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THE WINTER DISTRIBUTION OF THE WESTERN GULL-BILLED TERN (*GELOCHELIDON NILOTICA VANROSSEMI*)

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ABSTRACT: We surveyed 73 sites along the Gulf of California and Pacific coasts of mainland Mexico during five nonbreeding seasons from December 1999 to January 2007 to clarify the winter status and distribution of the western North American subspecies of the Gull-billed Tern (*Gelochelidon nilotica vanrossemi*), a taxon of conservation concern. We located birds at 44 of the 73 sites, (60%) with the largest numbers found around coastal lagoons with extensive tidal flats in southern Sonora, Sinaloa, and extreme northern Nayarit. Local concentrations were also noted at other sites from the Colorado River delta of extreme northwestern Sonora south to Guerrero. Resightings of birds banded as chicks at California breeding colonies establish the first evidence of connectivity to specific wintering sites in Mexico as far south as southern Sonora and possibly into Nayarit.

The Gull-billed Tern (*Gelochelidon nilotica*) is widespread in temperate, subtropical, and tropical regions of the Old and New Worlds, but many populations, particularly those in North America, appear to be declining (Parnell *et* al. 1995, Molina and Erwin 2006). The western North American subspecies (*G. n. vanrossemi*, the Western Gull-billed Tern) of southern California and western Mexico breeds at few known colonies, and its seasonal movements are poorly understood. The limited range and low population size of this subspecies (about 250 breeding pairs in the United States and perhaps as few as 600 pairs throughout its range in western Mexico; Molina and Erwin 2006, Palacios and Mellink 2007) has led to its listing as a species of special concern in California (Remsen 1978, Molina 2008) and a national bird of conservation concern (USDI 2002).

Gull-billed Terns are less dependent on marine and other aquatic habitats than are many other species of terns, and they commonly forage over a variety of terrestrial habitats. Their broad diet includes a variety of insects, marine invertebrates, reptiles, amphibians, small fish, and the small chicks of birds; as opportunistic feeders they often exploit ephemerally abundant populations of prey such as crickets and weevils (Molina 2008). These terns frequently forage singly or in groups of two or three individuals (Molina and Marschalek 2003). Nearly all of our knowledge of Gull-billed Tern ecology results from studies conducted during the breeding season (Parnell et al. 1995). Conservation efforts directed toward migratory species, however, require an understanding of distribution and ecology throughout the year (Coulter and Frederick 1997, Kushlan et al. 2002, Martin et al. 2007).

The winter range of the Western Gull-billed Tern has been outlined in the literature only in general terms (Howell and Webb 1995, Parnell et al. 1995), with some treatments (e.g., Hellmayr and Conover 1948, American Ornithologists' Union 1957) suggesting this subspecies winters south to Ecuador. Breeding populations in California (Salton Sea and south San Diego Bay) withdraw southward (Patten et al. 2003, Unitt 2004, Molina and Erwin 2006). Although Molina and Erwin (2006) presented more detail on winter distribution and included a brief analysis of the limited Christmas Bird Count (CBC) data available from Mexico, the extent of the subspecies' winter range in Mexico and the areas and habitats supporting important concentrations have not been described. Here we report on the results of surveys for Gull-billed Terns in western Mexico conducted during five winters between 1999 and 2007. Our objectives are to determine geographical areas and habitats of importance to this subspecies during the winter period and, secondarily, to link California-breeding Gull-billed Terns to specific sites used in the nonbreeding season. We also review other published and unpublished information on the winter range of *vanrossemi* to amplify our survey results.

METHODS

We conducted exploratory searches focused on Gull-billed Terns along the western coast of mainland Mexico south to Nayarit from December 1999 to January 2000, from December 2003 to January 2004 (Molina, Garrett), and in December 2004 (Molina, Garrett, and Larson) and along the Pacific coast of southern Mexico from Jalisco south to northwestern Chiapas in December 2004, January 2006, and January 2007 (Larson, Craig). Specific sites were visited from one to seven times over the full survey period, with ~50% of all sites visited two or more times and ~25% of sites visited three or more times (Table 1; Appendix). Our coverage extended from the Colorado River delta in extreme northwestern Sonora south to the Isthmus of Tehuantepec in northwestern Chiapas and concentrated on estuaries, tidal flats, shorelines of bays, river mouths, adjacent agricultural lands, and aquacultural impoundments. Ocean beach strands were covered less extensively. Difficulty of access prevented us from visiting the extensive estuarine flats of Bahía Adair between the Colorado River delta and Puerto

Table 1 Results of Winter Surveys for Gull-billed Terns in Western Coastal Mexico, 1999–2007

