

Yolo County: Beaver Lake along Sacramento River, 21 June 1982 (6 nests, Scoonover in CDFG files), May 1992 (200 "breeding birds," D. M. Fry in Cater et al. 1995b, pers. comm.), 16 May 2001 (25+ nests, D. M. Fry pers. comm.).

Delta or San Joaquin Valley: "3 mi inland from San Joaquin River," 3 June 1907 (1 egg set from nest in willows, H. A. Snow data slip, WFVZ).

Stanislaus County: San Joaquin River, 1.5 mi south of Hwy. 132, 14 July 1983 (30+ nests, H. L. Cogswell in MPCR files); Finnegan Cut, 2–4 June 1986 (20+ adults, "breeding colony," E. R. Cain in MPCR files); near Modesto sewage ponds, spring 1987 ("nested," H. Reeve in MPCR files).

Mariposa County: Eastman Lake, 14 June 1994 (7 pairs nesting in dead trees on northwest shoreline of lake, D. F. Drain in California Natural Diversity Database).

San Benito County: San Felipe Lake, 11 Apr–25 May onward 1998 (4–11 nests, FN 52:385).

Kings County: mouth of Kings River at north end of Tulare Lake, 19 June 1907 ("hundreds of nests in willows," Goldman 1908); Tulare Lake, 1 June 1942 (50–100 nests in dead cottonwoods on submerged levees, W. B. Minturn field notes), 19 May 1945 (100+ nests in trees surrounded by water well out on lake, W. B. Minturn field notes); Corcoran Irrigation District ponds, 10 June 1980 (6 nests; AB 34:925, MPCR files); South Wilbur Flood Area, 18 May 1979 (1 nest, R. Webster in MPCR files), summer 1983 (8 nests, G. Gerstenberg in MPCR files), 3 June 1984 (34 nests with 14 young, *fide* J. Houk in MPCR files), 31 May 1997 (24 nests, R. Hansen et al.), 28–29 July 1997 (22 nests, R. Hansen et al.).

Tulare County: Creighton Ranch Preserve, 9 Apr 1983 (10 nests, R. Hansen in MPCR files).

Kern County: Buena Vista Lake, 4 June 1903 (1 egg set from nest in willow in water, O. W. Howard data slip, WFVZ), 20 May–16 June 1907 ("breeding in immense numbers … two to six nests to the tree [drowned willows]," both fully fledged young and fresh eggs in late May, Linton 1908; data slip of C. B. Linton for 26 May 1907 [WFVZ] remarks "rookery of 10,000"), 8 June 1912 (roughly 300 nests [600 occupied nests about equally divided between pelicans and cormorants] on ground on Pelican Island; also grove of water-killed trees in river mouth crowded with nests of night-herons and cormorants, Lamb and Howell 1913), fall–winter prior to 1914 (visit to [seasonally unoccupied] nesting island "heavily coated with guano," Baily 1914), 5 May 1939 ("large colony," 2 egg sets, M. C. Badger, WFVZ), 15 May 1939 ("small colony beginning to nest" in willows, 1 egg set, R. Quigley, WFVZ), 28 May 1939 (1 egg set from nest in willow above water, L. T. Stevens, WFVZ), 10 May 1940 (1 egg set, J. H. Baumgardt, WFVZ), 10 May 1941 (1 egg set from "large colony" nesting in willows in lake, L. T. Stevens data slip, WFVZ), 31 May 1941 (1 egg set, K. E. Vorce, WFVZ).

Orange County: Anaheim Lake, starting in 1988 (up to 40 pairs in large eucalyptus grove at south end of lake, Gallagher 1997), 12 July 1988 (5 nests, AB 42:1332), nesting season 2000 (colony active, D. Purvis in litt.); Santa Ana River Lakes, "in recent years…no active nests in 1995," (Hamilton and Willick 1996), nesting season 2000 (inactive, D. Purvis in litt.); Bolsa Chica, 11 July 2002 (3 nests [at least 2 with young] on powerpoles standing in impoundment; P. Knapp, B. Daniels).

Los Angeles County: San Gabriel River Spreading Grounds in Pico Rivera, 8 May and 30 June 1995 (occupied nest or nests, M. San Miguel and T. & L. Bulmer *fide* K. Garrett), 21 April 1996 (building nest in flooded sycamore in middle of basin, L. Schmahl *fide* K. Garrett), 8 April 2001 (13–14 nests, L. Schmahl in litt.), 2 June 2002 (15 active nests, L. Schmahl *fide* K. Garrett); Rio Hondo Spreading Grounds, as of 2002 has been active for "at least 8 years" and colony has gotten bigger (K. Powell *fide* B. Daniels in litt.), 10 June 2002 (10 nests in 2 eucalyptus trees, with few leaves, on opposite sides of a narrow access road paralleling a channel, B. Daniels in litt.); Sepulveda Wildlife Area in the Sepulveda Basin in Encino, 3 August 2003 (2 nests with young (M. Kotin *fide* K. Garrett), nesting season 2004 (about 10 nesting pairs, nests in deciduous trees on an island in a lake at the Nature Center; M. Kotin, L. Allen).

