The Distribution and Conservation Status of the Gull-billed Tern (*Gelochelidon nilotica*) in North America

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Abstract.—The Gull-billed Tern (*Gelochelidon nilotica*) has until recently received little conservation and management attention within North America despite a relatively low overall population size and significant declines in parts of the breeding range. This lack of attention may stem in part from the wide distribution of the species, encompassing parts of six continents, and from its tendency to nest in relatively small, scattered and often ephemeral colonies. Populations of North American subspecies are alarmingly small. The current population of the eastern subspecies *aranea* in the U.S. is unlikely to exceed 3,600 pairs, with over 60% of these birds occurring in Texas. The Texas population has remained generally stable, but declines of populations in Maryland (where probably extirpated), Virginia, North Carolina, Florida, and possibly Georgia give cause for concern for this subspecies. For the western subspecies *vanrossemi,* as few as 250 pairs nest at only two locations in the U.S., both in California. When populations in western Mexico are considered, the entire *vanrossemi* population numbers only 600-800 pairs. Currently the Gull-billed Tern is listed as "endangered" or "threatened" in four states, and is considered to be of management concern in five others. The breeding range of the species has contracted and shifted slightly from its known historic range in the middle Atlantic states, but otherwise occupies its historic range in the United States and has expanded slightly to coastal southern California. Some range contraction in Mexico (e.g., in Sonora) may have occurred. In eastern Mexico, historical information is almost non-existent and knowledge of current distribution and abundance is incomplete. Main threats to populations in North America include loss of natural nesting islands through beach erosion or perturbations to estuarine functions, development or modification of upland habitats near breeding areas that may be important for foraging, and disturbances to colonies by humans and feral or human-subsidized predators. This species often nests on man-made substrates suggesting it could be responsive to management of breeding sites. Key research needs include more frequent and refined population monitoring, a better understanding of demographics, metapopulation dynamics and factors limiting populations as well as refinement of subspecies' breeding distributions and wintering ranges. *Received 25 January 2005, accepted 1 June 2006.*

Key words.—Gull-billed Tern, *Sterna nilotica*, *Gelochelidon nilotica*, *aranea*, *vanrossemi*, distribution, population status, trends.

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The Gull-billed Tern (*Gelochelidon nilotica*) has a wide, though discontinuous, distribution which encompasses parts of six continents. Variably placed within the monotypic genus *Gelochelidon* (Peters 1934; Hagemeijer and Blair 1997; American Ornithologists' Union 2006) or *Sterna* (American Ornithologists' Union 1998), recent analyses (Gochfeld and Burger 1996; Bridge *et al.* 2005) find it well separated from other *Sterna* terns. The foraging behavior of this tern differs markedly from most other terns; it does not plunge-dive, but rather swoops or dips to the surface to catch a variety of terrestrial as well as aquatic prey (Parnell *et al.* 1995).

As many as six subspecies have been described based on variation in overall size, bill size and shape, and coloration of the dorsal plumage (Blake 1977; Cramp 1985; Higgins and Davies 1996). Three of these subspecies—*nilotica* of Europe and Africa, *affinis* ("*addenda*" is a synonym) of eastern Asia, and *macrotarsa* of Australia—are confined to the Old World and not discussed further here. In the New World, the subspecies *groenvoldi* breeds locally in eastern South America from Brazil to northern Argentina (Blake 1977). We focus here on the two subspecies which occur in North America. *Aranea* breeds along the Atlantic and Gulf of Mexico coasts of the United States and northeastern Mexico, with most of the population withdrawing southward to winter locally from the Gulf Coast south to northern South America

(American Ornithologists Union 1957; Parnell *et al.* 1995; Fig. 1). *Vanrossemi* was described by Bancroft (1929) on the basis of specimens collected by Pemberton at the Salton Sea, California, in 1927; it averages larger than *aranea* in all measurements and has a bill that is longer and deeper than that of the nominate subspecies and, especially, *aranea*. *Vanrossemi* breeds very locally on the Pacific Coast and in the lower Colorado River delta region of southern California and northwestern Mexico, and very locally farther south in Mexico from Sinaloa to at least Colima; it winters in western Mexico and to an unknown extent south to the Pacific Coast of Central America and possibly northwestern South America (American Ornithologists Union 1957, Parnell et al. 1995; Fig. 1).

Within North America the Gull-billed Tern is generally quite localized as a breeder, and although it remains poorly studied across much of its range, it is suspected to have experienced important regional declines recently (Brinker 1996; Erwin *et al.* 1998; Florida Fish and Wildlife Conservation Commission 2003). At the federal level this species is included on the U.S. Fish and Wildlife Service's Birds of Conservation Concern (U.S. Fish and Wildlife Service 2002) in three of the seven administrative Regions (1, 2, and 4). It is considered a species of high concern in the North American Waterbird Conservation Plan (Kushlan *et al.* 2002). At the state level it is considered Endangered in Maryland, Threatened in Virginia, North Carolina, and Georgia, and Protected in New York. The species is also a Species of Special Concern or equivalent in South Carolina, Alabama, Louisiana and California.

Prior to Molina and Erwin's (2006) assessment of Gull-billed Terns in North America, the population status of the subspecies *aranea* along the Atlantic and Gulf of Mexico coasts of North America was most recently reviewed during the 1980s by Clapp et al. (1983) and Clapp and Buckley (1984). The status of the western North American subspecies *vanrossemi* is less well known and was reviewed most recently by Clapp *et al.* (1993), Parnell *et al.* (1995), Molina (2000, 2001), and Molina and Erwin (2006). Until recently its distribution in western Mexico had not been detailed.

The objectives in this review are to: (1) update the published record with current data on the status and distribution of the Gull-billed Tern in North America, (2) summarize historical data, including specimen data where knowledge of its distribution was fragmentary, (3) document apparent declines and threats in portions of the range, and (4) offer management suggestions to help stabilize populations and reverse declines.

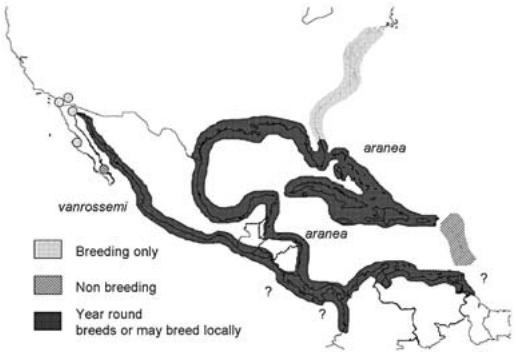

Figure 1. Breeding and non-breeding distributions of *aranea* and *vanrossemi* Gull-billed Terns in North America, the Caribbean, and northeastern South America. Subspecific identity of birds on Pacific coast of Central America and northwestern South America are unresolved as are the subspecific limits of *aranea* and *groenvoldi* in northeastern South America.

METHODS

Current status and recent population trends were assessed in North America by reviewing published literature and unpublished reports and by querying managers of colonial waterbird monitoring programs in all pertinent states. Because focused non-breeding surveys of Gull-billed Terns are lacking, Christmas Bird Count (CBC) data (as published in American Birds, Field Notes and at http//www.audubon.org) were compiled from coastal counts conducted from 1975-2005 to summarize known mid-winter occurrence. Information also derives from field work by the authors in California and western Mexico (KCM) and Virginia (RME). To construct a better understanding of the historical distribution of Gull-billed Terns in Mexico, the Caribbean, and Central and South America seventeen major museum collections in the U.S. and Mexico (see Appendix 1) were queried for dates and localities of their holdings in these areas.

RESULTS

Breeding Distribution and Abundance

Gelochelidon nilotica aranea

The subspecies *aranea* breeds (Fig. 1) along the Atlantic coast of the United States from Long Island, New York, south to northeastern Florida and locally in the interior of Florida. Along the Gulf coast, *aranea* breeds from Tampa Bay, Florida, west through coastal Alabama, Mississippi and Louisiana to Texas (where they are most numerous and widespread), and from there south to Tamaulipas [Matamoros (Friedmann *et al.* 1950) and Laguna Madre (Garza-Torres and Navarro 2003] and possibly Veracruz (at Isla Pajaros, Friedman *et al.* 1950; Appendix 1) and Tabasco, Mexico (Parnell *et al.* 1995; American Ornithologists Union 1998, Appendix 1). Gull-billed Terns appeared to be absent from the waterbird breeding colonies along the eastern coast of Yucatan (Rangel-Salazar *et al.* 1993). Although their status and distribution in the Caribbean is poorly known, *aranea* is thought to breed sporadically and in small numbers on Caribbean islands from the Bahamas (primarily) and possibly Cuba and Hispaniola, south to the British Virgin Islands and Anguilla (van Halewyn and Norton 1984; Sprunt 1984; Chardine *et al.* 2000; Appendix 1). In Central America, breeding locations of the Gull-billed Tern along the Caribbean coast have not been documented in Guatemala, Honduras, Nicaragua, Costa Rica, or Panama (Monroe 1968; Ridgely and Gwynne 1989; Stiles and Skutch 1989; Howell and Webb 1995). Our search of ornithological collections yielded no specimens taken during the breeding season from any Central American country (Appendix 1). In northeastern South America breeding in Venezuela has not been proven but was felt to be likely (Hilty 2003, Appendix 1). The species is present yearround in coastal Suriname but breeding locations have not been documented (Haverschmidt 1968; Spaans 1978).

Gelochelidon nilotica vanrossemi

In the western United States the subspecies *vanrossemi* breeds very locally in extreme southern California at San Diego Bay and inland at the Salton Sea (Fig. 1). A reference to breeding on the Copper River Delta in Alaska (Gochfeld and Burger 1996) is clearly erroneous (D. D. Gibson, pers. comm.). In western Mexico, *vanrossemi* is known to have bred at fewer than ten locations in the Colorado River Delta in northeastern Baja California, on the Pacific Coast of Baja California Sur, and in coastal Sinaloa, Nayarit and Colima (Parnell *et al.* 1995; American Ornithologists Union 1998; Danemann and Carmona 2000; Molina and Garrett 2001; Palacios and Mellink 2003; Fig. 2). Historically, van Rossem (1945) suspected Gull-billed Terns to be breeding in Estero Tobarí, Sonora in 1930, but colony sites there (Palacios and Mellink 1995) and elsewhere in Sonora (Russell and Monson 1998) had never been documented. The specimen record for Gull-billed Terns in Mexico is also fragmentary but in some cases has been helpful in elucidating the general locations of historical breeding sites thereby suggesting potential locations of present day ones. Adults in alternate plumage (and assumed to be breeders) were taken early in the twentieth century from Isla Montague,

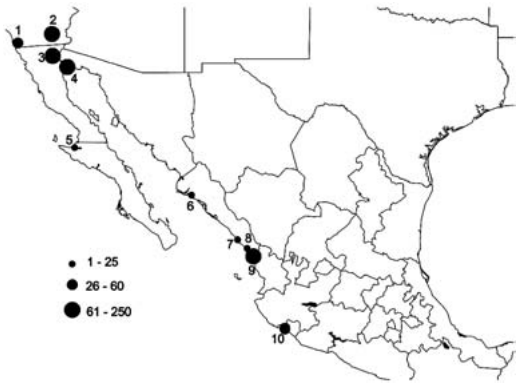

Figure 2. Locations and no. pairs of *vanrossemi* Gull-billed Tern breeding colonies in the U. S. and Mexico. 1 = San Diego Bay, California; 2 = Salton Sea, California; 3 = Cerro Prieto, Baja California; 4 = Isla Montague, Baja California; 5 = Guerrero Negro, Baja California Sur; 6 = El Rancho, Bahia Santa Maria, Sinaloa; 7 = Laguna Caimanero, Sinaloa; 8 = Teacapan, Nayarit; 9 = Laguna Pericos, Nayarit; and 10 = Laguna Cuyutlan, Colima.

northern Baja California; Bahía Santa María (specific localities of "Larricion" and "Las Tunas"), and from the Laguna Caimanero region (specific locality = Rosario) in Sinaloa (Appendix 1); breeding by this species has been confirmed recently at each of these sites (Fig. 2). Although documentation of historic breeding colonies is absent for southern Pacific Mexico, specimens that were probable breeders were taken from one site in Guerrero ("Cayacal"), and one in Oaxaca ("boca de Río Tonameca"; Appendix 1); the focused surveys of Palacios and Mellink (2003, 2006) failed to document current colony sites in those states. Away from the coastal lowlands, breeding by one to two pairs, representing either this subspecies or *aranea*, at each of two sites (Lake Xochimilco and Lake Texcoco) on the Mexican Central Plateau was documented in 2005 (H. Garza de la Silva, pers. comm.). These nest attempts at over 2200 m elevation represent the only North American breeding records at an altitude significantly above sea level.