Location[a]	Maximum[b]	Mean ± SE[c]	Encounter rate[d]	N[e]	Habitats[f]
Sonora					
El Golfo de Santa Clara (1)	19	6.2 ± 3.3	0.8	5	TF, SP
Bahía Kino (2A)	0	0 ± 0	0	3	TF, SP
Estero Santa Cruz (2B)	5	3 ± 1	1	3	TF
Presa Rodríguez (3)	0		0	1	RE, SSF
Estero Tastiota (4)	0	0 ± 0	0	3	TF, SP
Miramar-Tular, Guaymas (5)	0	0 ± 0	0	3	TF
Estero El Rancho (Empalme) (6)	19	7.2 ± 3.3	0.8	5	TF
Bahía Guásimas, north at shrimp ponds (7A)	0		0	1	TF, SP
Bahía Guásimas (7B)	1	0.5 ± 0.5	0.5	2	TF, SP
Estero Lobos at Liliba (8)	1		1	1	TF
Los Medanos (9)	2		1	1	TF, SP
Huatabampo vicinity (10)	2		1	1	AG, SFF
Estero Tóbari (11)	13	5 ± 2.2	1	5	TF, SFF
El Paredón Colorado (12)	0		0	1	TF
Yavaros (13)	3	1.2 ± 0.5	0.8	5	TF
Santa Bárbara, estero (14A)	18	12.5 ± 5.5	1	2	TF, SP
Santa Bárbara, beach (14B)	1	0.5 ± 0.5	0.5	2	TF, BS
Huatabampito (14C)	0		0	1	BS, TF
Agiabampo (15)	2	1 ± 1	1	2	TF
Sinaloa					
Río Fuerte, Las Grullas Margen Izquierda (16A)	0	0	0	1	RM, RC
El Colorado (16B)	1		1	1	TF
Cerro Cabazón (17)	27	23.5 ± 3.5	1	2	TF
Huitussi (18)	16	13 ± 3	1	2	TF, SP
Costa Azul (19)	10	7 ± 3	1	2	TF
La Reforma (20)	10	14.5 ± 4.5	1	2	TF
Ensenada Pabellones, northeast shore (21A)	20	12 ± 8	1	2	TF, SP
Arenitas (21B)	4		1	1	TF, SP, AG
Altata (21C)	0		0	1	TF
El Tambor (21D)	0		0	1	TF
Dautillos (21E)	0		0	1	TF, SP
Presa Eustáquio Buelna (22)	0		0	1	RE, SFF
Cospita (23)	7	3.5 ± 3.5	0.5	2	TF, SP
Ceuta (24A)	9		1	1	TF
Marmol (24B)	4		1	1	TF
Estero de Sábalo (Mazatlán Marina) (25)	11	4.1 ± 2	0.43	7	TF
Estero Urias (La Sirena) (26)	8		1	1	TF, SP
Laguna Caimanero, n. end near T. Beltran (27)	14		1	1	TF, SFF
Laguna Caimanero, n. end near Ejido G. V. Moreno (28)	0		0	1	TF, SFF
Agua Verde/Caimanero (29)	3	1.3 ± 0.9	0.66	3	TF, SP
Rio Baluarte mouth (30)	2	1 ± 1	0.5	2	TF, SP, RM
Estacada (31A)	7	3.5 ± 3.5	0.5	2	TF
Las Cabras (31B)	0		0	1	BS
Laguna Agua Grande (32A)	140	73.3 ± 34.2	1	3	TF, SFF
Nayarit					
Teacapán (32B)	0		0	1	TF, SP

(*Continued*)

Table 1 (*Continued*)

Location[a]	Maximum[b]	Mean ± SE[c]	Encounter rate[d]	N[e]	Habitats[f]
Tecuala (32C)	0		0	1	AG, SFF, SP
Valle de la Urraca, shrimp ponds (33)	10		1	1	SP
Playa El Novillero (34A)	0	0 ± 0	0	2	BS, TF
Palmar de Cuautla (34B)	0		0	1	BS, TF
Santa Cruz, wetlands (35)	3		1	1	AG
San Blas/G. Victoria, shrimp ponds (36)	23	12.5 ± 10.5	1	2	SP
San Blas, Los Miradores (37)	40	24.7 ± 7.8	0.83	6	SFF
Peso Island/Estero Pozo (38)	0		0	3	TF
Matanchén beach (39)	0		0	5	TF, BS
Union de Corrientes (40)	3		1	1	TF
Boca de Camichin (41)	5		1	1	TF, RM
Jalisco					
Barra de Navidad (42)	0	0 ± 0	0	2	TF, BS
Colima					
Rio Pascuales mouth (43)	30		1	1	RM, BS
Boca de Coahuayana, Apiza (44)	0		0	1	RM, BS
Michoacán					
Boca del Rio Neixpa (45)	0	0 ± 0	0	3	TF, BB
Guerrero					
Laguna Coyuca, Pie de la Cuesta (46)	1	0.5 ± 0.5	0.5	2	TF, BB
Laguna Tres Palos, Barra Viejo (47)	0		0	1	TF, SFF
Río Papagayo mouth (48)	11	2.6 ± 2.1	0.43	7	TF, BB
Barra de Tecomate (49)	1		1	1	TF, SFF
Laguna Chautengo, Pico del Monte (50)	19		1	1	TF, SFF
Río Marquelia, Playa del Bocana (51)	7	4 ± 3	1	2	RM, TF
Río Quetzala, Barra de Teconapa (52)	6	1.2 ± 1.2	0.2	5	RM, TF
Oaxaca					
Río Verde, El Azufre (53)	8	2.3 ± 1.9	0.5	4	RM, TF
Laguna Chacahua (54)	0		0	1	RM, TF
Barra Colotepec (55)	0	0 ± 0	0	4	RM, TF, AG
Río Copalita mouth (56)	0		0	1	RM, TF, BB
San Mateo del Mar, Laguna Superior (57A)	0		0	1	TF, SFF
Santa María del Mar, Laguna Superior (57B)	0		0	1	TF, SFF, SP
Chiapas					
Laguna de la Joya, Boca de Cielo (58)	1		1	1	RM, TF

[a]Numbers in parentheses correspond to locations mapped in Figures 1, 2.

[b]Highest count on a single visit.

[c]SE, standard error.

[d]Encounter rates are the proportions of visits with ≥1 detection.

[e]Number of visits.

[f]AG, agriculture, pasturelands; BB. barrier beach; BS, beach strand; RC. river channels; RE. reservoir; RM. river mouths; SFF, seasonally flooded flats; SP. shrimp ponds; TF, estuarine tidal flats.

Peñasco. Because extensive coverage by others suggested that Gull-billed Terns are absent from the Puerto Peñasco area (S. Ganley pers. comm.), we did not survey that section of coastline.

Our surveys were generally limited to areas with vehicular access. Paved roads and dirt tracks to small fishing villages allowed scrutiny of multiple sites within most major bay and estuary systems from Nayarit northward, although extensive areas of the larger bays could not be reached because of impenetrable mangrove borders and a complex array of tidal channels and embayments. At a few sites, such as Estero Santa Cruz in Sonora, Ensenada Pabellones in Sinaloa, San Blas in Nayarit, and Río Papagayo in Guerrero, we employed small boats to survey portions of lagoon systems not otherwise accessible. From Jalisco southward, the coastal highway allows thorough access to most of the suitable coastal habitat, although such habitats are relatively limited because of the steeper coastal topography from Jalisco south to Guerrero. An exception is the large Laguna Cuyutlán complex in Colima, which we were unable to survey because of difficulty of access.