San Bernardino County: Colorado River Valley near Needles (Calif. side?), 24 Apr 1947 (15 nests, AFN 1:188).

Riverside County: Blythe, 21 April (year?) (1 egg set, W. J. Sheffler, WFVZ); Lee Lake (*aka* Corona Lake), 10 mi south of Corona, 1 June 1983 (1 egg set from colony of 20 active nests in dead trees in flooded riparian area, data slip L. Kiff and R. Quigley, WFVZ).

San Diego County: Lake Henshaw ("nests plentifully" despite relentless persecution by fishermen, J. B. Dixon in Willett 1933), 30 May 1928 (1 egg set from "colony of 10 nests in this one tree," data slip of J. B. Dixon, WFVZ), 5 May 1932 (1 egg set from nest in cottonwood in lake, data slip E. N. Harrison, WFVZ); Lake Hodges, 13 May 1923 (3 nests and 2 more building in cottonwood in water, 2 egg sets, F. N. Gallup, WFVZ); Sweetwater Reservoir, 20 April–12 June 2001 ("active nests" seen from distance, P. Famolaro in litt.), 24 May 2001 (17 occupied nests in two trees, P. Famolaro in Unitt 2004).

Imperial County: Salton Sea, 20 April 1908 (147 nests with eggs [many others partly built] on Pelican Island, Grinnell 1908), 18 April 1909 (2 egg sets, MVZ); Palo Verde, 21 April 1935 (1 egg set from nest in dead willow in flood area of Colorado River, data slip G. B. Thomas Jr., WFVZ).

APPENDIX 7. Records of confirmed breeding of the Caspian Tern in the interior of California, 1899 to 2000, other than those listed or summarized in the text.

Siskiyou County: Meiss Lake, Butte Valley WA, summer 1979 (50 pairs, E. O'Neill in Gill and Mewaldt 1983), 19 June 2000 (19 nests, J. Llewellyn *fide* K. Novick in litt.); Lower Klamath Lake (CA or OR?), 1–7 July 1906 (300 birds in one colony [many eggs hatched], Chapman 1908).

Siskiyou/Modoc County: Tule Lake, early July 1899 (about 500 adults, "apparently nesting," Bailey 1902).

Modoc County: Big Sage Reservoir, 18 June 1976 ("nesting colony," B. E. Deuel in litt.), June 1979 ("not seen," B. E. Deuel in litt.), summer 1979 (75 pairs, E. O'Neill in Gill and Mewaldt 1983), 3 June 1981 (100 adults, B. E. Deuel in litt.); Goose Lake, aerial survey 4 June 1976 ("nesting on islands at south end," B. E. Deuel in litt.), summer 1977 (400 adults, estimate of 220 young produced, Winkler 1982; 200 pairs, D. Winkler in Gill and Mewaldt 1983, MPCR files), 15 June 1979 (about 100 pairs nesting on big island at south end," B. E. Deuel in litt.), nesting season 1985 (high water covered nesting islands, only a fraction of previous numbers nested on peninsula, AB 39:959).

Lassen County: Honey Lake, 25 May 1956 (1 egg set, about 50 pairs nesting, N. K. Carpenter, J. B. Dixon, WFVZ); Hartson Reservoir, Honey Lake WA, 26 May–2 June 1956 (50–100 pairs nesting, W. Anderson, MPCR files), 14–15 June 1976 (200–300 "nesting," B. E. Deuel, MPCR files), 16 July 1976 (about 200 including 78 immatures, T. Manolis, R. Stallcup, MPCR files), summer 1979 (10–20 pairs, A. Lapp in Gill and Mewaldt 1983), 14 May 1990 (40 nests, 400 adults, J. R. Jehl Jr. in Honey Lake WA files).

Mono County: Bridgeport Reservoir, early 1970s ("in recent years five to seven pairs have bred," R. Stallcup in Gaines 1977; this record is likely in error, R. Stallcup pers. comm.); Mono Lake, 15 June 1963 (1 egg set, L. R. Howsley, WFVZ); Mono Lake, Negit Islets, 1976 (6–12? pairs, 10? chicks fledged), 1979 (10–15 pairs), 1980 and 1981 (active), 1987 (1 pair, 1 chick,) (summary from D. Winkler and J. R. Jehl Jr. in Jehl 1986, Jehl in litt.); Mono Lake, Paoha Islets, 1982 (ca. 14 pairs, 3–4 chicks fledged), 1983 (ca. 14 pairs, 2 chicks), 1984 (5 pairs, 0 chicks), 1985 (2 pairs, 0 chicks), 1986 (1?, 0 chicks), 1987 (3 pairs, 0 chicks), 1988 (5 pairs, 2 chicks), 1989 (4–5 pairs, 1 chick), 1990 (5 pairs, 0 chicks), 1991 (7 pairs, 1 chick), 1992 (10 pairs, 2–3 chicks), 1993 (12–13 pairs, 3–5 chicks), 1994 (12–13 pairs, 0 chicks), 1995 (5 pairs, 1–2 chicks), 1996 (8 pairs, 0 chicks), 1997–2000 (0 pairs) (summary from Jehl 1997, J. R. Jehl Jr. in litt.).