Population Estimates and Trends

Gull-billed Terns are not considered to be abundant anywhere in their North American range (Parnell *et al.* 1995; Gochfeld and Burger 1996). The lack of quantitative estimates for historical populations (prior to the mid-1970s) of *aranea* and *vanrossemi* in North America, including Mexico, makes it difficult to track long-term population trends. After the mid-1970s the results of greater state census efforts became available, but these were often not collected simultaneously throughout an entire region. Furthermore, the unit chosen in reporting results (breeding pairs versus breeding adults) has been inconsistently applied among surveys. The two subspecies are considered separately below:

Gelochelidon nilotica aranea

During the late 19th century the Gull-billed Tern was "formerly much more abundant and more widely distributed on our Atlantic coast than it is to day, where it is now one of the rarest of the terns" (Bent 1921: p. 197). Before decimation, presumably by the millinery trade, Gull-billed Terns were thought to be "fairly common" as breeders in the marshes of Cape May Co., New Jersey, and prior to 1890 they apparently bred "in great abundance" on Cobb's and Hog islands, Virginia (Bent 1921: p. 197). According to Bent (1921) as of 1910, the species was not known to have bred in South Carolina.

Regional survey efforts to quantify *aranea* populations began in the late 1970s. For the southeastern U.S., Clapp *et al.* (1983) reported 3,472 birds (excluding Virginia and the Florida Gulf Coast) for the period from 1972 to 1979. For ease of comparison we use Erwin's (1979) pairs-to-adults conversion factor of 0.667 to convert Clapp *et al.*'s (1983) estimate of individuals into 2,292 pairs. Within a portion of this region, Portnoy *et al.* (1981) estimated 1,314 birds in North Carolina south to Atlantic Florida; Nisbet in Kress *et al.* (1983) equated this figure to 650 pairs. During the late 1970s and early 1980s Clapp and Buckley (1984) estimated a total of 3,019 pairs along the Atlantic Coast (North Carolina south) and Gulf of Mexico. This composite total was based on state censuses conducted in different years between 1976 and 1983. For the north and mid-Atlantic coast (Virginia north) in 1982, Buckley and Buckley (1984) reported a probable 1,000 pairs, yielding about 4,000 pairs for the entire eastern United States when combined with Clapp and Buckley's (1984) total. Spendelow and Patton (1988) estimated 5,400 birds for the entire U. S. during the period 1976-1982, which converts to about 3,500 pairs. However, Spendelow and Patton's (1988) report excluded the *vanrossemi* subspecies in California, and was believed to have also underestimated the population of Florida (Parnell *et al.* 1995). Although Gull-billed Terns are known to breed in the large lagoon system of Laguna Madre in Tamaulipas, Mexico (Garza-Torres and Navarro 2003), no historic or recent quantitative estimates are readily available for any Mexican state along the Gulf of Mexico coast. In summary, population estimates for the *aranea* subspecies in the U.S. by 1983 ranged from about 3,500 to 4,000 pairs.

The lack of systematic survey efforts at regular intervals in all states with *aranea* colonies in the U.S. since 1983 makes it difficult to compare recent population sizes with those reported above. In no single year have all states with colonies been surveyed simultaneously, and during the years 2000 to 2004 most states have reported counts for only one year (Table 1). Therefore, to estimate total numbers in recent years (2000-2004), we chose to sum the counts (or the mean count if more than one was conducted) for all states with breeding colonies. Our resulting estimate is 3,608 pairs. Summing the maximum counts reported would yield an upper estimate of 4,432 pairs for that period. Although our current range-wide estimates of *aranea* Gull-billed Terns do not differ substantially from those of earlier reports, at the state level longer term declines overshadow a few shorter term increases (Fig. 3, Table 1). In Maryland the Gull-billed Tern was considered fairly common in the 1950s (Parnell *et al.* 1995) with a peak population size of 25-30 pairs in that decade (Stewart and Robbins 1958); during the 1980s the number of breeding pairs fluctuated from 9 in 1985, 33 in 1986, 1 in 1987 to 0 in 1988 (Brinker 1996) and it is now probably extirpated (fide D. Brinker). In Virginia population estimates have declined by 60% between 1977 and 2003, and in North Carolina estimates have declined by 58% between 1977 and 2001. Similarly, in Georgia population size has declined 32% between 1995 and 2003, while numbers reported for Florida suggest a decline of about 70% between surveys conducted in 1975 and 2000. South Carolina exhibited a relatively modest increase of 36% between 1976 and 2003. In contrast to the significant declines observed in mid- and southern Atlantic states, modest increases have occurred in the northeastern Atlantic, in New York and New Jersey (Fig. 3, Table 1). Although these changes reflect a roughly five-fold increase in each case, the absolute population gains for these two states and South Carolina are small compared to the losses observed in Virginia, North Carolina, Georgia and Florida in recent years (Fig. 3, Table 1). Along the Gulf Coast, although Gull-billed Terns appeared to be increasing on recent surveys compared to earlier ones (Fig. 4, Table 1), breeding populations in this region show high inter-annual variability, especially in Texas for which the most comprehensive and continuous dataset exists, and Louisiana. The minimum and maximum state estimates for coastal Texas were 688 pairs in 1974 and 4661 pairs in 1983. Decadal means were as follows: 1599 pairs from 1973-1979, 2040 pairs in the 1980s, 1859 pairs in the 1990s and 2122 pairs from 2000-2003 (Table 1). Up to 200 pairs may nest at interior salt lakes in some years and are not covered by the annual coastal census (D. Blankinship, pers. comm.). Although the average colony size overall for Texas is about 56 pairs, this state supports the largest individual colonies of Gull-billed Terns in North America. From 2000-2003, the largest colonies contained an average of 719 pairs at Mustang Bayou, Galveston Bay; 501 pairs at STP Cooling Reservoir, Matagorda County Wetlands; 123 pairs at West Nueces Bay, Corpus Christi Bay; and 83 pairs at Laguna Vista Spoil, Lower Laguna Madre. Texas also exceeds all other states in the number of colony sites. The number of sites used by the tern in the state per decade increased from an average of 27 in the 1970s to 33-38 sites during the 1980s, 1990s and 2000s. With a mean population of just over 2100 pairs during 2000-2003, Texas continued to support well over half of *aranea* breeding in the U.S.; in 1976-1977 Parnell *et al.* (1995) indicated that Texas held nearly 59% of all breeding *aranea*. The extent to which population shifts within the Gulf Coast region (U.S. and Mexico) account for the high variability in statewide population counts is uncertain.

Gelochelidon nilotica vanrossemi

The earliest available assessment of the historical population size of *vanrossemi* Gull-billed Terns comes from Pemberton's (1927) account of his visit to the Salton Sea, California in 1927, when he estimated 500 pairs to be nesting at the lake's south end. This location was the sole nesting site for the species in the state. By 1937 fewer than 200 pairs

Table 1. Numbers of breeding pairs and colony sites of *aranea* Gull-billed Terns in the U.S.; years are those in which comprehensive state-wide censuses were performed unless otherwise noted.

Region and state	Year	Pairs	Colonies	Average Pairs/Colony
Atlantic Coast				
New York	1977	0	N/A	—
	1985	2	2	1
	1995	2	1	2
	2003	11	3	4
New Jersey	1977	19	4	5
	1985	17	3	5
	1995	18[a]	3	6
	2001	92[a]	5	18
Virginia	1977	729[a]	11	66
	1984	413	11	38
	1993	265	15	18
	1998	310	15	21
	2003	293	16	18
North Carolina	1977	621	21	30
	1985	174	4	44
	1995	249	10	25
	2001	258	7	37
South Carolina	1976	154[a]	4	39
	1988	254	10	25
	1995	165	8	21
	2003	239	7	34
Georgia	1995	80	1	80
	2003	54	1	54
Florida	1975	534	2	267
	1980-1985[b]	<75[c]	6-8	<9-13
	2000	17	3	6
Gulf Coast				
Alabama	1976[d]	23	1	23
	2001[e]	87	3	29
	2002[e]	50	1	50
	2003[e]	9	1	9
	2004[e]	85	3	28
Mississippi	1976[d]	2	1	2
	1994[f]	0	N/A	—
	1995[f]	0	N/A	—
	1996[f]	2	1	2
	1997[f]	1	1	1
	1998[f]	0	N/A	—

[a]Breeding pairs estimated from counts of individuals by multiplying individuals by 0.667.
[b]Data from Smith and Alvear 1997.
[c]Minimum estimate due to incomplete state survey coverage.
[d]Portnoy 1977.
[e]R. Clay, Alabama Department of Natural Resources.
[f]Mississippi Colonial Waterbird Count.
[g]Results of fixed wing aerial surveys; Martin and Lester 1990.
[h]Results of helicopter surveys; Louisiana Natural Heritage Program, Louisiana Department of Wildlife and Fisheries.
[i]Michot *et al.* 2004.
[j]Data from Texas Colonial Waterbird Census (http://texascoastalprogram.fws.gov/TCWC.html), accessed 26 Feb 2004.

Table 1. (Continued) Numbers of breeding pairs and colony sites of *aranea* Gull-billed Terns in the U.S.; years are those in which comprehensive state-wide censuses were performed unless otherwise noted.