We used spotting scopes with 20–60× eyepieces for field identification at distances up to 1 km. The Gull-billed Tern's distinctive swooping foraging behavior (Parnell et al. 1995) often allowed identification of birds at greater distances. The duration of our observations at each site ranged from 30 minutes to several hours. At strongly tidal sites we extended our observation periods or made return visits to ensure that some data were recorded during periods when extensive tidal flats were exposed.

We recorded the coordinates at each site by the global-positioning system and classified the habitats into nine categories: beach strands (with no associated estuaries), barrier beaches (adjacent to estuaries), river mouths, estuarine tidal flats, seasonally flooded (nontidal) flats and salt pans, river channels, aquacultural (mainly shrimp) ponds, freshwater reservoirs, and agricultural areas (irrigated or not, including pastureland).

At each site we recorded the number of Gull-billed Terns encountered; when possible we scrutinized individual birds for bands. Gull-billed Terns have been banded intensively in southern California since 1993 (Molina unpubl. data). Because most western Mexican colonies have been documented only recently (Palacios and Mellink 2007), no Gull-billed Terns have been banded in these colonies (Molina et al. 2006, X. Vega pers. comm.). Therefore we have assumed that banded birds sighted in western Mexico were banded as chicks at Salton Sea or San Diego colonies in California.

We did not survey the coast south of the Isthmus of Tehuantepec because of time and funding constraints. As noted below, however, the subspecific identity of Gull-billed Terns wintering along the Pacific coast of Central America and northwestern South America is uncertain (Molina and Erwin 2006 and below), so we decided that the isthmus established an appropriate southern limit for our field surveys.

Additional information for El Golfo de Santa Clara in the Colorado River delta of extreme northwestern Sonora came from 18 visits from October to February, 1996–2007, by Molina and Garrett.

RESULTS

Survey Results

We visited 73 sites (see Appendix) and detected Gull-billed Terns at 44 (60%) of them (Table 1, Figures 1, 2), with a maximum single-day count of 140 at Laguna Agua Grande in extreme southern Sinaloa on 3 December 2004. Five other sites in Sinaloa, Nayarit, and Colima yielded single-day counts ≥20, and 12 additional sites in Sonora, Sinaloa, Nayarit, and Guerrero yielded counts ≥10. By summing the highest count for each site, we found a total of 547 birds. At sites visited three or more times (Table 1), Gull-billed Terns were detected on >50% of visits to Los Miradores, San Blas, Nayarit (5/6 visits), Río Papagayo mouth, Guerrero (4/7), Estero Tóbari, Sonora (5/5), Estero El Rancho (Empalme), Sonora (4/5), Yavaros, Sonora (4/5), Laguna Agua Grande, Sinaloa (3/3), El Golfo de Santa Clara, Sonora (4/5), Estero Santa Cruz, Sonora (3/3), and Agua Verde/Caimanero, Sinaloa (2/3).

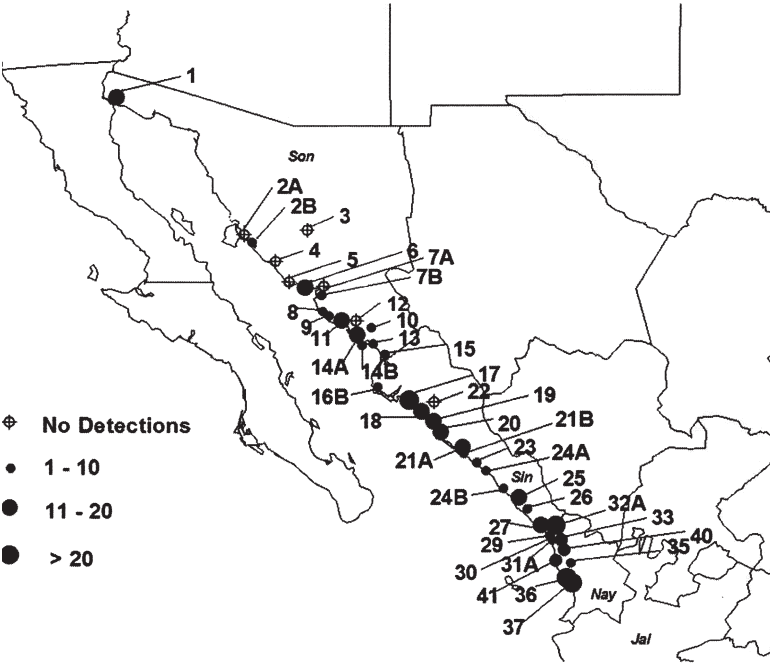

Figure 1. Locations of survey sites and maximum single-day counts of Gull-billed Terns in western Mexico, from Sonora south to Nayarit. For ease of illustration the following locations with no observations are not depicted: 14C, 16A, 21C–E, 28, 31B, 32B–C, 34A–B, 38, 39, and 44. See Table 1 for location codes.

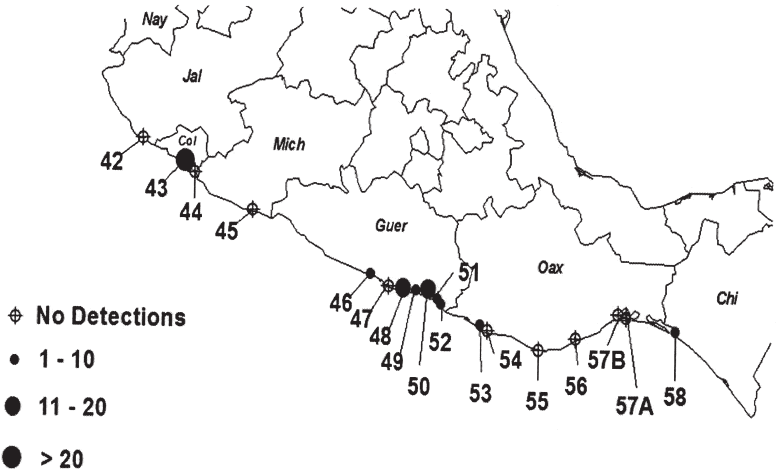

Figure 2. Locations of survey sites and maximum single-day counts of Gull-billed Terns in western Mexico, from Jalisco south to Chiapas. See Table 1 for location codes.