Sutter County: Sutter Basin, overflow lands along Sacramento River (near Reigo at least in 1915), 21 May 1910 (4 egg sets, large colony, H. A. Snow, C. S. Thompson, WFVZ), 25 May 1911 (25 egg sets, H. A. Snow, SBMNH, WFVZ; plus 2 egg sets attributed to "Marysville" [Yuba Co.] likely by date to be from Sutter Basin/County), 25 May 1912 (1 egg set, H. A. Snow, WFVZ), 25 May 1915 (100 egg sets, large colony, H. A. Snow, WFVZ).

Stanislaus County: Woodward Reservoir, 14 June 1925 (13 egg sets), 20 June 1925 (4 egg sets), 12–26 June 1932 (15 egg sets) (all W. B. Sampson, WFVZ).

San Benito County: San Felipe Lake, 21 June 1993 ("nested," AB 47:1147).

Kings County: South Wilbur Flood Area, 2 Aug 1982 (450 "breeding," K. & R. Hansen, MPCR files); Tulare Lake Drainage District South Evaporation Basin, nesting season 1985 (about 400 pairs "nested," AB 39:959); Tulare Lake Basin, summer 1983 (40 "nesting," G. Gerstenberg, MPCR files), 31 July 1983 (fewer than normal nested, 1st juvenile seen this date, R. Hansen, MPCR files); Hacienda Ranch Flood Basin, 24 June 1987 (200 including many chicks, R. A. Erickson, J. C. Sterling, MPCR files); Westlake Farms North Evaporation Basin (all data from J. Seay/H. T. Harvey & Associates), 7 June 1993 (10 nests on small island, preyed on by 16 June), 23 June 1994 (8 nests on island preyed on by 8 July [ninth nest found that date also preyed on]); Westlake Farms Section 3 alternative wetland (all data from J. Seay/H. T. Harvey & Associates), 19 May–23 June 1994 (1 nest on small island), 18 June–11 July 1996 (1 nest on large island).

Kern County: Buena Vista Lake, 22 May 1923 (1 egg set, colony of about 30 pairs attempting to nest, but eggs trampled by pelicans and eaten by gulls, J. G. Tyler, egg data slip from Tyler's field notes copied by R. Hansen), 27 May 1923 (4 egg sets, about 30 pair attempting to nest, Whitney for A. H. Miller; MVZ, WFVZ).

Riverside County: Lake Elsinore, 23 July 1995 (adult with downy chick, NASFN 49:980).

Imperial County: Salton Sea, 21 May 1927 ("a few nests," "about a dozen pairs," Pemberton 1927; 2 egg sets, O. W. Howard, J. S. Rowley, WFVZ), 12–19 May 1928 (10 egg sets, small colony, W. C. Hanna, SBCM), 1 June 1928 (1 egg set, A. Barr, SBCM [attributed to "Riverside Co." but likely refers to site in Imperial Co.]), 9 June 1928 (1 egg set, A. H. Miller, MVZ), 18 May 1929 (2 egg sets, colony of about 25 pairs, W. C. Hanna, SBCM), 18 May 1930 (2 egg sets, G. Willett, WFVZ), 2–4 June 1933 (3 egg sets, colony of about 40 pairs, S. B. Peyton, WFVZ; 2 egg sets, J. B. Abbott et al. WFVZ), 13–18 April 1940 (adults seen these dates, Abbott 1940; "five or six pairs said…to nest," L. Goldman in Abbott 1940), 12 April 1946 (2 egg sets, F. N. Gallup, WFVZ), 13–17 May 1947 (1 egg set, F. N. Gallup, WFVZ; 2 egg sets, J. H. Baumgardt, WFVZ), nesting season 1949 ("…did not start nesting until the last of April," AFN 3:224), 22 May 1949 (3 egg sets, colony of about 40 pairs, E. & B. Cardiff, W. C. Hanna, SBCM), 4 June 1949 (1 egg set, colony of about 15 pairs, E. M. Hall, WFVZ), nesting season 1956 (succeeded in nesting and rearing young, AFN 10:410), June 1957 (40 adults nested and raised 12 young, AFN 11:429), nesting season 1959 (successful nesting assumed based on numerous flying young seen in midsummer, AFN 13:455), 25 June 1992 (30 nests on Mullet Island, AB 46:1178), June 1993 (60 nests, AB 47:1150), nesting season 1994 (120 pairs successfully fledged young, NASFN 48:989), summer 1996 (at least 1000 pairs nesting on Mullet Island, NASFN 50:996), summer 1997 (at least 1200 pairs, FN 51:1054).

APPENDIX 8. Egg set records (number of sets, abbreviation of institution) of the Black Tern in California, 1886 to 1960.

