NESTING LEAST TERNS *STERNULA ANTILLARUM* AT ESTERO CARDONAL, SONORA, MEXICO: A NEWLY DISCOVERED COLONY IN THE GULF OF CALIFORNIA

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Received 16 June 2011, accepted 4 September 2011

On the Pacific Coast of the United States and Mexico, the Least Tern *Sternula antillarum* breeds from San Francisco Bay, California, south to Chiapas, Mexico. The species arrives in California in March and April from wintering grounds as far away as South America and begins breeding in late April and June on sandy beaches and salt flats, often adjacent to coastal wetlands or river mouths (Thompson *et al*. 1997). Coastal Least Tern nests normally consist of small scrapes in the sand, sometimes with a lining of shell fragments. Colony sizes range from a few to several hundred nests (Thompson *et al*. 1997).

As obligate coastal ground nesters, Least Terns on the Pacific coast of North America have experienced population declines over the past 100 years due to the increase of human populations in coastal regions. Most threats to nesting Least Terns are anthropogenic, including loss of nesting habitat to coastal development, destruction of nests by humans (often by off-road vehicle traffic), and predation by pets and human-tolerant species such as dogs, cats, crows, ravens and coyotes. In both the United States and Mexico, the Least Tern is considered endangered, largely because of such threats. In Mexico, Least Terns are currently designated as protected by NOM-059-SEMARNAT-2010 (Secretaría de medio ambiente y recursos naturales [SEMARNAT] 2010), and, in the United States, the California subspecies is listed as endangered under the US Endangered Species Act of 1973.

In California, where extensive active management occurs, the breeding population, estimated at 7130–7352 pairs, has increased steadily since monitoring began in 1969 (Marschalek 2010). In Mexico, Least Terns have been surveyed only sporadically outside of the Baja California Peninsula, and, even there, efforts have been minimal when compared with those in the United States. Palacios & Mellink (1996) estimated 400 breeding pairs in 24 nesting locations within the Gulf of California in the states of Sonora, Baja California, and Baja California Sur. More recently Mellink *et al*. (2007) surveyed the coast of southwestern Mexico, finding 16 colonies and an estimated 500 individuals, while Rosemartin & van Riper (2011), surveying the northern Sonoran coast, documented eight colony sites and 141 pairs. On the Pacific coast of Baja California, Massey (1977) and Zuria & Mellink (2002) reported several colonies of Least Terns. We describe a previously undocumented colony — now the only confirmed Least Tern nesting site along a 320 km stretch of coast in central Sonora that has never been systematically surveyed for nesting Least Terns.

Estero Cardonal (28°27'43"N, 111°42'16"W) is a 920 ha coastal wetland located along the eastern coast of the Gulf of California, 46 km south of the town of Bahía de Kino, Sonora, Mexico. A barrier beach and dune system runs along the western and southwestern margins of Estero Cardonal, separating the lagoon, mangrove channel/island, mud, sand and salt flat habitats from the sea. These dunes often shift under the influence of strong wind and waves, usually during late-summer storms. Such changes have drastically affected Estero Cardonal, including the sporadic closing and opening of the mouth on the west side of the lagoon during the 12 years following Hurricane Lester in 1992 (H. Galavis, pers. comm.). This led to the desiccation of much of Estero Cardonal. In 2004, a new mouth opened on the south side of the lagoon. Since then, the aquatic community has re-established. Several areas where Black Mangrove *Avicennia germinans* had died show signs of regrowth, invertebrate and fish fauna have recolonized, and thousands of waterbirds regularly roost and feed within the lagoon.

There are extensive halophyte flats—consisting of *Allenrolfea occidentalis*, *Frankenia palmeri*, *Salicornia* spp.—to the north and east of the lagoon, including several large areas of salt flat habitat with sparse vegetation. In the past 10 years, the coastal ecosystems north and south of Estero Cardonal have been overtaken by shrimp aquaculture. The land directly adjacent to Estero Cardonal is the last undeveloped coastal lowland ecosystem in central Sonora, and the site is one of the only undeveloped coastal wetlands in the state of Sonora (Glenn *et al*. 2006). Estero Cardonal is located in the Ejido El Cardonal, a communal land holding. On the southern margin of Estero Cardonal is El Cardonal, a small fishing settlement of about 40 people.