Habitat Associations

Some habitat affinities of wintering Gull-billed Terns emerged from our survey data. At 18 sites at which ≥10 birds were recorded on a single visit, the habitats (Table 1) were tidal flats (13 sites), shrimp ponds (7), seasonally flooded flats (5), beach strand (1), barrier beach (1), and river mouth (1). At sites with habitat complexes that included adjacent (or nearly adjacent) estuaries, tidal mudflats, and sandy beach strands we typically encountered Gull-billed Terns exclusively on tidal or seasonally flooded flats and estuaries rather than on beach strands (Table 2).

We did not detect any Gull-billed Terns at the two freshwater reservoirs we surveyed in multiple years (Presa Rodriguez in Hermosillo, Sonora, and Presa Eustáquio Buelna in Guamúchil, Sinaloa), and the species was generally absent from the extensive agricultural habitats we traversed. The

Table 2 Cumulative Number of Gull-billed Terns Found in Winter on Beaches Adjacent to Estuaries or Seasonally Flooded Mudflats in Sonora, Sinaloa, and Nayarit[a]

Site complex	Beach strand site	Birds	Estuarine site	Birds
El Golfo de Santa Clara	Playa El Golfo de S. C.	0 (25)	Delta flats	258 (25)
Bahía Kino	Playa Kino/Nuevo Kino	0 (3)	Estero Santa Cruz	9 (3)
Guaymas	Miramar-Tular	0 (3)	Estero El Rancho (Empalme)	36 (5)
Bahía Santa Bárbara	Playa Santa Bárbara	1 (2)	Estero Santa Bárbara	25 (2)
Bahía Yavaros	Huatabampito	0 (1)	Estero Yavaros	6 (5)
Mazatlán	Playas de Mazatlán	0 (7)	Estero de Sábalo	29 (7)
San Blas	Matanchén	0 (5)	Los Miradores	148 (6)

[a]Number of visits to each habitat type in parentheses.

one exception was the occurrence of two Gull-billed Terns in agricultural habitat not immediately adjacent to wetlands near Huatabampo, Sonora, on 18 December 2003.

Observations of Banded Birds

We encountered an adult with auxiliary bands indicating natal origin at the Salton Sea at Estero Santa Cruz near Bahía Kino, Sonora, on 10 January 2004 and a first-winter bird with a U.S. Geological Survey (USGS) band at Empalme, Sonora, 11 January 2004.

DISCUSSION

The largest concentrations of Gull-billed Terns during our surveys occurred around the extensive coastal lagoons of southern Sonora, Sinaloa, and northern Nayarit (Table 1, Figures 1, 2). Smaller but still significant concentrations were found in the Colorado River delta (at least in the eastern portion), in the vicinity of San Blas, Nayarit, and locally in coastal Colima and Guerrero (Figures 1, 2). Northwestern Mexico, from the Colorado River delta south to the vicinity of San Blas, Nayarit, is characterized by wide coastal plains, within which Alonso-Rodriguez and Páez-Osuna (2003) listed some 35 lagoon systems. In contrast, the coast from southern Nayarit south nearly to the Isthmus of Tehuantepec, where we encountered far fewer terns, is characterized by greater topographic relief and restricted coastal floodplains; for example, Mellink and de la Riva (2005) noted that only one large coastal wetland (Laguna Cuyutlán, Colima) is found between southern Nayarit and central Guerrero.

Our surveys, although not exhaustive, add considerably to the limited existing knowledge of the winter distribution of the Gull-billed Tern in western Mexico and adjacent regions. We did not conduct field surveys in California, Baja California, and Baja California Sur because Gull-billed Terns usually retreat south from their few breeding sites in these areas, with only small numbers remaining into early September (Patten et al. 2003, Unitt 2004). Because of the recent increase in winter reports of this species from these states, we summarize details here. There are ten mid-winter (November to February) records of one to four individuals at the Salton Sea (Patten et al. 2003, McCaskie and Garrett 2007a, b). No birds are known to have overwintered on the California coast; the latest records for the San Diego area are of single birds on 19 September 2002 (Unitt 2004) and 18–20 November 2004 (McCaskie and Garrett 2005). Isla Montague, a site of intermittent nesting in the Colorado River delta of northeastern Baja California, may hold wintering birds around the island's extensive tidal flats and channels. It is unclear whether winter surveys reported by Mellink et al. (1997) included sightings within the Baja California portion of the delta, but the habitat at Isla Montague is contiguous with the flats of the eastern delta in extreme northwestern Sonora where we regularly found relatively large numbers of birds in winter (Tables 1, 2). Gull-billed Terns depart their other regular breeding site in northeastern Baja California at the Cerro Prieto geothermal ponds (Molina and Garrett 2001) by September, but there are recent mid-winter sightings for that site as well: an adult on 6 January 2005 (Erickson et al.

2005), up to two from 13 December 2005 to 24 January 2006 (Erickson et al. 2006; R. A. Erickson pers. comm.), and three on 25 January 2007 (Hamilton et al. 2007). There are no mid-winter records for the Pacific coast of the state of Baja California; the species is unrecorded on the Ensenada Christmas Bird Count, conducted annually since December 2001.

In Baja California Sur one was found in late fall at Laguna Ojo de Liebre near Guerrero Negro (where the species has recently bred; Palacios and Mellink 2007) on 21 October 2006 (Erickson et al. 2007). A small wintering population has been recently documented in the El Centenario/Chametla wetland just west of La Paz. Up to four, representing the first confirmed winter record for the peninsula, were there from 18 October 2002 to 6 March 2003 (Erickson et al. 2003a, b). In subsequent winters up to seven individuals have been observed at this locality (Hamilton et al. 2007), although the species has not been recorded on either of the two Ensenada de La Paz CBCs (which include El Centenario) conducted since winter 2005–06.