Northeastern California

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

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

El Dorado County: near Bijou, Lake Tahoe, 19 June 1899 (1, WFVZ), 9 June 1911 (5, WFVZ), 10 June 1912 (2, WFVZ), 6 June 1918 (9, WFVZ); Lake Tahoe, 6 June 1910 (1, WFVZ); Rowland's Marsh (*aka* Al-Tahoe), Lake Tahoe, 22 June 1902 (1, WFVZ), 10 June 1909 (1, MVZ; 2, WFVZ), 23 May–15 June 1910 (5, MVZ; 2, WFVZ), 30 May–9 June 1914 (7, MVZ; 11, WFVZ), 30 June 1918 (1, CAS), 5 June 1919 (1, CAS), 30 May 1920 (1, CAS), 14 June 1928 (1, MVZ), 21 June 1930 (1, MVZ), 15 June 1939 (2, MVZ); near Tallac, Lake Tahoe, 22 June 1911 (1, WFVZ).

Central Valley

Sacramento Valley

Colusa County: Maxwell, 23 June 1939 (1, WFVZ).

Yolo County: Woodland, 11 May 1886 (1, WFVZ).

Sacramento–San Joaquin River Delta

Sacramento County: 0.5 mi south of Freeport, 15 June 1899 (2, MVZ); Bear Lake, 27 May 1923 (5, WFVZ); vicinity of Sacramento (Sacramento Co. ?, Delta ?), 7 June 1902 (1, CAS), 13 May 1906 (2, CAS); Stone Lake, 15–29 May 1921 (23, WFVZ), 4 June 1922 (1, WFVZ), 13–30 May 1923 (4, WFVZ).

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

San Joaquin Valley

Madera County: Chowchilla (egg record says "Merced Co."), 23 June 1900 (5, CAS); 15 mi west of Madera, 30 June 1923 (1, SBCM); "Madera Co.," near Firebaugh, Fresno Co., 16–17 May 1927 (8, WFVZ); "Madera Co.," 10 mi east of Firebaugh, Fresno Co., 26 May 1927 (1, SBCM; 3, WFVZ); 10 mi from Firebaugh (? Co.), 5 June 1927 (1, SBCM); "Madera Co.," 28 May 1928 (1, WFVZ), 9 June 1930 (3, WFVZ).

Merced County: near Brito, 21 May 1919 (1, SBCM); Dos Palos, 17–22 May 1912 (4, SBMNH; 1, WFVZ), 8 June 1927 (1, WFVZ); Gadwall, 16 May 1914 (1, MVZ), 1–2 July 1917 (6, CAS), 12 May–4 June 1918 (12, CAS; 2, MVZ); Gustine, 14 May 1931 (1, WFVZ), 5 June 1932 (1, WFVZ), 12 June 1934 (1, WFVZ), 7 June 1937 (5, WFVZ); Los Banos, 17 May 1898 (1, WFVZ), 8 June 1901 (1, WFVZ), 5 June 1905 (3, WFVZ), 2 June 1908 (2, WFVZ), 26 May 1910 (3, WFVZ), 2 July 1913 (1, CAS), 7 June 1914 (1, SBCM; 1, WFVZ), 29 May–25 June 1916 (11, CAS; 1, WFVZ), 3–4 June 1918 (4, SBCM), 26 June 1919 (1, WFVZ), 30 May 1920 (1, WFVZ), 28 May 1921 (1, WFVZ), 3–4 June 1922 (3, WFVZ), 1–18 June 1923 (1, MVZ; 14, WFVZ), 21 May–21 June 1925 (2, SBMNH; 7, WFVZ), 23 May–20 June 1926 (8, WFVZ), 3 June 1928 (1, WFVZ), 30 May–1 July 1930 (5, SBMNH; 17, WFVZ; 1, MVZ), 14 June 1931 (1, WFVZ), 13 May–5 June 1932 (9, WFVZ; 1, MVZ), 12 May–12 June 1934 (1, MVZ; 3, WFVZ), 11–13 May 1935 (5, WFVZ), 25 May 1936 (4, WFVZ), 14 May–1 June 1937 (11, WFVZ), 4 June 1938 (1, WFVZ), 10 May–7 June 1939 (8, WFVZ), 19 May 1940 (4, WFVZ), 9 June 1941 (1, WFVZ), 9 June 1942 (2, WFVZ); 4–6 mi south of Los Banos, 21–23 May 1919 (2, MVZ), 30 May 1920 (1, WFVZ), 12–21 June 1931 (5, WFVZ); 8–10 mi east of Los Banos, 7 May 1927 (1, MVZ), 13 May–1 June 1935 (1, MVZ; 4, WFVZ); 5–10 mi northeast of Los Banos, 9 May 1936 (1, WFVZ), 14 May 1937 (3, WFVZ), 31 May

1939 (1, WFVZ); "Merced Co.," 20 May 1899 (1, WFVZ), 25 May–1 July 1908 (16, CAS), 26 May 1909 (9, CAS), 15–28 May 1926 (2, WFVZ), 28 May 1928 (1, WFVZ), 9 June 1930 (2, WFVZ), 25 June 1931 (1, WFVZ), 12–19 May 1935 (1, MVZ; 3, WFVZ), 3 May–9 June 1936 (2, MVZ; 18, WFVZ), 10 May 1939 (1, WFVZ), 5 June 1946 (1, WFVZ), 22–23 June 1948 (2, SDNHM; 2, WFVZ), 22–23 May 1949 (6, WFVZ); San Joaquin River at Los Banos Crossing, 15 May 1897 (2, MVZ).