Region and state	Year	Pairs	Colonies	Average Pairs/Colony
	1999[f]	0	N/A	—
	2000[f]	0	N/A	—
	2001[f]	0	N/A	—
	2002[f]	5	1	5
	2003[f]	2	1	2
	2004[f]	150	1	150
Louisiana	1976[d]	154	4	39
	1990[g]	161	3	54
	1991[h]	30	1	30
	1992[h]	350	2	175
	1993[h]	650	3	217
	1994[h]	290	4	73
	1995[h]	400	3	133
	1996[h]	173	4	43
	1997[h]	248	11	23
	1998[h]	1120	5	224
	1999[h]	590	5	118
	2001[i]	440	4	110
Texas[j]	1973[c]	2187	27	81
	1974[c]	688	17	41
	1975[c]	1289	23	56
	1976	1098	21	52
	1977	1632	32	51
	1978	2034	30	68
	1979	2267	38	60
	1980	1810	33	55
	1981	2046	39	53
	1982	2123	40	53
	1983	4661	33	141
	1984	2416	47	51
	1985	1926	42	46
	1986	1075	32	34
	1987	1946	38	51
	1988	1243	36	35
	1989	1150	40	29
	1990	2868	37	78
	1991	913	21	44
	1992	1372	35	39
	1993	1553	34	46
	1994	3706	41	90
	1995	2553	28	91
	1996	914	37	25
	1997	1576	36	44

[a]Breeding pairs estimated from counts of individuals by multiplying individuals by 0.667.
[b]Data from Smith and Alvear 1997.
[c]Minimum estimate due to incomplete state survey coverage.
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Table 1. (Continued) Numbers of breeding pairs and colony sites of *aranea* Gull-billed Terns in the U.S.; years are those in which comprehensive state-wide censuses were performed unless otherwise noted.

Region and state	Year	Pairs	Colonies	Average Pairs/Colony
	1998	2293	41	56
	1999	846	29	19
	2000	2791	39	72
	2001	1840	36	51
	2002	2565	39	66
	2003	1292	29	45

[a]Breeding pairs estimated from counts of individuals by multiplying individuals by 0.667.
[b]Data from Smith and Alvear 1997.
[c]Minimum estimate due to incomplete state survey coverage.
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nested (Grinnell and Miller 1944). The decline continued through the 1950s and 1960s with 60 pairs in 1952, 75 pairs in 1957, 40-50 pairs in 1959 and just a few pairs through the 1960s (Remsen 1978). By 1976 only 17 pairs nested (McCaskie 1976) and "perhaps twice this number may have nested in 1977" (Remsen 1978: p. 18). During the 1980s the largest count reported was a minimum of 75 pairs in 1986 (McCaskie 1986). It is unlikely that these early estimates were the result of exhaustive censuses, but rather estimates based on visits made to traditional nesting areas as was typical at the time. However, the extensive attention and coverage the Salton Sea received from the birding community from the 1960s through the 1980s (Patten *et al.* 2003) suggests that these "opportunistic" censuses probably track the population there fairly accurately. Still the lack of systematic survey efforts at Salton Sea colonies until the early 1990s makes it difficult to rigorously compare recent population sizes with those reported above. From 1992 through 2005 the mean number of pairs at the Salton Sea was 124 ± 37 (SD, range 65-209; Molina 2004; Molina and Erwin 2006).

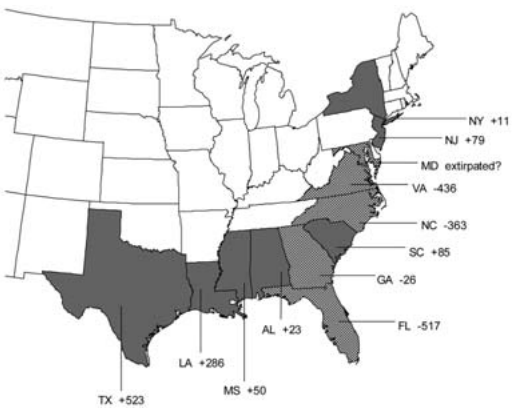

Figure 3. Apparent trends of reported numbers of breeding pairs of *aranea* Gull-billed Terns in states on the Atlantic and Gulf of Mexico coasts from state-wide censuses conducted between the 1970s and 2000s. The trend for Georgia was calculated using the 1995 census, the first statewide census available. States with population increases are shown with solid shading; those with decreases shown with diagonal hatching.

Focused censuses of *vanrossemi* Gull-billed Terns in coastal California began when the species colonized a single site, the saltworks in south San Diego Bay, in 1986; this remains the only coastal California site. The population in San Diego increased to 30 pairs in 1992, declined to 8-20 pairs for the remainder of the 1990s and subsequently increased to 31-50 pairs in 2005 (Patton 2006). The relatively large range of reported estimates within years makes it difficult to assess

Table 2. Numbers of breeding pairs and colony sites of *vanrossemi* Gull-billed Terns in the U.S. and Mexico; years are those in which comprehensive state-wide censuses were performed unless otherwise noted.

Region and state	Year	Pairs	Colonies	Average Pairs/Colony
Pacific Coast				
United States				
California[a,b]	1992	136	4	34
	1993	131	4	33
	1994	113	4	28
	1995	82	3	27
	1996[c]	>155	3	55
	1997	160	3	53
	1998	131-133	3	44
	1999	112-121	3	37-40
	2000	135-142	4	34-36
	2001	173	2	87
	2002[c]	≥97-101	2	≥49-51
	2003	187-192	4	47-48
	2004	157	2	79
	2005[d]	240-259	5	48-52
Mexico[e]				
Baja California	2003	183	2	92
	2004[a]	≥234	2	≥117
	2005[a]	274	2	137
Baja California Sur	2003	14	1	14
	2005	10	1	10
Sonora	2003	0	N/A	—
	2005	0	N/A	—
Sinaloa	2003	12	1	12
	2005[a,e]	27	2	14
Nayarit	2003	122-152	2	61-76
	2005	185	2	93
Jalisco	2003	0	N/A	—
	2005	0	N/A	—
Colima	2003	15	1	15
	2005	55	5	11
Michoacan	2003	0	N/A	—
	2005	0	N/A	—
Guerrero	2003	0	N/A	—
	2005	0	N/A	—
Oaxaca	2003	0	N/A	—
	2005	0	N/A	—
Chiapas	2003	0	N/A	—
	2005	0	N/A	—

[a]Molina 2004 and 2005, Molina *et al.* 2006.
[b]Patton 2006.
[c]Minimum estimate due to incomplete state survey coverage.
[d]Numbers reported from San Diego varied from 31-40, 43-48, and "about 50" pairs.
[e]Palacios and Mellink 2003, 2006 except where otherwise noted.

the true size of this small population. During the early 1990s, California's population was estimated at about 120 pairs (Clapp *et al.* 1993; Parnell *et al.* 1995). From 1992 to 2005 the mean number of pairs in the state was 144 ± 40 (SD, range 82-240 pairs; Table 2)

and is only currently approaching a peak population level of about 200 pairs last documented in the late 1930s (Grinnell and Miller 1944). In the years since 1992 (except for 1996 when data are unavailable for San Diego) the Salton Sea accounted for 66% to 95% of all nesting pairs in the state.

Historical population estimates of *vanrossemi* Gull-billed Terns breeding along the Pacific coast of Mexico are unavailable. In addition to the descriptions of the colonies at Cerro Prieto in the Mexicali Valley (Molina and Garrett 2001), at Isla Montague in the northern Gulf of California (Palacios and Mellink 1993), and in Bahía Santa María, Sinaloa (Muñoz del Viejo *et al.* 2004), the locations of additional coastal colonies in Mexico as recently documented by Palacios and Mellink (2003, 2006) included one site in Baja California Sur (Guerrero Negro salt evaporation ponds), one site in Sinaloa (Laguna Caimanero), two sites in Nayarit (Laguna Pericos and Teacapan), and one in Colima (Laguna Cuyutlan; Fig. 3). No breeding sites were documented from the states of Sonora, Michoacan, Guererro, Oaxaca, or Chiapas. These authors estimated the entire *vanrossemi* population in western Mexico in 2003 to be 376 pairs among just seven colony sites. Comprehensive surveys repeated in 2005 by Palacios and Mellink (2006) and Molina *et al.* (2006) revealed a total of 551 breeding pairs among eight colonies in western Mexico (Table 2). The colonies at Cerro Prieto and Isla Montague, in Baja California, consistently supported over half of the total population in western Mexico; except for the colony at Laguna Pericos in Nayarit which supported over 100 pairs, all other sites support 25 or fewer pairs and many appear to be occupied irregularly (Fig. 3). In 2003 and 2005, the entire North American population of *vanrossemi* Gull-billed Terns ranged from about 533 to 810 pairs (Table 2).

Winter Distribution, Abundance, and Trends

Gelochelidon nilotica aranea

This subspecies winters from the southeastern U.S., south to northeastern South America. At least small numbers appear to winter in the West Indies (American Ornithologists Union 1998).

Along the U.S. Atlantic coast, the Gull-billed Tern winters on the southern coast of Florida (AOU 1998; Fig. 1) and rarely from as far north as central coastal South Carolina (Parnell *et al.* 1995). In Florida only a few coastal CBC circles regularly reported Gull-billed Terns over the last several decades. The species was reported from 80% (43 of 54) of the Coot Bay-Everglades National Park counts conducted from 1950-51 through 2004-05. The average number of birds reported for this Gulf-coast count circle (based on non-zero counts) was 20 ± 18 (SD, range = 1-73 birds). In most years, over 80% of all birds reported from Florida CBCs were from this long-running count but since the late 1970s Gull-billed Terns have declined markedly on the Coot Bay count; generally fewer than ten birds were detected annually during the 1990s and early 2000s. This species is now only very rarely encountered on Atlantic coastal counts.

Along the Gulf coast, Gull-billed Terns were rarely recorded on coastal CBCs in Alabama (Dauphin Island and Mobile) and Mississippi (Southern Hancock County and Jackson County); maximum counts in these states consisted of one to five birds. Gull-billed Terns winter more commonly along the coast of Louisiana, and Texas from the Bolivar Peninsula and Galveston Bay south to the Lower Laguna Madre. Detections of Gull-billed Terns are variable on Louisiana CBCs, but appear to be concentrated in Cameron Parish in the western part of the state (Table 3). Of a handful of count circles that most regularly encounter Gull-billed Terns, the Sabine National Wildlife Refuge count circle is the most continuous, with 87% (26/30) of counts between 1975-76 and 2004-05 detecting the tern. This species was less frequently encountered on the Creole (13/23 counts) and Johnsons Bayou (11/29 counts) CBCs. The tern is detected annually at both of the more recent established counts at Crowley in 1988-89 and Lacassine National Wildlife Refuge-Thornwell in 1998-99. In the absence of comprehensive survey efforts during winter, these areas also appear

Table 3. Summary statistics for Gull-billed Terns reported from Christmas Count Circles in Louisiana and Texas between 1975-76 and 2004-05 (calculations conducted on non-zero values; N = number of counts).

	Mean (±SD)	Range	N
Louisiana			
Sabine NWR	6.2 ± 7.0	1-28	26
Johnsons Bayou	2.9 ± 3.0	1-11	11
Lacassine NWR-Thornwell	18.3 ± 16.8	4-43	7
Crowley	68.1 ± 61.8	1-201	15
Creole	7.5 ± 13.9	1-49	13
Texas			
Freeport	15.8 ± 12.4	1-45	30
Aransas NWR	2.9 ± 2.12	1-8	20
Laguna Atascosa	19.6 ± 20.6	1-74	29
Corpus Christi	3.1 ± 2.31	1-9	28
Bolivar Peninsula	10.0 ± 11.6	1-56	29
Houston	3.7 ± 5.8	1-20	17
San Bernard	21.8 ± 25.6	1-106	20
Galveston	4.8 ± 5.7	1-22	20
Coastal Tip	22.3 ± 21.6	3-86	18
Port Aransas	9.5 ± 9.3	1-43	26
Matagorda Mad I. Marsh	69.2 ± 46.6	17-162	12

to be of numeric importance for wintering birds in Louisiana presently. A maximum count of 201 birds occurred on the Crowley count in 1994-95. The species was rarely encountered on the more easterly coastal counts of New Orleans and Grand Isle.