Prior to our surveys there were few specific winter records of the Gull-billed Tern from the Pacific coast of mainland Mexico. For Sonora, Russell and Monson (1998) cited no records between 6 October and 19 February. Nine 1993–94 surveys between September and February of the Colorado River delta from El Golfo de Santa Clara west to Isla Montague (Baja California) yielded no more than a single Gull-billed Tern on any visit (Mellink et al. 1997). In contrast, our high counts at El Golfo de Santa Clara over the late fall and winter between 1996 and 2007 were of 80 on 15 October 2007, 66 on 18 November 2002, 42 on 7 October 2000, and 19 on 25 January 2004; all observations were over the extensive tidal flats along the uppermost gulf and an adjacent set of active shrimp ponds (Garrett unpubl. data). A CBC conducted since winter 2004–05 in the Colorado River delta (entirely north of the head of the Gulf and including mainly the Ciénega de Santa Clara area of Sonora) has recorded Gull-billed Terns twice, with a high count of four birds on 20 December 2006.

Of the three remaining coastal CBCs in Sonora, on 18 counts from winter 1989–90 to winter 2006–07, the one at Puerto Peñasco has never recorded Gull-billed Terns (11 birds listed in the CBC database for the 19 December 1999 count are in error, and in fact there are no October to February records of this species at Puerto Peñasco; S. Ganley pers. comm.). The San Carlos Bay CBC near Guaymas has recorded single birds twice and two birds once on 11 counts since winter 1994–95. The only CBC in coastal southern Sonora, at Navopatía on Estero Agiabampo, has been conducted just twice, yielding four birds on 29 December 2005 and seven on 29 December 2006. These CBC results corroborate our survey findings that wintering Gull-billed Terns in Sonora concentrate in the far northwestern and southern coastal regions.

Our surveys appear to provide the only detailed information on the status and distribution of Gull-billed Terns in Sinaloa, a state whose avifauna has never been summarized comprehensively. In Nayarit, the San Blas CBC reported from one to 52 terns on 12 of 14 counts conducted from 1980–81 to 2004–05. We found Gull-billed Terns most consistently and abundantly at the Los Miradores wetlands and associated shrimp ponds, both within the San Blas CBC circle.

Our survey data suggest that wintering Gull-billed Terns are generally absent from the coastal wetlands of Jalisco; this is largely confirmed by other published surveys. Gómez de Silva (2005) reported one bird at Barra de Navidad on 12 January 2005, but Esparza-Salas (2001) recorded none during monthly surveys at Laguna Xola-Paramán from November 1997 to August 1998. Hernández-Vázquez and Mellink (2001) did not detect Gull-billed Terns during ~16 censuses of the Majahuas and El Chorro estuaries from 3 September 1995 through 25 April 1996. Hernández-Vázquez (2005) later reported small numbers of birds as winter visitors from these two estuaries and at the other large coastal wetlands of Laguna Agua Dulce, Chalacatepec, and Ermitaño in surveys conducted monthly from November 1998 through February 2000, but none from the coastal wetlands of San Juan, La Manzanilla, El Tule, and Barra de Navidad. Gull-billed Terns, however, may occur regularly in the interior of Jalisco at Laguna Sayula, a shallow seasonal lake surrounded by agricultural lands north of Ciudad Guzman (at ~1500 m elevation) about 110 km inland from the coast. Howell (1994) reported six adults there on 2 March 1994, and two were there on 2 March 1995 (S. N. G. Howell pers. comm.). We are aware of one mid-winter report, of two birds, at Laguna Sayula on 16 January 2007 (C. Bushell pers. comm.).

Although Schaldach's (1963) monograph on Colima included some information from coastal censuses conducted in January and December 1959, he failed to observe Gull-billed Terns and cited no other records for the state. Howell (1994) considered the species to occur "regularly, at least in February and March, on the coast of Colima" citing three birds on 6 March 1995 in Manzanillo. Mellink and de la Riva (2005) surveyed Laguna de Cuyutlán near Manzanillo from September 1996 through March 1997 but did not record any Gull-billed Terns on eight visits. We were unable to survey Cuyutlán, but given the apparent extent of suitable habitat and our detections of birds at nearby Boca de Pascuales, it is likely that Gull-billed Terns also over-winter there.

There are no thorough published avifaunal surveys available for coastal Guerrero and Michoacán; much of the coastal slope in this region is steep and lacks large coastal wetlands suitable for Gull-billed Terns. Our data suggest that the species is relatively numerous only at several coastal sites in southeastern Guerrero; there, Palacios and Mellink (2007) reported 35 Gull-billed Terns at Laguna Coyuca on 28 October 2003. We encountered no birds in Michoacán.

In Oaxaca, Binford (1989) considered the species to be a "very uncommon winter resident;" our data agree with this characterization. Surveys by Mellink et al. (1998) in November 1995 and November 1996 along the Costa Chica (western coastline) of Oaxaca similarly lacked detections of Gull-billed Terns.

The state of Chiapas also lacks a thorough avifaunal survey. We surveyed only the far northwestern corner of Chiapas, encountering few Gull-billed Terns. Although only one of seven specimens from the Gulf of Tehuantepec was taken in winter (Molina and Erwin 2006), there are several large wetlands with seemingly appropriate habitat that require exploration.

Important Habitat Associations

Our data suggest that the most important natural habitat and foraging substrate for the Gull-billed Tern in western Mexico are the extensive tidal mudflats within large lagoons and estuaries, where we have observed crabs and small fish to be the predominant prey taken by these terns. As opportunistic foragers (Parnell et al. 1995) Gull-billed Terns frequently exploit concentrated prey at shrimp ponds, especially during the harvest when water levels are drawn down and shrimp are more accessible. In the northern part of the region the ponds are usually harvested in October and November; shrimp ponds in Sonora are typically dry and inactive from December until March (Páez-Osuna et al. 2003, Glenn et al. 2006). Farther south, in Sinaloa and Nayarit, where ambient winter temperatures are more moderate (Páez-Osuna et al 2003), shrimp ponds were still active and attractive to Gull-billed Terns into late December. Aquacultural impoundments, almost exclusively devoted to shrimp production, are becoming an increasingly prominent feature of the coastal landscape of northwestern Mexico from Sonora to Nayarit, as underscored by a recent estimate of their extent of ~51,000 hectares (Páez-Osuna et. al 2003). Only 3% of shrimp farming in Mexico occurs outside of the Gulf of California region (Páez-Osuna et al. 2003, Páez-Osuna and Ruiz-Fernandez 2005), and satellite imagery (Google Earth) and our field experience indicate that there is little or no active aquaculture from Jalisco south to the isthmus. If aquacultural ponds concentrate Gull-billed Terns, as we surmise, the scarcity of such habitats in these southern regions may contribute to the low numbers of Gull-billed Terns there relative to those encountered farther north.