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

Kings County: 12 mi from Corcoran (egg record says "Kern Co."), 24 May 1940 (1, WFVZ); Gernsey Slough, 3 June 1946 (2, WFVZ); 3 mi east of Hanford, 24 May 1922 (1, SBMNH); near Stratford, 23–24 May 1936 (10, WFVZ); border of Tulare Lake, 4 mi west of Waukena, Tulare Co., 6 June 1893 (3, MVZ); Tulare Lake, 8 June 1941 (11, WFVZ); Tulare Lake (Kings Co.), 24 May–8 June 1941 (9, SBMNH; 9, WFVZ); 14 mi northwest of Tulare, 6 June 1893 (1, MVZ).

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

APPENDIX 9. 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 to mid-July 1971 (1 nest, Gould 1974); North Basin, Eagle Lake, late May–late June 1996 (29 nests, Shaw 1998), early June to mid-July 1997 (21 nests, Shaw 1998); southwest shore, Eagle Lake, late May to mid-July 1971 (6 nests, Gould 1974); near Spaulding's, Eagle Lake, 9 June 1925 ("many nests," Grinnell et al. 1930), late May to mid-July 1970 (30 nests, Gould 1974), late May to mid-July 1971 (33 nests, Gould 1974), early June to mid-July 1997 (11 nests, Shaw 1998); eastside bays (Troxel and Duck Island bays), Eagle Lake, late May to 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 (*aka* Al-Tahoe), Lake Tahoe, 1 June 1909 ("scores of nests," Ray 1913).

Central Valley

Sacramento Valley

Butte County: west of Biggs, 6 July 1987 (2 nests, J. Snowden in litt.); 3 mi south of Durham, 1 June 1985 (2 nests, J. Hornstein); 2 mi northeast 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: south side of White Rd. 0.7 mi west of Browning Rd., 26 June 1999 (2+ nests, B. Williams in litt.).

Sutter County: south 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); east of Armour Rd. between Kirkville Rd. and Varney Rd., May–July 1977 (2 nests, Lee 1984); jct. Hwy. 113 and Kirkville Rd., June–July 1977 (8 nests, Lee 1984); north of Kirkville Rd. adjacent to Sutter Bypass, June–July 1977 (11 nests, Lee 1984); north 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).

San Joaquin Valley

Merced County: near 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 near Merced, prior to 1904 ("number of nests recorded," Mailliard 1904).

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

Fresno County: near 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 south 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 (*aka* 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 west 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.).

APPENDIX 10. Records of confirmed breeding of the Forster's Tern in the interior of California, 1896 to 2000, other than those listed or summarized in the text.

Siskiyou County: Meiss Lake, Butte Valley WA, 20 June 1979 ("nesting," B. E. Deuel in litt.), June 1980 ("nesting," B. E. Deuel in litt.), 30 May 1984 (200 adults, standing or sitting on nesting structures built for Canada Geese, B. E. Deuel, MPCR files).

Siskiyou/Modoc County: north end Tule Lake, summer 1905 (small colony, Finley 1907).

Modoc County: Alturas, 26 May 1914 (2 eggs sets, F. C. Holman, CAS); Willow Ranch, 21 May 1923 ("a few pairs nesting," Mailliard 1927); Big Sage Reservoir, 18 June 1976 ("thriving colony;" AB 30:999, MPCR files), 5 June 1980 ("colony… doing very well, B. E. Deuel in litt.); Goose Lake, aerial survey 4 June 1976 ("nesting on islands at south end," B. E. Deuel in litt.), summer 1977 (250 pairs "nested," D. Winkler, MPCR files; Winkler 1982), aerial survey 3 June 1981 ("260 nesting," B. E. Deuel in litt.), 20 June 1999 (on two small islands off southeast shore, 161 nests with eggs, D. Shuford).

Lassen County: Grasshopper Meadows, 6 June 1918 (8 egg sets, BWE, CAS); Eagle Lake, 9 June 1925 (1 egg set, J. Moffitt, WFVZ; "nearly 100 pairs…nesting" near Spaulding's, J. Moffitt in Grinnell et al. 1930), summer 1970 (9 nests, 150 pairs, Gould 1974), summer 1971 (70 nests, 75 pairs, Gould 1974), summer 1974 (28 nests, Lederer 1976), summer 1996 (41 nests, Shaw 1998), summer 1997 (25 nests, Shaw 1998); Hartson Reservoir, Honey Lake WA, 2 June 1956 (15 nests, W. Anderson, MPCR files); Dakin Unit, Honey Lake WA, 22 June 1980 (10+ adults, very defensive D. A. Airola, MPCR files), 19 June 1999 (28 nests, D. Shuford); Fleming Unit, Honey Lake WA, 26 May 1984 (~10 pairs "nesting," T. & A. Manolis, MPCR files); Leavitt Lake, 28 May 1958 (6–7 pairs, VKC, MPCR files); Mountain Meadows Reservoir, summer 1971 (26 nests, Gould 1974), 23 May 1982 (38 nests, 90+ adults, D. A. Airola, MPCR files).