In Texas, the Gull-billed Tern is regularly reported from at least eleven count circles (Table 3). From 1975-76 through 2004-05, it was most consistently reported from the following CBCs: Freeport (30/30 counts), Laguna Atascosa (29/29 counts), Corpus Christi (28/30 counts), San Bernard (20/20 counts), Coastal Tip (18/18 counts), Matagorda Mad I. Marsh (12/12) and Bolivar Peninsula (29/30 counts). The largest annual means (non-zero values only), in descending order, occurred on the Matagorda Mad I. Marsh, Coastal Tip, San Bernard, Laguna Atascosa, and Freeport CBCs. A maximum count of 162 birds occurred on the Mad I. Marsh count in 1999-2000. During the 1970s annual peak counts of Gull-billed Terns were consistently reported from Florida count circles, but beginning in the 1980s that pattern had shifted west to Louisiana and Texas. The timing of this shift corresponded to the marked apparent decline of Florida's breeding population (Table 1) but is possibly compounded by an increase in CBC effort in Louisiana and Texas.

In eastern Mexico, Gull-billed Terns winter along the coast of Tamaulipas, and presumably, the coast of Veracruz (Appendix 1). In far northeastern Tamaulipas, for Christmas Bird Counts conducted from the winters 1997-98 through 2003-04, the number of Gull-billed Terns detected within the count circle of Rancho Rincon de Anacahuitas generally ranged from one to 14 birds but a high count of 145 birds was made in 2001-02. The Gull-billed Tern is mapped by Howell and Webb (1995) as occurring in winter along the entire Gulf of Mexico and Caribbean coastlines of Mexico, Belize (where uncommon; Russell 1964; Jones 2003) and Honduras. Reports in *North American Birds* and museum holdings indicate that a few birds winter in coastal Yucatan (Appendix 1). Along the coast of Belize, the species was unrecorded from the Belize City CBC (established in 1972) until the winter of 1991-92; since then Gull-billed Terns were regularly detected in small numbers (one to eleven birds) from 1992-93 through 2001-2002. A maximum count of 53 birds occurred in 2004-05. This species is considered rare to uncommon in winter along the Caribbean coast of Guatemala (Land 1970), Honduras (Monroe

1968), Costa Rica (Stiles and Skutch 1989), and Panama (Ridgely and Gwynne 1989). Since 1980-81 Gull-billed Terns were rarely recorded on the Atlantic Panama Canal (twelve birds in winter 1981-82 and two birds in 2004-05) and Central Panama Canal (three birds in 2003-04) Christmas Bird Counts. In contrast, this species (subspecies unknown) was more frequently encountered on the Pacific Panama Canal count where birds were recorded on 72% (18/25) of counts conducted during the same period; the number of individuals varied widely, ranging from one to 200 individuals. In 1971-1972, Spaan (1978) reported Gull-billed Terns to be present throughout the year along the Surinam coast with peak numbers (up to 200-300 birds) occurring in March and again in August through October. A bird collected by Haverschmidt in late October 1963 was banded as a chick in a South Carolina colony, thus providing some evidence that Surinam birds are of the subspecies *aranea* rather than of *groenvoldi* of nearby Brazil (Haverschmidt 1968; Spaans 1978).

Gelochelidon nilotica vanrossemi

Along the Pacific Coast, the Gull-billed Tern retreats almost entirely from southern California and Baja California, although there are a few mid-winter records for the Salton Sea (Patten *et al.* 2003) and a few birds have been recently noted to winter in southern Baja California Sur in La Paz Bay (Erickson *et al.* 2003; Fig. 1). In mainland Mexico, this species primarily winters along the eastern shore of the Gulf of California from the Colorado River Delta south to Sinaloa, and from there southward along the Pacific Coast of Mexico to Nayarit, Colima and Oaxaca (Binford 1989; Howell and Webb 1995; K. C. Molina, unpubl. data). Mid-winter surveys from Sonora to Nayarit in 2003 and 2004 (K. C. Molina, unpubl. data) have yielded small concentrations (14 to 60 birds) at several sites from El Golfo de Santa Clara in the Colorado River delta, Estero Tobarí and Santa Barbara in Sonora south to Cerro Cabezon, the Marismas Nacionales near Acaponeta, La Reforma, Laguna Caimanero and Mazatlan in Sinaloa, and San Blas in Nayarit. In Guerrero, 35 Gull-billed Terns were found at Laguna Coyuca, near Acapulco, in early November 2003 (E. Palacios, pers. comm.).

Historically, few Christmas Bird Counts were conducted in coastal western Mexico, although several in northern Sonora (Puerto Penasco, San Carlos) and Baja California have now been established for some years. One exception was the fairly early establishment of the San Blas count in Nayarit. CBCs conducted there from winter 1980-81 to 1989-90 recorded Gull-billed Terns on eight of ten counts, averaging 20 ± 21 birds per count (SD, range = one to 52) over that time span. Conduct of the San Blas CBC was interrupted from 1993-94 through 2002-03; upon its resumption in 2003-04 no birds were detected and only four were recorded on the 2004-05 count. In Oaxaca, Binford (1989) considered this species to be a very uncommon winter resident and possibly a local permanent resident as records span August through April. South of the Isthmus of Tehuantepec this species is considered an "uncommon" non-breeding visitor in coastal Chiapas (Howell and Webb 1995), and along the Pacific coast of Guatemala the Gull-billed Tern is a rare transient and winter visitor (Land 1970), with available specimens from "Chiapam" (= Champerico) having been identified as *vanrossemi* (Hellmayr and Conover 1948).

Summer Non-breeding

Small numbers of *aranea* and *vanrossemi* Gull-billed Terns over-summer within the respective portions of their winter ranges in Mexico (Howell and Webb 1995). Contreras-Balderas (1993) considered *aranea* Gull-billed Terns as year-round residents in Tamaulipas; although information is lacking, it is likely that most such birds are of pre-breeding age. In California, non-breeders (presumably in their second calendar year) have been occasionally noted at breeding colonies at the Salton Sea (K. C. Molina, pers. obs.).

On the Pacific coast of Costa Rica, Stiles and Skutch (1989) considered this species to

be a locally common non-breeding summer resident with sightings consisting of mostly young birds. According to Spaan (1978) this species over-summers on the Surinam coast, with counts of up to 59 birds in June.

Status and Subspecific Identity of Birds on the Pacific Coast of Central America and Northern South America

Taxonomic issues surrounding New World Gull-billed Terns concern the diagnosability of the three subspecies and the identity of breeding and non-breeding birds from the Isthmus of Tehuantepec, Mexico to northern South America. Because *aranea* and *vanrossemi* are distinguished on the basis of average morphometric differences but overlap substantially in most characters (Table 1 in Parnell *et al.* 1995), individual specimens are often not identifiable to subspecies. Furthermore, the specimen record is poor for much of Central America and northwestern South America and further work is clearly needed. To illustrate this point, the species possibly breeds on the Pacific coast of Central America (e.g., Panama; Ridgely and Gwynne 1989), but proven breeding records are lacking and the subspecific identity of possible breeders is unknown. Individuals from the small colony recently documented on the northern coast of Nariño Department, western Colombia (Johnston-Gonzalez *et al.* 2005) have not been identified to subspecies, and egg measurements reported from this colony do not resolve the subspecific identity of these birds. Measurements of individuals from southwestern Ecuador, the only other known breeding location for Gull-billed Terns along the Pacific coast of South America, are consistent with the eastern subspecies *aranea* (Marchant 1958; Ridgely and Greenfield 2001). The few specimens from Peru have not been assigned to subspecies; most records are from May to September and breeding has not been documented (T. S. Schulenberg, pers. comm.).

Similarly, the subspecific identity of birds wintering on the Pacific coast of Central and northern South America is poorly understood. Several sources (Peters 1934, AOU 1957) indicate that *vanrossemi* winters south to Ecuador but sight records and specimens are few and have not been or cannot be identified to subspecies. In El Salvador, Gull-billed Terns are rare; the three published records were from May, June and early August (Thurber *et al.* 1987; Komar 2001). Dickey and van Rossem (1938) did not mention this species during their field work there in the late 1920s and 1930s. The Gull-billed Tern is an uncommon transient and winter visitor on the Pacific coast of Honduras (Monroe 1968). Slud (1964) considered the tern to be a regular fall migrant in small numbers along the Pacific coast of Costa Rica based on at least two late September specimens taken from the Pacific coast; more recently, Stiles and Skutch (1989) considered it to be a locally common fall migrant and winter resident. In Panama, it is considered to be uncommon to locally common; its appearance is erratic and numbers are variable with no pronounced season of maximum abundance (Ridgely and Gwynne 1989). Wetmore's (1965) description of several hundred Gull-billed Terns foraging over the ocean up to 50 km offshore of Isla San Jose in the Gulf of Panama seems at odds with all other published reports of this species from this area which are closer inshore and involve much smaller flocks. The only other report well offshore in the Pacific was of a single bird about 25 km off the southern tip of the Nicoya Peninsula, Costa Rica (Pitman 1986). This species is rare along the coast of northwestern South America in Colombia (Buenaventura Bay; Hilty and Brown 1986), Ecuador, (Ridgely and Greenfield 2001) and Peru (Hilty and Brown 1986, AOU 1998).

In summary, no specimen identified as *vanrossemi* has been taken south of Guatemala, where a specimen from the "Chiapam" series fits this race, according to Hellmayr and Conover (1948). The single specimen from the Pacific coast of Honduras as well as those from Panama and Ecuador appeared from measurements to be *aranea* (Marchant 1958, Wetmore 1965, Monroe 1968, Ridgely and Greenfield 2001), so many, if not all, Gull-billed Terns on the Pacific coast of Central

and South America may be of this subspecies. This pattern of eastern North American and Caribbean breeding populations wintering on the Pacific Coast is shown in some other taxa, e.g., Sandwich Tern, *S. sandvicensis* (AOU 1998), Herring Gull (*Larus argentatus*; Cooke 1941) and Laughing Gull (*L. atricilla*; Dickey and van Rossem 1938), with the cross-continental movement presumably occurring at the Isthmus of Panama and possibly also the Isthmus of Tehuantepec in Mexico.