We rarely found winter Gull-billed Terns along beach strands, even though other tern species (particularly the Royal, *Thalasseus maximus*, and Forster's, *Sterna forsteri*) are frequent in such habitats. In contrast, Gull-billed Terns frequently forage along beach strands near San Diego, California, during the breeding season (Molina and Marschalek 2003). Similarly, foraging over agricultural fields by these terns is very common during the breeding season in the Imperial Valley of California (Molina unpubl. data), though we detected such behavior only once in our winter surveys in Mexico. During our surveys, the agricultural lands appeared to be less intensively irrigated than those of the Imperial Valley.

Linking Breeding Colonies and Wintering Areas

In addition to the two known or presumed California-banded Gull-billed Terns we found during winter in Sonora, we know of one other bird with a USGS band in San Blas, Nayarit, on 13 January 2002 (S. N. G. Howell pers. comm.). Further evidence of linkages of natal sites in California to those sites in Mexico occupied by nonbreeding birds is our observation in May 2002 of four banded one-year-old birds (two with auxiliary bands unique to Salton Sea colonies) and one two-year-old (with auxiliary bands unique to the San Diego colony) at Estero Tóbari, Sonora. Our efforts to resight banded birds were hampered by this species' tendency not to gather in large groups and to spend considerable time in the air foraging.

Conservation Implications

Molina and Erwin (2006) estimated the total breeding population of *vanrossemi* at 600–800 breeding pairs. The overall population of this subspecies could thus be conservatively estimated at about 1500 breeding birds plus an unknown number of prebreeding individuals. On the basis of a rate of 0.75 fledglings per nesting pair per year—an average based on studies in San Diego and at the Salton Sea (Molina unpubl. data)—and an annual survival rate of about 0.8 over the first two years, suggested by studies of the Royal (Buckley and Buckley 2002, Collins and Doherty 2006) and Least (*Sternula antillarum*) Terns (Thompson et al. 1997), prebreeding birds probably number roughly 1000. Our focused surveys located about 547 total individuals (sum of the highest counts at each site, irrespective of year), indicating that (1) many more birds occupy unsurveyed sites, (2) many birds were missed at surveyed sites because of the extent of the habitats, and/or (3) many birds spend the nonbreeding season outside western Mexico, presumably from Guatemala south through Central America and perhaps to northwestern South America (though as noted below it is unlikely that many or most birds in these areas are *vanrossemi*).

Specific bays and estuaries that appear to be particularly important to the species in winter include the Colorado River delta, Estero El Rancho (Empalme), Estero Tóbari, and Bahía Santa Bárbara in Sonora; Bahía San Ignacio–Bahía Navachiste (including the Cerro Cabazón site; Figure 3), and Bahía Santa María–Ensenada Pabellones in Sinaloa, and the Marismas Nacionales, which encompass a series of coastal wetlands between Mazatlán, Sinaloa, and San Blas, Nayarit (Figure 4). The mouth of the Río Pascuales in Colima is important, and we suspect that the extensive potentially suit-

Figure 3. These extensive tidal mudflats at Cerro Cabazón, Bahía San Ignacio, Sinaloa, photographed 11 December 2004, represent a predominant foraging habitat of Gull-billed Terns wintering in western Mexico.

Photo by Kathy C. Molina

Figure 4. Our largest single-day count of wintering Gull-billed Terns in western Mexico was on 3 December 2004 at the southern end of the Laguna Agua Grande complex in the Marismas Nacionales, represented in part by these seasonally flooded flats just east of Valle la Urraca on the Sinaloa/Nayarit border.

Photo by Kathy C. Molina

able habitat surrounding nearby Laguna Cuyutlán is as well. Many of these wetlands have been identified as "Areas de Importancia para la Conservación de las Aves" (AICAs; Benítez et al. 1999) by the Mexican government. Healthy populations of *vanrossemi* Gull-billed Terns in the nonbreeding season appear to depend on maintaining the ecological integrity of these large tidal estuaries and seasonally flooded flats in western Mexico's coastal lowlands.

Several workers have expressed concern over actual and potential environmental degradation of bay and estuarine ecosystems as a result of the rapidly expanding development of the shrimp-farming industry in Mexico (Páez-Osuna et al. 2003), to which we would add the impacts of coastal development for tourism, such as at Estero Sábalo, Mazatlán Marina (pers. obs.). The negative impacts of aquaculture include the deterioration of water quality of adjacent wetlands due to eutrophication and interruptions to natural hydrology patterns, as well as the direct loss of natural habitat through conversion to aquacultural impoundments. Because shrimp ponds may concentrate foraging birds in winter, as they appear to do in the breeding season (Palacios and Mellink 2007), the occasional practice of lethal control of shrimp-eating birds at these systems (Molina and Erwin 2006) may also pose threats to Gull-billed Tern populations.

Research Recommendations

Our exploratory surveys identify and quantify important wintering areas for subspecies *vanrossemi* of the Gull-billed Tern, but substantial improvements in our understanding of the nonbreeding ecology of this subspecies are possible. Research priorities include a more thorough quantification of use of the larger coastal wetlands in western Mexico (such as the Marismas Nacionales in southern Sinaloa and northern Nayarit) as well as more rigorous examinations of habitat use at finer spatial scales. Because land-based surveys of such extensive estuaries and lagoons cannot be comprehensive, the use of boats and possibly aircraft in survey efforts is recommended. More survey effort is also needed in the lagoons and estuaries south of Nayarit such as at Laguna Cuyutlán, a known breeding locality, and in Chiapas.

Given the emerging importance of establishing the connectivity of breeding and nonbreeding sites of migratory bird populations (Martin et al. 2007), we also recommend increased efforts to ascertain such links through increased banding/resighting effort and (as developing technology allows), satellite tracking and, possibly, indirect techniques such as stable-isotope analysis.