Plumas County: Lake Almanor, 26 May 1992 (150 adults, "breeding colony" on island, H. Green, MPCR files); Sierra Valley, off Marble Hot Springs Rd. (Dyson Lane), 10 June–4 July 1998 (10–13 June, 3–8 adults [plus 3–4 subadults], D. Shuford, J. McCormick; 4 July, two adults repeatedly carrying food to distant site, J. McCormick).

El Dorado County: Rowland's Marsh (*aka* "Al Tahoe" or "near Copeland's"), 8–12 June 1901 (7 egg sets, M. S. Ray, WFVZ), 10–24 June 1912 (2 egg sets, M. S. Ray, MVZ), 4–20 June 1901 and 16 June–3 July 1902 ("about 100 nests examined in 1901 and 1902," Ray 1903), 30 May–9 June 1914 (18 egg sets, C. Littlejohn, M. S. Ray, MVZ, WFVZ), 10 June 1916 (2 egg sets, M. S. Ray, MVZ, WFVZ), 6 June 1918 (3 egg sets, H. W. Carriger, G. Wells, WFVZ), 5 June 1919 (2 eggs sets, J. Moffitt, CAS), 17 June 1921 (1 egg set, M. S. Ray, R. S. Wheeler, MVZ), 14 June 1922 (5 egg sets, M. S. Ray, MVZ, WFVZ), 5 June 1927 (5 egg sets, J. Moffitt, CAS), 21 June 1930 (1 egg set, M. S. Ray, MVZ); Bijou, Lake Tahoe, 16 June 1896 (1 egg set, W. H. Osgood, WFVZ), 10 June 1912 (1 egg set, C. Littlejohn, WFVZ), 6 June 1918 (3 egg sets, D. S. De Groot, WFVZ), 18 June 1921 (5 egg sets, R. S. Wheeler, WFVZ); "Lake Tahoe," 12 June 1906 (1 egg set, M. S. Ray, MVZ), 16 June 1918 (1 egg set, G. Wells, WFVZ), summer 1977 (failed, AB 31:1183); Pope Marsh, South Lake Tahoe, 14 June 1998 (29+ nests, D. Shuford. K. Laves).

Mono County: Bridgeport (Sweetwater) Reservoir, 17–21 June 1934 (7 egg sets, E. N. Harrison, WFVZ), 9 June 1992 ("nests," R. Stallcup, MPCR files); Crowley Lake, 22 July 1991 (at least 16 nests, E. Strauss, P. J. Metropulos, MPCR files).

Sutter County: near Reigo, Sutter Basin, 25 May 1911 (3 egg sets, H. A. Snow, WFVZ).

Sacramento County: vicinity of Sacramento (Co. ?), 28 June 1908 (1 egg set, F. G. Coomes, CAS).

Stanislaus County: Turlock Lake, 12 July 1995 (59 nests, H. Reeve), 26 July 1995 (71 nests, colony abandoned, H. Reeve), 12 July 1999 (120+ adults/~55 pairs, 16 nests with eggs, 20 medium to large chicks; J. Gain, J. Turner); Woodward Reservoir, 12 July 1999 (~15 pairs [12 nests with eggs, 6 mobile chicks]; J. Gain, J. Turner).

Merced County: Los Banos, 2 and 12 July 1913 (2 egg sets, P. J. Fair, CAS), 23 May 1914 ("eggs taken," Dawson 1923), 3 June 1914 (4 egg sets, W. L. Dawson, SBMNH), 23 June 1921 (7 egg sets, NKC, WFVZ), 12–18 June 1923 (4 egg sets, J. Burnham, R. S. Wheeler, MVZ, WFVZ), 28 May–2 July 1925 (64 egg sets, D. B. Bull [colony of about 200 pairs], H. W. Carriger, C. L. Field, C. Littlejohn, W. E. Unglish, R. S. Wheeler [colony of 10–15 pairs nearby]; MVZ, WFVZ), 15

May–20 June 1926 (18 egg sets, H. W. Carriger, J. E. Cole, D. De Groot [largest colony was one of 10 nests on single island], W. B. Sampson, J. G. Tyler [large scattered colony]; SBMNH, WFVZ), 19 June 1932 (1 egg set, W. B. Sampson, WFVZ), 5 June 1946 (2 egg sets, G. Brem Jr., WFVZ), 17 June 1946 (3 egg sets, colony of about 15 pairs, G. Brem Jr., WFVZ); 3.5–5 mi southeast of Los Banos, 6–20 June 1925 (40 egg sets, W. B. Sampson, WFVZ), 12 June 1926 (1 egg set, W. B. Sampson, WFVZ); near Dos Palos, 4 June 1933 (6 egg sets, H. W. Carriger, WFVZ); "Merced County," 22–25 June 1908 (6 egg sets, RHB, CAS), 1–6 June 1935 (6 egg sets, H. R. Eschenburg; MVZ, SBCM, SDNHM, WFVZ), 7 June 1939 (1 egg set, G. Brem Jr., WFVZ), 23 June 1948 (1 egg set, G. Brem Jr., WFVZ).