Habitat Use

Gull-billed Terns are primarily a coastal species in North America, occupying inland wetlands only very locally, e.g., Polk County and near Lake Okeechobee in Florida (Smith and Gore 1996); La Sal Vieja and East Lake in Willacy County (D. Blankinship, pers. comm.), Falcon Reservoir, Zapata County and Lake Casa Blanca, Webb County in Texas (Lockwood and Freeman 2004), the Salton Sea in southern California (Parnell *et al.* 1995), and the Mexicali Valley of northeastern Baja California (Molina and Garrett 2001). Nesting colonies are generally located on natural barrier islands, dredged-material islands, and islands within marshes and estuaries (Texas Colonial Waterbird Society 1982; Palacios and Mellink 1992; Leberg *et al.* 1995; Parnell *et al.* 1995; Mallach and Leberg 1999; Gonzalez-Bernal *et al.* 2003). This species has occasionally nested on gravel rooftops in coastal Texas (P. Glass, pers. comm.), Louisiana (Purrington 2001, 2002), and Florida (Coburn 1996; Sprandel *et al.* 1998), sometimes in large concentrations (R. Purrington, pers. comm.). Inland, nesting occurs on natural and constructed islands in brackish and saline lakes, on islands and levees in constructed impoundments, and on peninsulas that become insular when flooded (Parnell *et al.* 1995; Molina and Garrett 2001; Molina 2004; D. Blankinship, pers. comm.). In South America, Gull-billed Terns nest on sandy beaches near river mouths (Johnston-Gonzalez *et al.* 2005), coastal lagoons and estuaries, and salt evaporation ponds (Ridgely and Greenfield 2001). Colony sites are typically located near suitable foraging habitats including open mudflats in tidal estuaries, river margins, beaches, salt marshes, freshwater marshes, aquacultural impoundments (such as shrimp ponds), and a variety of upland habitats including open scrub, pasturelands and irrigated agricultural fields and associated drains (Parnell *et al.* 1995). These coastal lowland habitat types are also used during the non-breeding season. In Louisiana, this species seems to particularly favor flooded rice fields (S. Cardiff, pers. comm.) and potentially those fields whose seasonal management shifts to crayfish production. Throughout western Mexico, they are attracted to active commercial shrimp ponds (K. C. Molina, pers. obs.). Gull-billed Terns also visit interior salinas and marshes on the southwestern Mexican central plateau, near Ciudad Guzman, Colima (S. N. G. Howell, pers. comm.). In Ecuador during the non-breeding season, they favor shrimp or salt-evaporation ponds and mudflats (Ridgely and Greenfield 2001). In Surinam, high numbers of birds were commonly observed over rice fields (Spaans 1978).

DISCUSSION

Conservation Issues

Breeding populations of Gull-billed Terns along Mexico's Gulf coast have yet to be enumerated, but it is unlikely that Tamaulipas and Veracruz support numerous and large, yet undescribed, colonies. Therefore, with an estimated U.S. population of 3,600 to 4,400 pairs of *aranea* and an entire North American (U.S. and Mexico) population of 560 to 800 pairs of *vanrossemi*, the Gull-billed Tern is no more numerous than several other larids of conservation concern in the region. For example, the federally endangered Roseate Tern (*S. dougallii*) numbers about 3,500 pairs (Gochfeld *et al.* 1998) in eastern North America or 16,000 breeding individuals (Kushlan *et al.* 2002) in North America and the Caribbean; this species has a global distribution nearly as cosmopolitan as that of the Gull-billed Tern. While the North American population of the Least

Tern (*S. antillarum*) numbers 60,000 to 100,000 breeders (Kushlan *et al.* 2002), the federally endangered subspecies *browni* of California currently totals some 6,000 to 7,000 pairs (D. Marschalek, pers. comm.) compared to fewer than 200 California pairs (on average) of *vanrossemi* Gull-billed Terns; *browni* Least Terns and the threatened interior subspecies, *athalassos*, which numbers about 6,800 pairs (Thompson *et al.* 1997), are each alone more numerous than the combined total of *aranea* and *vanrossemi* Gull-billed Terns. Therefore, even in the absence of recent precipitous declines or imminent population threats, the conservation of North American Gull-billed Terns warrants concern by virtue of their low population size. *Vanrossemi* is, in fact, one of the least numerous larid taxa in the world (Gochfeld and Burger 1996).

Aranea Gull-billed Terns were once more numerous along the Atlantic coast than they are today, apparently having never recovered to pre-millinery trade levels. Historic population levels in Mexico are unknown, and, in fact, present population size estimates and detailed documentation of specific colony sites are still lacking from all Mexican states in the Gulf of Mexico. Habitat loss and degradation in several parts of their eastern North American range are believed responsible for declines observed today. Threats to Gull-billed Tern reproduction common to all Atlantic coastal states include: (1) flooding of low-lying sites whether on barrier islands or estuarine marshes, (2) colonization and succession of vegetation, particularly on dredged-material islands, (3) disturbance by recreating humans especially on coastal beaches and barrier islands, and (4) predation by increasing populations of human commensals such as red foxes (*Vulpes vulpes*), raccoons (*Procyon lotor*) and Laughing (*L. atricilla*), Herring (*L. argentatus*) and Great Black-backed (*L. marinus*) gulls. The actual loss of some nesting islands as a result of erosion and submergence and the loss of suitability of others due to vegetation succession were contributing factors to the apparent extirpation of Gull-billed Terns in Maryland (Brinker 1996). In Virginia, the number of sites at which this species has attempted to nest has increased over the last three decades, with a concomitant decrease in colony size (Table 1). This "fragmentation" of breeding colonies resulting from increasing levels of disturbance by humans and predators is a byproduct of intensive coastal development on barrier beaches. Small colony size may negatively affect colony members' ability to effectively repel mammalian, and, particularly, avian predators such as gulls (Sears 1979; Møller 1981; Parnell *et al.* 1995; K. Molina, pers. obs.). Habitat loss, degradation and the reduction of suitable alternative sites as a result of development may be forcing Gull-billed Terns to nest in sub-optimal sites of small area and low elevation that can be subjected to regular tidal inundations as well as those associated with storm events (Erwin *et al.* 1998). In Virginia, North Carolina and South Carolina increasing coastal development may increase exposure to predation by increasing populations of human-subsidized species such as gulls, owls, raccoons, and foxes (Blus and Stafford 1980; Parnell *et al.* 1995; O'Connell and Beck 2003).

Habitat loss and degradation is also an important factor affecting reproductive success along the Gulf coast. The development and increased recreation pressure at barrier islands, and the erosion and vegetation succession of dredge-material islands due to the lack of periodic sediment replenishment negatively affect the suitability of the relatively few nesting islands used by Gull-billed Terns off the coasts of Alabama, Mississippi and Louisiana. The relatively new phenomenon of breeding on rooftops may reflect a shortage of suitable and more traditional habitats for colony sites.

Fledging success rates of Gull-billed Terns are largely unknown. Furthermore, comparisons among sites may be complicated by use of different measures of success. For *aranea*, they are suspected to be poor as few juvenile sightings near breeding areas are reported (Erwin *et al.* 1998). The single study of reproductive success, conducted in Virginia in the mid 1990s, suggested low rates of fledgling survival

(0.53 presumed fledglings per nest; Eyler *et al.* 1999) and potential recruitment (Erwin *et al.* 1998). In South Carolina, Blus and Stafford (1980) qualitatively assessed the reproduction of Gull-billed Terns from 1969 through 1975 and concluded that it was low overall. In Texas, Chaney *et al.* (1978) monitored a total of 20 nests at two colony sites and reported a 29% hatch rate for 38 eggs but to our knowledge, studies of fledging success have not been undertaken there. For California *vanrossemi*, productivity estimates of 0.33 and 0.20 fledglings per nest attempt reported by Molina (2000, 2001) for Salton Sea colonies in 2000 and 2001, respectively, were lower than those reported for Virginia colonies (Eyler *et al.* 1999). A comparison of the number of fledglings per pair (using medians calculated from reported ranges of values) between two California colonies yielded 0.57 and 0.31 fledglings per pair for the Salton Sea in 2000 and 2001, respectively, while 1.23 and 0.95 fledglings per pair were estimated for the San Diego Bay colony in those years (Molina and Erwin 2006).

In California, *vanrossemi* Gull-billed Terns colonies on islands near the lake's shore (Salton Sea) or on constructed levees and islands in brackish to saline impoundments (Salton Sea and San Diego Bay saltworks) are not subjected to tidal influence. However, lake level declines of the Salton Sea as a result of water transfers to urban areas threaten the isolation of existing inshore islands which increases exposure to mammalian predation and human disturbance (Molina 2004). In western Mexico, in contrast, this species nests predominantly on low-lying coastal islands that are routinely affected by regular tidal and storm-related inundations. Consequently, reproductive success at these sites is frequently poor (Peresbarbosa and Mellink 2001, pers. obs). In 2004 and 2005, no Gull-billed Tern chicks fledged from either the Isla Montague colony in the northern Gulf of California (K. C. Molina, unpubl. data) where the tidal range is among the most extreme in North America, or at the El Rancho colony in Sinaloa (X. Vega, pers. comm.). In contrast, the reproductive success at the inland colony at the Cerro Prieto Campo de Geotérmica in Baja California, whose habitat characteristics (islands in saline impoundments) are very similar to those of the Salton Sea was high in 2004 and 2005 and in earlier years (K. C. Molina, unpubl. data). Vegetation succession of current nesting habitats probably pose less of a threat to the continued suitability of sites in California and western Mexico than in eastern North America as it is generally minimized by the hypersalinity of surrounding habitats.

In San Diego Bay, California, the Gull-billed Tern has been the subject of predator control in the management of two federal and state listed species, the endangered California Least Tern and Western Snowy Plover (*Charadrius alexandrinus nivosus*). Because of the Gull-billed Tern's unique (for a tern) feeding behavior on a wide variety of terrestrial as well as aquatic prey, it commonly forages on beach strand, dune and upland habitats in the bay (Molina and Marschalek 2003) which, coincidentally, serve as concentrated breeding sites for these listed species. Although population level impacts of predation by Gull-billed Terns on these species have not been quantified, they are perceived as problematic by local managers (U.S. Fish and Wildlife Service 2005). The size of their single colony in San Diego Bay has varied over time, with a recent reported peak of 31-50 pairs (R. Patton, pers. comm.), but Gull-billed Terns have not expanded their breeding to any other site in coastal California and thus do not appear to represent an expanding threat to Least Terns and Snowy Plovers. Also apparently unique to San Diego Bay is the threat of collisions between terns and military aircraft; in 2004 two Gull-billed Terns were lethally removed from a military base when they were believed to pose a threat to naval aircraft.

In western Mexico, the Gull-billed Tern sometimes comes into conflict with commercial aquaculture, particularly at shrimp production facilities. These sites appear to concentrate foraging Gull-billed Terns and oth-

er piscivorous species, especially during the early winter months when a maximum of 66 birds was noted at one set of ponds in northwestern Sonora in late November (pers. obs.); in contrast, on productive tidal flats and estuaries at the same locality, high counts of this species rarely exceeded four to eight birds (K. Garrett, unpubl. data). Although the lethal control of depredating birds is illegal in Mexico, such practice appears to be widespread during impoundment draw-down and shrimp harvesting phases (K. C. Molina, pers. obs.; K. Larsen, pers. comm.). The level of mortality associated with this practice and its population impacts have not been quantified. Wintering populations of many waterbird species, including terns, congregate at commercial crayfish ponds in Texas and Louisiana (Huner 2000); considering their foraging behavior elsewhere within their range, Gull-billed Terns may potentially come into conflict with crayfish production along the Gulf coast.

Because this species often forages in flooded agricultural habitats and coastal wetlands, exposure to pesticide residues, heavy metals, and other contaminants is a potential concern. The few existing studies of limited scale indicated that selenium and DDE may be of most concern. Blus and Stafford (1980) reported DDE levels in two of 37 eggs from South Carolina colonies to be 8.75 and 10.71 ug/g; these two eggs had abnormal shells. In California, Audet *et al.* (1997) reported the mean concentration of p, p'-DDE from six eggs from the Salton Sea in 1991 to be 1.32 ppm (wet wt., range = 0.54 to 2.8 ppm). The concentration of total DDT from one Gull-billed Tern egg from San Diego Bay was considered elevated at 2.9 ppm (wet wt.), but below levels associated with reproductive impairment in other species (U.S. Fish Wildlife Service 1995). Although the geometric mean concentration of selenium for the six eggs from the Salton Sea was 4.10 ppm (dry wt., range 3.4 to 5.3 ppm; Audet *et al.* 1997), a level below those known to impair reproduction in some bird species, it was above the threshold level of concern (Setmire *et al.* 1993).