The importance to wintering *vanrossemi* of the Pacific coast south of the Isthmus of Tehuantepec, and indeed south into northwestern South America, needs to be established by morphometric and molecular analysis to determine the subspecific identity of birds in that region. It may be reasonable to expect some Gull-billed Terns of the subspecies *G. n. aranea* from the Atlantic coast of North America and Gulf of Mexico to winter on the Pacific side; at least one other tern, the Sandwich (*T. sandvicensis*), winters commonly on the Pacific coast in this region yet breeds only on the Atlantic/Caribbean side (American Ornithologists' Union 1998). Molina and Erwin (2006) discussed the uncertainties of subspecies allocation of Gull-billed Terns along the Pacific coast of Central America and northwestern South America; in short, few reference specimens exist, and overlap in characters has hampered proper subspecies assignment. Both *vanrossemi* and *aranea* have been collected in Pacific Guatemala (Hellmayr and Conover 1948, Dickerman 2006), but we are not aware of specimens confidently assignable to *vanrossemi* taken farther south. We propose, absent convincing evidence of the regular occurrence of *vanrossemi* south of the Isthmus of Tehuantepec, that this subspecies may in fact be essentially endemic to western Mexico and adjacent southernmost California; at the very least, management of this subspecies should not be based on the unsubstantiated assumption that appreciable breeding or even nonbreeding populations exist south of there.

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APPENDIX. Dates of visits and coordinates for Gull-billed Tern survey locations in Mexico in winter 1999–2000, 2003–04, 2004–05, 2006, and 2007.

Sonora

1. El Golfo de Santa Clara, 31° 42′ 37″ N, 114° 31′ 53″ W (5 Dec 99; 29 Jan 00; 25 Jan 04; 8 Nov 04; 17 Jan 05). **2A.** Bahía Kino, 28° 50′ 33″ N, 111° 58′ 15″ W (10 Jan 04; 7, 8 Dec 04). **2B.** Estero Santa Cruz, 28° 48′ 36″ N, 111° 55′ 00″ W (10 Jan 04; 7, 8 Dec 04). **3.** Presa Rodríguez, Hermosillo, 29° 03′ 55″ N, 110° 54′ 56″ W (10 Jan 04). **4.** Estero Tastiota, 28° 22′ 31″ N, 111° 26′ 40″ W (10 Jan 04; 8, 17 Dec 04). **5.** Miramar-Tular (Guaymas) 27° 55′ 53″ N, 110° 56′ 45″ W (14 Jan 04; 8, 17 Dec 04). **6.** Estero El Rancho (Empalme), 27° 57′ 53″ N, 110° 50′ 28″ W (11, 13 Jan 04; 8, 9, 17 Dec 04). **7A.** Bahía Guásimas, north, 27° 53′ 49″ N, 110° 37′ 52″ W (11 Jan 04). **7B.** Bahía Guásimas, 27° 53′ 03″ N, 110° 35′ 23″ W (11 Jan 04; 9 Dec 04. **8.** Estero Lobos (at Liliba), 27° 21′ 08″ N, 110° 16′ 00″ W (12 Jan 04). **9.** Los Medanos, 27° 09′ 47″ N, 110° 16′ 00″ W (12 Jan 04). **10.** Huatabampo vicinity, 27° 02′ 36″ N, 109° 48′ 40″ W (18 Dec 03). **11.** Estero Tóbari, 27° 06′ 04″ N, 109° 58′ 19″ W (18 Dec 03; 12, 13 Jan 04; 9, 15 Dec 04). **12.** El Paredón Colorado, 27° 04′ 36″ N, 109° 56′ 07″ W (15 Dec 04).

13. Yavaros, 26° 42′ 09″ N, 109° 31′ 23″ W (18 Dec 03; 13 Jan 04; 10, 11, 14 Dec 04. **14A.** Santa Bárbara, estero, 26° 42′ 03″ N, 109° 39′ 13″ W (18 Dec 03; 10 Dec 04). **14B.** Santa Bárbara, beach, 26° 41′ 34″ N, 109° 39′ 04″ W (18 Dec 03; 10 Dec 04). **14C.** Huatabampito, 26° 41′ 32″ N, 109° 34′ 45″ W (10 Dec 04). **15.** Agiabampo, 26° 22′ 05″ N, 109° 09′ 46″ W (19 Dec 03; 11 Dec 04).

Sinaloa

16A. Río Fuerte, Las Grullas El Margen Izquierda, 25° 51′ 12″ N, 109° 19′ 50″ W (19 Dec 03). **16B.** El Colorado, 25° 45′ 27″ N, 109° 19′ 00″ W (19 Dec 03). **17.** Cerro Cabazón, 25° 34′ 09″ N, 108° 51′ 39″ W (19 Dec 03; 11 Dec 04). **18.** Huitussi, 25° 30′ 31″ N, 108° 44′ 56″ W (19 Dec 03; 11 Dec 04). **19.** Costa Azul, 25° 05′ 57″ N, 108° 08′ 25″ W (17 Dec 03; 12 Dec 04). **20.** La Reforma, 24° 04′ 16″ N, 108° 03′ 30″ W (17 Dec 03; 12 Dec 04). **21A.** Ensenada Pabellones, northeast shore, 24° 27′ 19″ N, 107° 29′ 38″ W (3 Jan 00; 13 Dec 04). **21B.** Arenitas, 24° 20′ 26″ N, 107° 28′ 13″ W (3 Jan 00). **21C.** Altata, 24° 37′ 49″ N, 107° 55′ 30″ W (4 Jan 00). **21D.** El Tambor, 24° 45′ 02″ N, 108° 01′ 35″ W (4 Jan 00). **21E.** Dautillos, 24° 43′ 09″ N, 107° 58′ 20″ W (4 Jan 00). **22.** Presa Eustáquio Buelna, Guamúchil, 25° 29′ 39″ N, 108° 03′ 14″ W (17 Dec 03; 12 Dec 04). **23.** Cospita, 24° 06′ 37″ N, 107° 07′ 44″ W (4 Jan 00; 20 Dec 03). **24A.** Ceuta, 23° 54′ 59″ N, 106° 58′ 13″ W (3 Jan 00; 20 Dec 03). **24B.** Marmol, 23° 29′ 14″ N, 106° 37′ 11″ W (5 Jan 00). **25.** Estero de Sábalo (Mazatlán Marina), 23° 16′ 39″ N, 106° 27′ 42″ W (3, 5, 6 Jan 00; 16, 20, 21 Dec 03; 1 Dec 04). **26.** Estero Urias (La Sirena), 23° 12′ 03″ N, 106° 21′ 44″ W (21 Dec 03). **27.** Laguna Caimanero (n. end near Teodoro Beltran), 23° 00′ 45″ N, 106° 09′ 06″ W (21 Dec 03). **28.** Laguna Caimanero (n. end near Ejido Gregorio Moreno), 22° 58′ 23″ N, 106° 07′ 18″ W (21 Dec 03). **29.** Agua Verde/Caimanero, 22° 52′ 38″ N, 106° 01′ 03″ W (28, 29 Dec 99; 13 Dec 03). **30.** Río Baluarte mouth, 22° 50′ 18″ N, 106° 02′ 20″ W (29 Dec 99; 13 Dec 03). **31A.** Estacada (s. end Laguna Grande/Las Canales), 22° 46′ 50″ N, 105° 51′ 09″ W (2 Jan 00; 3 Dec 04). **31B.** Las Cabras, 22° 44′ 38″ N, 105° 54′ 18″ W (2 Jan 00). **32A.** Laguna Agua Grande, s.e. end, 22° 32′ 52″ N, 105° 36′ 33″ W (32A);13, 16 Dec 03; 3 Dec 04.