Madera County: Firebaugh (Co.?), 23 June 1919 (2 egg sets, A. M. Ingersoll, WFVZ); Columbia Ranch (Co.?), 22 June 1921 (2 egg sets, G. Bancroft Sr. and Jr., WFVZ); 15 mi west of Madera, 30 June 1923 (1 egg set, scattered colony nesting in overflow pasture, J. G. Tyler, egg data slip from Tyler's field notes copied by R. Hansen); 12 mi east of Firebaugh/20 mi west of Madera, 13 June 1925 (15 egg sets, scattered colony of about 100 pairs, J. G. Tyler; MVZ ,WFVZ, Tyler's field notes).

Fresno County: Columbia Ranch, east of Firebaugh, 8 June 1920 (1 egg set, G. Bancroft, WFVZ), 22 June 1921 (10 egg sets, G. Bancroft, WFVZ), 28–30 June 1922 (3 egg sets, G. Bancroft, WFVZ).

Kings County: "Kings County," 30 June 1938 (9 egg sets, C. O. Reis, WFVZ); Gearnsey's Slough, 30 June 1938 (13 egg sets, I. D. Nokes, WFVZ); Tulare Lake, 8 June 1941 (10 egg sets, E. N. Harrison [large colony], L. Stevens; WFVZ, SBMNH), 1 June 1945 (1 egg set, L. T. Stevens, WFVZ); South Wilbur Flood Area, 2 Aug 1982 (300 adults "breeding," K. & R. Hansen, MPCR files), 22 July 1983 (65+ adults, 4 nests, R. Hansen, MPCR files), 3 June 1984 (14 adults, 1 nest, *fide* J. Houk, MPCR files); Tulare Lake Drainage District South Evaporation Basin, summer 1985 (20 pairs "nesting," G. Gerstenberg, MPCR files); Westlake Farms North Evaporation Basin, 3–9+ June 1994 (2 nests on island, 1 abandoned by 23 June, *fide* J. Seay/H. T. Harvey & Associates); Westlake Farms South Evaporation Basin, 12–25 May 1991 (up to 4 pairs "nesting," R. A. Erickson, D. G. Yee, W. R. Holt, MPCR files); Lost Hills Water District and Rainbow Ranch's compensation wetland at Westlake Farms, Section 23 (all data from J. Seay/H. T. Harvey & Associates), 24 May–13 July 1995 (3 nests on border dike), 9 May–5 June 1996 (3–4 nests on contour islands, 1 preyed on by 23 May), 1 June–7 July 1999 (2–3 nests on contour island); Westlake Farms Section 3 alternative wetland (all data from J. Seay/H. T. Harvey & Associates), 9 June–14 July 1994 (7 nests on small islands), 10 May–14 June 1995 (1–2 nests on small islands), 3 June 1997 (1 nest on small island, destroyed by 11 June), 1–22 June 1999 (3–5 nests, all preyed on); East Hacienda Ranch Flood Basin, 29 June 1997 (2 nests, R. Hansen).