Suggestions for Management and Further Research

The following suggestions to aid the management and conservation of North American Gull-billed Terns are offered.

Population monitoring

To refine breeding population estimates in North America, focused surveys that are coordinated range-wide and performed over a single season should be conducted at least every two to three years using standardized methods (Steinkamp *et al.* 2001; Kushlan *et al.* 2002). Long-term trends are difficult to ascertain from previous censuses that have been incomplete and lacked a range-wide perspective. The documentation of colony sites and population estimates for this species along Gulf coast of Mexico is integral to this effort. A focal survey of Gull-billed Terns during winter should be conducted in the Gulf Coast states and throughout the species' range in Mexico, Central America, the Caribbean, and northern South America, particularly along the Surinam coast where Spaans (1978) speculated that up to 10,000 Gull-billed Terns may possibly winter. Such a survey should be repeated at five-year intervals.

Habitat management and protection

Although a significant proportion of Gull-billed Tern colony sites in North America occur on public lands, not all are managed specifically for colonially nesting waterbirds (Molina and Erwin 2006). Colony sites should receive adequate protection from human disturbance and from non-native and human-subsidized native predators. When and where feasible, the number of potential colony sites should be increased—Gull-billed Terns have relatively low colony site fidelity and respond favorably to novel alternative sites (Molina 1997; Erwin *et al.* 1998). The integrity and suitability of colony sites with respect to erosion, tidal overwash, and vegetation succession need to be evaluated frequently so that management actions, such as vegetation removal, predator removal, or

replenishment of dredged material, can be taken in a timely fashion to maintain or enhance existing nesting habitats. In California, a permanent moratorium on the previous practice of lethal removal of depredating adults should be instituted immediately; other actions designed to limit Gull-billed Tern reproduction (e.g., the removal and transfer of egg clutches to other sites) should not be implemented unless deemed warranted based on sound biological and ecological studies (Kushlan *et al.* 2002).

Research

No thorough, modern review of Gull-billed Tern geographical variation has been attempted, and a comprehensive study of variation combining molecular data, a multivariate analysis of a robust set of morphometric data, and quantitative colorimetric analysis is urgently needed. Such a review could help elucidate the subspecific identity of breeding populations on the Pacific Coast south of the Isthmus of Tehuantepec and also further our understanding of the southern limits of the winter range of both *aranea* and *vanrossemi*.

Demographic studies, conducted across their range, are needed to address juvenile and adult survival, recruitment, and identification and quantification of important mortality factors on the breeding grounds. Further research on diet and food-limitation is critical to a better understanding of factors limiting reproductive success. Assessment of metapopulation dynamics to determine the degree of mixing among localized populations in western U.S. and northwestern Mexico should be conducted, using re-sightings of marked individuals and exploring the use of genetic approaches. Such information is integral to the development of population viability models. Stable isotope analysis of feathers and other tissues could provide additional insight on diet and patterns of dispersal.

Population-level impacts of predation by Gull-billed Terns on Least Terns and Snowy Plovers should be investigated and quantified. More extensive studies examining contaminant levels of Gull-billed Terns across their range should be conducted. Finally diet, habitat use, and important sources of mortality of Gull-billed Terns in the nonbreeding season should be described and quantified.

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LITERATURE CITED

American Ornithologists' Union. 1957. Checklist of North American Birds, 5th ed. American Ornithologists' Union, Washington, D.C.

American Ornithologists' Union. 1998. Check-list of North American Birds, 7th ed. American Ornithologists' Union, Washington, D.C.

American Ornithologists' Union. 2006. Forty-seventh Supplement to the American Ornithologists' Union Check-List of North American Birds. Auk 123: in press.

Audet, D. J., M. Shaughnessy and W. Radke. 1997. Organochlorines and selenium in fishes and colonial waterbirds from the Salton Sea. Report to U. S. Fish and Wildlife Service, Environmental Contaminants Division, Carlsbad, California.

Bancroft, G. 1929. A new Pacific race of the Gull-billed Tern. Transactions San Diego Society of Natural History 5: 283-286.

Bent, A. C. 1921. Life histories of North American gulls and terns. U. S. National Museum Bulletin 113.

Binford, L. C. 1989. A distributional survey of the birds of the Mexican state of Oaxaca. Ornithological Monographs No. 43, American Ornithologists' Union.

Blake, E. R. 1977. Manual of Neotropical Birds, v. 1. The University of Chicago Press, Chicago.

Blus, L. J. and C. J. Stafford. 1980. Breeding biology and relation of pollutants to Black Skimmers and Gull-billed Terns in South Carolina. Special Scientific Report-Wildlife No. 230, U.S. Fish and Wildlife Service, Washington, D.C.

Bridge, E. S., A. W. Jones and A. J. Baker. 2005. A phylogenetic framework for the terns (*Sternini*) inferred from mtDNA sequences: implications for taxonomy and plumage evolution. Molecular Phylogenetics and Evolution 35: 459-469.

Brinker, D. F. 1996. Gull-billed Tern. Pages 160-161 *in* Atlas of the Breeding Birds of Maryland and the District of Columbia (C. S. Robbins and E. A. T. Blom, Eds.), University of Pittsburgh Press, Pennsylvania.

Buckley, P. A. and F. G. Buckley. 1984. Seabirds of the North and Middle Atlantic coast of the United States: their status and conservation. Pages 101-133 *in* Status and Conservation of the Worlds' Seabirds (J. Croxall, P. G. H. Evans and R. W. Schreiber, Eds.), ICBP Technical Publication No. 2, Cambridge.

Chaney, A. H., B. R. Chapman, J. P. Karges, D. A. Nelson, R. R. Schmidt and L. C. Thebeau. 1978. Use of dredged material islands by colonial seabirds and wading birds in Texas. Technical Rept. D-78-8, U. S. Army Engineer Waterways Exp. Stn. Vicksburg, Mississippi.

Chardine, J. W., R. D. Morris, J. F. Parnell and J. Pierce. 2000. Status and conservation priorities for Laughing Gulls, Gull-billed Terns, Royal Terns and Bridled Terns in the West Indies. Pages 65-79 *in* Status and Conservation of West Indian Seabirds (E. A. Schreiber and D. S. Lee, Eds.) Society of Caribbean Ornithology Special Publication No. 1, Ruston, Louisiana.

Clapp, R. B., D. Morgan-Jacobs and R. C. Banks. 1983. Marine birds of the southeastern United States and Gulf of Mexico, Part 3: Charadriiformes. FWS/OBS-83/30, U.S. Fish and Wildlife Service, Div. Biol. Serv. Washington, D.C.

Clapp, R. B. and P. A. Buckley. 1984. Status and conservation in the southeastern United States. Pages 135-155 *in* Status and Conservation of the Worlds' Seabirds (J. Croxall, P. G. H. Evans and R. W. Schreiber, Eds.). ICBP Technical Publication No. 2, Cambridge.

Clapp, R. B., P. A. Buckley and F. G. Buckley. 1993. Conservation of temperate North Pacific terns. Pages 154-163 *in* The Status, Ecology, and Conservation of Marine Birds of the North Pacific (K. Vermeer, K. T. Briggs, K. H. Morgan and D. Siegel-Causey, Eds.). Canadian Wildlife Service Special Publication, Ottawa.

Coburn, L. M. 1996. Gull-billed Tern nesting on a roof in northwest Florida. Florida Field Naturalist 24: 76-77.

Contreras-Balderas, A. J. 1993. Avifauna de Laguna Madre, Tamaulipas. Pages 553-338 *in* Biodiversidad Marina y Costera de Mexico (S. I. Salazar-Vallejo and N. E. Gonzalez, Eds.). CONABIO y CIQRO, Mexico.

Cooke, M. T. 1941. Banded birds recovered in El Salvador. Auk 58: 590.

Cramp, S., ed. 1985. Handbook of the Birds of Europe, the Middle East and North Africa, vol. 4, Terns to Woodpeckers. Oxford University Press, Oxford.

Danemann, G. D. and R. Carmona. 2000. Breeding birds of the Guerrero Negro saltworks, Baja California Sur, Mexico. Western Birds. 31: 195-199.

Dickey, D. R. and A. J. van Rossem. 1938. The birds of El Salvador. Zool. Series, Field Museum of Natural History, No. 23.

Erickson, R. A., R. A. Hamilton, E. Palacios and R. Carmona. 2003. The Winter Season, Baja California Peninsula. North American Birds 57: 260-262.

Erwin, R. M. 1979. Coastal waterbird colonies: Cape Elizabeth, ME to Virginia. Biol. Services Program, FWS/OBS-79/10, Washington, D.C.

Erwin, R. M., J. D. Nichols, T. B. Eyler, D. B. Stotts and B. R. Truitt. 1998. Modeling colony-site dynamics: A case study of Gull-billed Terns (*Sterna nilotica*) in coastal Virginia. Auk 115: 970-978.

Eyler, T. B., R. M. Erwin, D. B. Stotts and J. S. Hatfield. 1999. Aspects of hatching success and chick survival in Gull-billed Terns in coastal Virginia. Waterbirds 22: 54-59.

Florida Fish and Wildlife Conservation Commission. 2003. Florida's breeding bird atlas: A collaborative study of Florida's birdlife. Http://www.wildflorida.org/bba/ (accessed 1 Dec 2005).

Friedmann, H., L. Griscom and R. T. Moore. 1950. Distributional check-list of the birds of Mexico. Pacific Coast Avifauna 29.

Garza-Torres, H. A. and A. G. Navarro S. 2003. Breeding records of the Sooty Tern in Tamaulipas and its distribution on the Gulf of Mexico. Huitzil 4: 22-25.

Gochfeld, M. and J. Burger. 1996. Family Sternidae (Terns). Pages 624-667 *in* Handbook of the Birds of the World, Vol. 3. Hoatzin to Auks (J. del Hoyo, A. Elliott and J. Sargatal, Eds.), Lynx Edicions, Barcelona.

Gochfeld, M., J. Burger and I. C. T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). *In* The Birds of North America, no. 370 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia and American Ornithologists' Union, Washington, D.C.

Gonzalez-Bernal, M. A., X. Vega and E. Mellink. 2003. Nesting of Western Gulls in Bahia de Santa Maria-La Reforma, Sinaloa, Mexico. Western Birds 34: 175-176.

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna 27.

Hagemeijer, W. J. M. and M. J. Blair, eds. 1997. The EBCC Atlas of European Breeding Birds. T. and A. D. Poyser, London.

Haverschmidt, F. 1968. Birds of Surinam, Livingston Publishing Co., Wynnewood, Pennsylvania.

Hellmayr, C. E. and B. Conover. 1948, Catalogue of birds of the Americas, part 1, No. 2: Field Museum of Natural History Zoological Series 13.

Higgins, P. J. and S. J. J. F. Davies, eds. 1996. Handbook of Australian, New Zealand and Antarctic Birds, v. 3. Oxford University Press, Melbourne.