Nayarít

32B. Teacapán, 22° 32′ 38″ N, 105° 43′ 23″ W (2 Jan 00). **32C.** Tecuala, 22° 23′ 40″ N, 105° 34′ 31″ W (13 Dec 03). **33.** Valle de la Urraca (shrimp ponds), 22° 33′ 19″ N, 105° 38′ 34″ W (16 Dec 03). **34A.** Playa El Novillero, 22° 22′ 53″ N, 105° 39′ 44″ W (13 Dec 03; 4 Dec 04). **34B.** Palmar de Cuautla, 22° 13′ 14″ N, 105° 38′ 14″ W (13 Dec 03). **35.** Santa Cruz wetlands, 21° 58′ 56″ N, 105° 27′ 34″ W (14 Dec 03). **36.** San Blas (shrimp ponds near Guadalupe Victoria), 21° 35′ 13″ N, 105° 17′ 11″ W (14, 16 Dec 03). **37.** San Blas (Los Miradores), 21° 32′ 53″ N, 105° 15′ 29″ W (31 Dec 99; 1, 2 Jan 00; 14, 16 Dec 03; 6 Dec 04). **38.** Peso Island/Estero Pozo, 21° 31′ 55″ N, 105° 17′ 19″ W (16 Dec 03; 6 Dec 04; 25 Jan 07). **39.** Matanchén, 21° 31′ 35″ N, 105° 14′ 44″ W (31 Dec 99; 1, 2 Jan 00; 16 Dec 03; 6 Dec 04). **40.** Union de Corrientes, 21° 58′ 29″ N, 105° 29′ 13″ W (15 Dec 03). **41.** Boca de Camichin, 21° 44′ 25″ N, 105° 29′ 16″ W (15 Dec 03).

Jalisco

42. Barra de Navidad, 19° 11′ 56″ N, 104° 40″ 55″ W (8 Dec 04; 23 Jan 07).

Colima

43. Boca de Pascuales, 18° 51′ 45″ N, 103° 58′ 00″ W (9 Dec 04). **44.** Río Coahuayana mouth (Apiza), 18° 42′ 00″ N, 103° 43′ 56″ W (9 Dec 04).

Michoacán

45. Boca del Río Neixpa, 18° 03′ 04″ N, 102° 36′ 14″ W (9, 10 Dec 04; 22 Jan 07).

Guerrero

46. Laguna Coyuca at Pie de la Cuesta, 16° 56′ 54″ N, 99° 52′ 56″ W (10 Dec 04; 13 Jan 06). **47.** Laguna Tres Palos, Barra Viejo, 16° 41′ 24″ N, 98° 22′ 37″ W (11 Dec 04). **48.** Río Papagayo, 16° 41′ 05″ N, 98° 23′ 43″ W (11 Dec 04; 9, 10, 11, 13, 14 Jan 06; 20 Jan 07). **49.** Barra de Tecomate, 16° 38′ 13″ N, 98° 45′ 25″ W (1 Jan 06). **50.** Laguna Chautengo, Pico del Monte, 16° 36′ 23″ N, 98° 52′ 40″ W (1 Jan 06). **51.** Río Marquelia, Playa la Bocana, 16° 33′ 17″ N, 97° 11′ 13″ W (12 Dec 04; 2 Jan 06). **52.** Río Quetzala, Barra de Teconapa, 16° 30′ 10″ N, 97° 16′ 15″ W (12 Dec 04; 2, 3, 9 Jan 06; 19 Jan 07).

Oaxaca

53. Río Verde, Azufre, 15° 59′ 07″ N, 96° 12′ 37″ W (13, 17 Dec 04; 4, 8 Jan 06. **54.** Laguna Chacahua, 15° 58′ 07′ N, 96° 18′ 58″ W (4 Jan 06). **55.** Barra Colotepec, 15° 48′ 33″ N, 96° 58′ 33″ W (13, 17 Dec 04; 5, 7 Jan 06). **56.** Río Copalita mouth, 15° 47′ 13″ N, 96° 03′ 13″ W (14 Dec 04). **57A.** San Mateo del Mar (Laguna Superior), 16° 12′ 40″ N, 93° 01′ 50″ W (6 Jan 06). **57B.** Santa María del Mar (Laguna Superior), 16° 13′ 24″ N, 93° 08′ 41″ W (6 Jan 06).

Chiapas

58. Laguna de la Joya, Boca de Cielo, 15° 50′ 52″ N, 93° 39′ 55″ W (15 Dec 04).