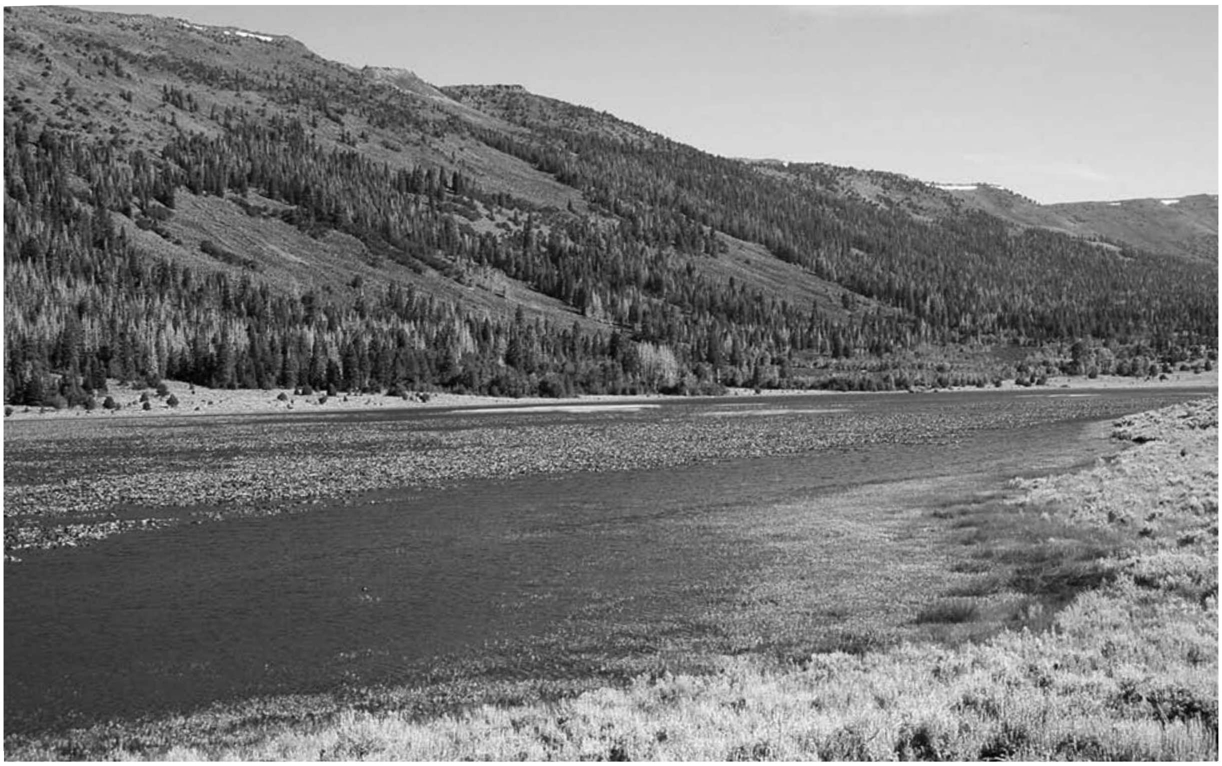
Kern County: Buena Vista Lake, 18–19 June 1914 (2 egg sets, L. M. Huey, WFVZ), 2–11 July 1920 (21 egg sets, colony of about 500–600 pairs, A. van Rossem, WFVZ), 15 July 1921 (1 egg set, A. van Rossem, WFVZ), 15 June–24 July 1922 (13 egg sets, A. H. Miller [large colony], L. G. Peyton [colony of 25–30 pairs], A. van Rossem; MVZ, WFVZ), 23 May 1923 (5 egg sets, colony of about 100 pairs just beginning to nest, J. G. Tyler; MVZ, WFVZ, Tyler's field notes), 4–5 July 1937 (6 egg sets, J. S. Rowley, W. J. Sheffler, and G. B. Thomas Jr., WFVZ), 1–12 June 1938 (10 egg sets, M. C. Badger, E. M. Hall [colony of about 50 pairs], E. N. Harrison, and L. Stevens; SBCM, SBMNH, WFVZ), 11 June 1945 (1 egg set, J. H. Baumgardt, WFVZ), 14 June 1947 (4 egg sets, J. H. Baumgardt, WFVZ), 19–20 June 1954 (3 egg sets, K. E. Vorce, WFVZ); Lost Hills Water District alternative habitat, west of Kern NWR and adjacent to Kern River channel, 10 June 1999 (2 nests, preyed on by 24 June, J. Seay/H. T. Harvey & Associates).

Orange County: Burris Sand Pit (reservoir), adjacent to Santa Ana River between cities of Anaheim and Orange, summer 1999 (about 12–15 nests, D. Willick), 11 July 2000 (24 pairs [nest sites], D. Willick et al.).

Imperial County: mouth of New River, Salton Sea, 17 May 1970 (2 nests, AFN 24:717); south end Salton Sea, nesting season 1972 (20 pairs "nested," AB 26:906), 4 July 1976 (32 nests, AB 30:1004), June 1991 (3 nests, apparently abandoned by mid-July, AB 45:1162); north end of Salton Sea, nesting season 1978 (over 200 pairs "nested," AB 32:1208–1209).

California Gulls (*Larus californicus*) nesting against or near greasewood scrub (*Sarcobatus vermiculatus*) on Hansen Island in Middle Alkali Lake in Surprise Valley, against the backdrop of the cloud-draped eastern flank of the Warner Mountains, Modoc County, California, 17 May 1994. Because of very shallow water and mud from the shoreline to the island, canids, presumably coyotes (*Canis latrans*), reached the island and destroyed nests and killed some adult gulls.

California Gulls (*Larus californicus*) on large nests apparently built up to evade rising waters in Hartson Reservoir on the Dakin Unit of Honey Lake Wildlife Area, Lassen County, California, with the eastern flank of the Diamond Range of the Sierra Nevada in the background, 20 May 1995.



High-elevation nesting habitat for Black Terns (*Chlidonias niger*), dominated by a floating yellow pond-lily (*Nuphar luteum* ssp. *polysepalum*), on Boot Lake at 6560 ft (2000 m) elevation in the southern Warner Mountains, Lassen County, California, 26 June 1997.

Nesting habitat for Black Terns (*Chlidonias niger*) at Hager Basin North in the Devil's Garden Ranger District of Modoc National Forest, Modoc County, California, 24 May 1997. This is one of many shallow-water marshes dominated by spikerush (*Eleocharis* spp.) and *Juncus* spp. used by this species in this region.

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