Hilty, S. L. 2003. Birds of Venezuela, 2nd ed. Princeton University Press, Princeton, New Jersey.

Hilty, S. L. and W. L. Brown. 1986. A Guide to the Birds of Colombia. Princeton University Press, Princeton.

Howell, S. N. G. and S. Webb. 1995. A Guide to the Birds of Mexico and Northern Central America. Oxford University Press, Oxford.

Huner, J. V. 2000. Louisiana's agricultural wetlands as waterbird habitat: a synopsis. Louisiana Ornithological Society News 189: 3-4.

Johnston-Gonzalez, R., D. Arbelaez-Alvarado and I. Angarita-Martinez. 2005. First nesting records of the Gull-billed Tern (*Gelochelidon nilotica*) in Colombia. Ornitologia Colombiana No. 3: 84-87.

Jones, H. L. 2003. Birds of Belize. University of Texas Press, Austin.

Kress, S. W., E. H. Weinstein and I. C. T. Nisbet. 1983. The status of tern populations in northeastern United States and adjacent Canada. Colonial Waterbirds 6: 84-106.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. Acosta-Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Eliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

Komar, O. 2001. Contribuciones a la avifauna de El Salvador. Cotinga 16: 40-45.

Land, H. C. 1970. Birds of Guatemala. Livingston Publ. Co., Wynnewood, Pennsylvania.

Leberg, P. L., P. Deshotels, S. Pius and M. Carloss. 1995. Nest sites of seabirds on dredge islands in coastal Louisiana. Proceedings Annual Conference Southeastern Association of Fish and Wildlife Agencies 49: 356-366.

Lockwood, M. W. and B. Freeman. 2004. The TOS Handbook of Texas Birds. Texas A&M University Press, College Station.

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

Marchant, S. 1958. The birds of the Santa Elena Peninsula, S. W. Ecuador. Ibis 100: 349-387.

Martin, R. P. and G. D. Lester. 1990. Atlas and census of wading bird and seabird nesting colonies in Louisiana: 1990. Louisiana Department of. Wildlife and Fisheries, Louisiana Natural Heritage Program. Special Publication. No. 3. 182 pp.

McCaskie, G. 1976. The Nesting Season. The Southern Pacific Coast. American Birds 30: 1004.

McCaskie, G. 1986. The Nesting Season, Southern Pacific Coast. American Birds 40: 1255.

Michot, T. C., C. W. Jeske, W. J. Vermillion, J. Mazourek and S. Kemmerer. 2004. Atlas and census of wading bird and seabird nesting colonies in south Louisiana, 2001. BTNEP Report No. 32.

Molina, K. C. 1997. Habitat tern-about at the Salton Sea. Western Tanager 64: 3.

Molina, K. C. 2000. Breeding populations of Gull-billed Terns (*Sterna nilotica vanrossemi*) in southern California, 2000. Final report to U.S. Fish and Wildlife Service, Carlsbad, California.

Molina, K. C. 2001. Breeding populations of Gull-billed Terns (*Sterna nilotica vanrossemi*) and Caspian Terns (*S. caspia*) at the Salton Sea, 2001. Final report to U.S. Fish and Wildlife Service, Portland, Oregon.

Molina, K. C. 2004. Breeding larids of the Salton Sea: trends in population size and colony site occupation. Studies in Avian Biology 27: 92-99.

Molina, K. C. 2005. The breeding of terns and skimmers at the Salton Sea, 2005. Report to U.S. Fish and Wildlife Service, Sonny Bono Salton Sea National Wildlife Refuge, Calipatria, California.

Molina, K. C. and K. L. Garrett. 2001. The breeding birds of Cerro Prieto Geothermal Ponds, Mexicali Valley, Baja California. Monographs in Field Ornithology 3: 23-28.

Molina, K. C. and D. A. Marschalek. 2003. Foraging behavior and diet of breeding Western Gull-billed Terns (*Sterna nilotica vanrossemi*) in San Diego Bay. Species Conservation and Recovery Program Rep. 2003-01. California Department of Fish and Game, Habitat Conservation Planning Branch, Sacramento, California.

Molina, K. C. and R. M. Erwin. 2006. The status and distribution of the Gull-billed Tern (*Sterna nilotica*) in North America. Report to U.S. Fish and Wildlife Service, Portland, Oregon.

Molina, K. C., X. Vega, M. Roman and O. Hinojosa-Huerta. 2006. Monitoring breeding colonies and postbreeding movements of terns and skimmers in coastal northwestern Mexico and southern California in 2004 and 2005. Final report to U.S. Fish and Wildlife Service, Sonoran Joint Venture, Tucson, Arizona.

Moller, A. P. 1981. Breeding cycle of the Gull-billed Tern *Gelochelidon nilotica* Gmel., especially in relation to colony size. Ardea 69: 193-198.

Monroe, B. L., Jr. 1968. A Distributional Survey of the Birds of Honduras. Ornithological Monographs No. 7, American Ornithologists Union.

Muñoz del Viejo, A., X. Vega, M. A. Gonzalez and J. M. Sanchez. 2004. Disturbance sources, human predation and reproductive success of seabirds in tropical coastal ecosystems of Sinaloa State, Mexico. Bird Conservation International 14: 191-202.

O'Connell, T. J. and R. A. Beck. 2003. Gull predation limits nesting success of terns and skimmers on the Virginia barrier islands. Journal of Field Ornithology 74: 66-73.

Palacios, E. and E. Mellink. 1992. Breeding bird records from Montague Island, northern Gulf of California. Western Birds 23: 41-44.

Palacios, E. and E. Mellink. 1993. Additional records of breeding birds from Montague Island, northern Gulf of California. Western Birds 24: 259-252.

Palacios, E. and E. Mellink. 1995. Breeding birds of Esteros Tobarí and San José, southern Sonora. Western Birds 26: 99-103.

Palacios, E. and E. Mellink. 2003. Status, distribution, and ecology of nesting larids in western Mexico, with

emphasis on *vanrossemi* Gull-billed Terns and Caspian Terns. Final report to U.S. Fish and Wildlife Service, Portland, Oregon.

Palacios, E. and E. Mellink. 2006. Status, distribution, and ecology of nesting *vanrossemi* Gull-billed Terns in western Mexico. Final report to U.S. Fish and Wildlife Service, Portland, Oregon.

Parnell, J. F., R. M. Erwin and K. C. Molina. 1995. Gull-billed Tern (*Sterna nilotica*). *In* The Birds of North America, no. 140 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia and American Ornithologists' Union, Washington, D.C.

Patten, M. A., G. McCaskie and P. Unitt. 2003. Birds of the Salton Sea: status, biogeography, and ecology. University of California Press, Berkeley.

Patton, R. 2006. The status of Western Gull-billed Terns at South San Diego Bay National Wildlife Refuge. Final report to San Diego National Wildlife Refuge Complex, Chula Vista, California.

Pemberton, J. R. 1927. The American Gull-billed Tern breeding in California. Condor 29: 253-258.

Peresbarbosa, E. and E. Mellink. 2001. Nesting waterbirds of Isla Montague, northern Gulf of California, Mexico: loss of eggs due to predation and flooding, 1993-1994. Waterbirds 24: 265-271.

Peters, J. L. 1934. Check-list of Birds of the World, Vol. 2. Harvard University Press, Cambridge.

Pitman, R. L. 1986. Atlas of seabird distribution and relative abundance in the Eastern Tropical Pacific. Administration Report LJ-86-02C. National. Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California.

Portnoy, J. W. 1977. Nesting colonies of seabirds and wading birds: coastal Louisiana, Mississippi, and Alabama. U.S. Fish and Wildlife Service FWS/OBS-7707.

Portnoy, J. W., R. M. Erwin and T. W. Custer. 1981. Atlas of gull and tern colonies: North Carolina to Key West, Florida (including pelicans, cormorants, and skimmers). U.S. Fish Wildlife Service FWS/OBS-80/05.

Purrington, R. D. 2001. The Nesting Season, Central Southern Region. North American Birds 55: 443.

Purrington, R. D. 2002. The Nesting Season, Central Southern Region. North American Birds 56: 447.

Rangel-Salazar, J. L., P. L. Enriquez-Rocha and J. Guzman-Poo. 1993. Colonias de reproduccion de Aves Costeras en Sian Ka'an. Pages 833-840 *in* Bioversidad Marina y Costera de Mexico (S. I. Salazar-Vallejo and N. E. Gonzalez, Eds.), CONABIO y CIQRO, Mexico.

Remsen, J. V., Jr. 1978. Bird species of special concern in California. Nongame Wildlife Investigations, Wildlife Management Branch Administrative Report 78-1. California Department of Fish and Game, Sacramento, California.

Ridgely, R. S. and P. J. Greenfield. 2001. The Birds of Ecuador: Status, Distribution and Taxonomy. Cornell University Press, Ithaca, New York.

Ridgely, R. S. and J. A. Gwynne, Jr. 1989. A Guide to the Birds of Panama, 2nd ed. Princeton University Press, Princeton, New Jersey.

Russell, S. M. 1964. A distributional study of the birds of British Honduras. Ornithological Monograph No. 1, American Ornithologists' Union.

Russell, S. M. and G. Monson. 1998. The Birds of Sonora. University of Arizona Press, Tucson.

Sears, H. F. 1979. Colonial nesting as an anti-predator adaptation in the gull-billed Tern. Auk 96: 202-203.

Setmire, J. G., R. A. Schroeder, J. N. Densmore, S. L. Goodbred, D. J. Audet and W. R. Radke. 1993. Detailed study of water quality, bottom sediment, and biota associated with irrigation drainage in the Salton Sea area, California, 1988-90. USGS Water Resources Investigation Report 93-4014. U.S. Geological Survey, Sacramento, California.

Slud, P. 1964. The birds of Costa Rica: distribution and ecology. Bulletin of the American Museum of Natural History, vol. 128.

Smith, H.T. and E. M. Alvear. 1997. Recent breeding reports of the Gull-billed Tern in Florida: status undetermined? Florida Naturalist 70: 22-23

Smith, H. T. and J. A. Gore. 1996. Gull-billed Tern. Pages. 624-632 *in* Rare and Endangered Biota of Florida. Vol. V. Birds (J. A. Rodgers, Jr., H. W. Kale and H. T. Smith, Eds.). University of Florida, Gainesville.

Spaans, A. L. 1978. Status of terns along the Surinam coast. Bird-Banding 49: 66-76.

Spendelow, J. A. and S. R. Patton. 1988. National atlas of coastal waterbird colonies in the contiguous United States: 1976-1982. U.S. Fish and Wildlife Service Biological. Report 88(5).

Sprandel, G. L., H. A. Bolte and D. T. Cobb. 1998. Gull-billed Tern fledged on a roof in northwest Florida. Florida Field Naturalist 26: 94-96.

Sprunt, A., IV. 1984. The status and conservation of Seabirds of the Bahama Islands. Pages 157-168 *in* Status and Conservation of the Worlds' Seabirds (Croxall, P. G. H. Evans and R. W. Schreiber, Eds.). ICBP Technical Publication No. 2, Cambridge.

Steinkamp, M. J., B. G. Peterjohn and J. L. Keisman. Incorporating precision, accuracy and alternative sampling designs into continental monitoring program for colonial waterbirds. Ornis Hungarica 12-13: 209-216.

Stewart, R. E. and C. S. Robbins. 1958. Birds of Maryland and the District of Columbia. North American Fauna 62, Washington, D.C.

Stiles, F. G. and A. F. Skutch. 1989. A Guide to the Birds of Costa Rica. Cornell University Press, Ithaca, New York.

Texas Colonial Waterbird Society. 1982. An Atlas and Census of Texas Waterbird Colonies 1973-1980. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas.

Texas Colonial Waterbird Census. 2004. http://texascoastalprogram.fws.gov/TCWC.html., accessed 26 February 2004.

Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch and J. L. Atwood. 1997. Least Tern (*Sterna antillarum*). *In* The Birds of North America, no. 290 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia and American Ornithologists' Union, Washington D.C.

Thurber, W. A., J. F. Serrano, A. Sermeño and M. Benitez. 1987. Status of uncommon and previously unreported birds of El Salvador. Proceedings Western Foundation of Vertebrate Zoology 3: 109-293.

U.S. Fish and Wildlife Service. 1995. Proposed South San Diego Bay National Wildlife Refuge level III preacquisition survey. Division of Environmental Contaminants, Carlsbad California.

U.S. Fish and Wildlife Service. 2002. Birds of Conservation Concern. Division of Migratory Bird Management, Arlington, Virginia.

U.S. Fish and Wildlife Service. 2005. San Diego Bay National Wildlife Refuge. Draft Comprehensive Conservation Plan/Environmental Impact Statement for

Sweetwater Marsh and South San Diego Bay Units. U.S. Fish and Wildlife Service, California/Nevada Refuge Planning Office, Sacramento, California.

van Halewyn, R. and R. L. Norton. 1984. The status and conservation of seabirds in the Caribbean. Pages 169-222 *in* Status and Conservation of the Worlds' Seabirds (J. Croxall, P. G. H. Evans and R. W. Schreiber, Eds.). ICBP Technical Publication No. 2, Cambridge.

van Rossem, A. J. 1945. Birds of Sonora. Louisiana State University Press, Baton Rouge, Louisiana.

Wetmore, A. 1965. The birds of the Republic of Panama, Part 1. Smithsonian Miscellaneous. Collections., Vol. 150.

Appendix. Origins and associated data of study skin specimens of *Gelochelidon nilotica* housed in North American ornithological collections.

State	Locality	Collection #[a]	Date
Atlantic South America			
Argentina	Buenos Aires, General Lavalle	MCZ 85108	07-May-1921
Argentina	Barrancas al Sud	AMNH 746150	18-Sep-1904
Argentina	Barrancas al Sud	AMNH 746151	10-Feb-1903
Argentina	Barrancas al Sud	AMNH 746152	18-Sep-1904
Brazil	Southeast coast	MCZ 142127	no data
Brazil	Southeast coast	MCZ 142128	no data
Caribbean			
Bahamas	Powell Cay	CMNH 131019	21-Apr-1946
Bahamas	Cat	MCZ 332816	12-Jun-1986
Bahamas	Rum Cay	NMNH 189651	10-Jul-1903
Bahamas	San Salvador, Lake Ferdinand	NMNH 276337	20-Aug-1923
Bahamas	Long Cay, Fortune Island, Windsor Wells	NMNH 324847	12-Jul-1930
Bahamas	Grand Bahama, Matthewstown	FMNH 2053	12-Jul-1891
Bahamas	no data	FMNH 2054	18-Jul-1891
Bahamas	Great lnagua	FMNH 33285	27-May-1879
Bahamas	Great lnagua, Horse Pond	FMNH 33286	20-Jul-1891
Bahamas	Mayaguana, North West Point	FMNH 33287	17-Aug-1891
Bahamas	Long Island, Clarence Harbor	FMNH 33288	11-Jun-1879
Bahamas	Great lnagua, Curry Pond	FMNH 33289	25-Jul-1891
Bahamas	Great lnagua, Matthewstown	FMNH 33628	27-May-1879
Bahamas	Great lnagua, Matthewstown	FMNH 110146	27-May-1879
Bahamas	Miraporvas	FMNH 110147	24-May-1879
Belize	Stann Creek Dist., Stann Creek	LSUMZ 20953	28-Mar-1956
Belize	Stann Creek Dist., Stann Creek	LSUMZ 20954	28-Mar-1956
Belize	Stann Creek Dist., Stann Creek	LSUMZ 20955	28-Mar-1956
Belize	Stann Creek Dist., Stann Creek	LSUMZ 20956	28-Mar-1956
Cayman Islands	Grand Cayman, Newlands	LSUMZ 141813	09-Sep-1961
Costa Rica	Limon Prov., Jimenez	YPM 55830	29-Sep-1926
Cuba	Camaguey Prov., Playa Santa Lucia	LSUMZ 141812	29-Jun-1959
Cuba	Guantanamo, La Sabana, Los Canos	NMNH 453429	17-Sep-1919
Cuba	Camaguey Prov., Camaguey	YPM 1379	no data
Cuba	Isla de la Juventud Prov., Rio de las Casas	FLMNH 8405	24-Jul-1958
Dominican Republic	Monte Christi	NMNH 354133	05-Aug-1927
Guyana	East Demerara-West coast Berbice	YPM 25008	no data
Haiti	Ouest Dept., 10 mi NW Cabaret	LSUMZ 141814	14-Aug-1962
Haiti	Ouest Dept., 10 mi NW Cabaret	LSUMZ 141815	14-Aug-1962
Haiti	Ouest, Fonds Parisien, Etang Saumatre	NMNH 252849	05-May-1920
Haiti	Ouest, Fonds Parisien, Etang Saumatre	NMNH 252850	05-May-1920
Puerto Rico	Boqueron	NMNH 354132	03-Sep-1928
Turks and Caicos	Caicos Island, Fort George Cay	NMNH 324845	25-Jul-1930
Turks and Caicos	Caicos Islands, Grand Caicos Island	NMNH 324846	26-Jul-1930
Venezuela	Yaracuy, Tucacas	NMNH 595547	25-Sep-1952
Venezuela	Anzoatequi, Barcelona	NMNH 448571	25-May-1951
Virgin Islands	Cockroach Cay	PSM 14328[b]	26-Jun-1941
Virgin Islands	St. Croix	FMNH 127861	22-Aug-1 940

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[b]Clutch of eggs.

Appendix. (Continued) Origins and associated data of study skin specimens of *Gelochelidon nilotica* housed in North American ornithological collections.

State	Locality	Collection #[a]	Date
Virgin Islands	St. Croix	FMNH 127862	16-May-1940
Virgin Islands	St. Thomas	FMNH 158801	12-Jul-1940
Virgin Islands	St. Thomas	FMNH 158802	12-Jul-1940
Virgin Islands	St. Croix	FMNH 158803	24-Sep-1940
Virgin Islands	St. Croix	FMNH 158804	10-Sep-1942
Virgin Islands	St. Croix	FMNH 158805	22-Aug-1940
Virgin Islands	St. Croix	FMNH 158806	30-Apr-1940
Virgin Islands	St. Croix	FMNH 158807	10-Sep-1941
Virgin Islands	St. Croix	FMNH 158808	18-May-1940
Virgin Islands	St. Croix	FMNH 158809	18-May-1940
Gulf of Mexico			
San Luis Potosi	Ebano, Laguna Cerro la Pez	LSUMZ 14997	19-Mar-1950
San Luis Potosi	Cerro la Pez	LSUMZ 16424	03-Oct-1950
San Luis Potosi	Cerro la Pez	LSUMZ 16425	03-Oct-1950
San Luis Potosi	Velasco	LSUMZ 19070	10-Sep-1952
San Luis Potosi	Velasco	LSUMZ 19071	10-Sep-1952
Tabasco	19 mi. N Villahermosa	LSUMZ 22795	16-May-1959
Tabasco	19 mi N Villahermosa	UNAM 017704	05-May-1959
Tamaulipas	Altamira	FMNH 13411	02-Apr-1902
Tamaulipas	Tampico	ANSF 77204	28-Oct-1923
Veracruz	3 Km N Lerdo de Tejada	UNAM 021899	12-Dec-1969
Veracruz	Isla de los Pajaros, 85 mi S of Rivera	NMNH 193618	25-Apr-1904
Yucatan	Frogreso, 4 km W Puerto Yucalpeten	CMNH 144799	01-Dec-1971
Yucatan	4 km W Progreso, Puerto Yucalpeten	UNAM 017682	12-Dec-1971
Pacific Central America			
Guatemala	Chiapam	NMNH 30846	Feb-1863
Guatemala	4 km WSW La Avellana	AMNH 813231	13-Aug-1974
Honduras	Choluteca Dept., 2.5 mi. NE Cedeno	LSUMZ 29013	09-Oct-1962
Panama	Cocle, Agua Dulce, Gallo	NMNH 477581	16-Jan-1963
Panama	Cocle, Agua Dulce, Gallo	NMNH 477582	16-Jan-1963
Panama	Cocle, Agua Dulce, Gallo	NMNH 477583	17-Jan-1963
Panama	Cocle, Agua Dulce, Gallo	NMNH 477584	16-Jan-1963
Panama	Cocle, Agua Dulce, Gallo	NMNH 477585	17-Jan-1963
Pacific Mexico			
Baja California	Isla Montague	NMNH 272380	16-May-1915
Baja California	Isla Montague	NMNH 285342	16-May-1915
Chiapas	Mojarras	UMMZ 102132	16-May-1939
Chiapas	La Polka	UMMZ 102133	17-May-1939
Chiapas	La Polka	UMMZ 102134	17-May-1939
Colima/Michoacan	Rio Coahuyana; on state border	NMNH 31867	Sep-1863
Guerrero	Cayacal, vic. Ciudad Lazaro Cardenas	NMNH 185429	12-Apr-1903
Guerrero	Cayacal	NMNH 185430	12-Apr-1903
Guerrero	Cayacal	NMNH 185440	12-Apr-1903
Oaxaca	15 mi. W Puerto Angel, boca Rio Tonameca	LSUMZ 33017	19-Apr-1964
Oaxaca	Tehuantepec	MCZ 73039	12-Aug-1869

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[b]Clutch of eggs.

Appendix. (Continued) Origins and associated data of study skin specimens of *Gelochelidon nilotica* housed in North American ornithological collections.

State	Locality	Collection #[a]	Date
Oaxaca	Tehuantepec, San Mateo del Mar	NMNH 058945	22-Feb-1869
Oaxaca	Tehuantepec, San Mateo del Mar	NMNH 059758	06-Aug-1869
Sinaloa	Bahia Santa Maria, Las Tunas	LSUMZ 39554	10-May-1959
Sinaloa	Bahia Santa Maria, Larricion	MLZ 9488	28-Apr-1934
Sinaloa	Rosario	NMNH 157322	25-Jul-1897
Pacific South America			
Ecuador	Prov. Guayas, 15 km SE Salinas	WFVZ 46176	23-Feb-1989
Ecuador	Vagueria	AMNH 746153	02-Sep-1901
Ecuador	Vagueria	AMNH 746154	03-Sep-1901
Ecuador	Prov. Guayas, S. Elena Peninsula	ANSP 185099	22-Jun-1992
Ecuador	Prov. Guayas, Repasa Jorge Velasquez Ibarra	ANSP 185100	21-Jun-1992
Peru	Lima Dept., Beach at Ventanilla	LSUMZ 72159	Aug-1972

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[b]Clutch of eggs.