During monthly waterbird surveys at Estero Cardonal between 28 October 2009 and 20 June 2010, we discovered Least Terns nesting on 19 May 2010. We revisited Estero Cardonal on 28 May, 9 June, and 20 June 2010, to search for Least Tern nests. On 28 May and 20 June 2010 we checked nest contents in the early morning hours to avoid overheating eggs when incubating birds were flushed from the nests. On those dates, we observed birds landing on the ground from a distance of 15–100 m and sketched a map of the area that we used to locate each nest. When a nest was found, we determined its location with a Trimble GeoXT GPS unit and noted the number of eggs or chicks present. We imported and processed the spatial data with ArcGIS 9.3.1. Nests were plotted on satellite imagery from Google Earth, and polygons were drawn around each nesting area based on visual habitat characteristics from an eye altitude of 300 m. These polygons were then imported into ArcGIS.

We found 55 nests in six clusters and classified their surrounding habitats as barrier beach/dune, salt flat, dust flat and sand flat

(Table 1). The majority of nests (78.2%) were found in Clusters 1 and 2, located along the southwestern portion of the lagoon (Fig. 1). Cluster 1 was a dry salt flat with a few scattered shells, while Cluster 2 was a sand flat with a high density of shells. Other nests were found along the barrier beach (n = 1) and between sand dunes on the seaward side of the dune system (n = 6). On 20 June, five nests (Cluster 6) were found to the north of the lagoon on a soft dust substrate interspersed with halophytic vegetation (*Allenrolfea occidentalis*). Of the 55 nests discovered, 31 nests were checked for contents: 10 nests had one egg, 19 nests had two eggs, two nests had three eggs and one nest contained a single chick (Table 1).

Evidence of flooding from high spring tides was seen in Cluster 2 on 20 June. Flooding likely occurred during the spring tides of 11–14 June. Whether any nests were lost to flooding is unknown. Additionally, we noted countless tracks of trucks and off-road vehicles throughout the colony, as well as tracks of domestic dogs and cats.

Estero Cardonal's topography, availability of suitable substrate, and productivity in terms of available food resources, make it an attractive nesting site for Least Terns. The numerous salt flats, sand flats, and the intact barrier beach/dune ecosystem are prime nesting habitat. The diversity and amount of available habitat would allow birds to change habitat following an unsuccessful nesting attempt, as Zuria & Mellink (2002) documented in the northern Gulf of California. Colony flooding is well known in the Gulf of California, and renesting often occurs after such events (Massey & Fancher 1989, Muñoz del Viejo & Vega 2002, Zuria & Mellink 2002). Such events may explain both the new nests discovered on later visits to the Estero Cardonal colony and the scarcity of chicks seen. While a maximum of 31 nests were seen on any one day (28 May 2010), up to 210 adults were seen at one time during four visits (i.e. 9 June 2010, 12 days after we recorded the maximum number of nests). On our last visit (20 June), 360 Least Terns in mixed plumages (adult breeding, adult non-breeding and juvenile) were present, suggesting the presence of additional undiscovered nests. Although the estimate of colony size needs refinement, our record of 31 nests indicates the size of the Estero Cardonal colony is above average for the Gulf of California. Palacios & Mellink (1996) reported an average colony size of 23.3 pairs (SD = 35.7) in the Gulf of California, and Rosemartin & van Riper (2011) found an average of 17.6 (SD = 34.8) nests per colony in northern Sonora in 2006–2008. If Palacios & Mellink's (1996) estimate of 400 pairs for the Gulf of California is accurate, the colony at Estero Cardonal supports about 8% of the Gulf of California nesting population.

Least Terns are increasingly threatened by the rapid development of low-lying coastal land for shrimp aquaculture and tourist infrastructure in northwestern Mexico. Estero Cardonal is one of the last undeveloped coastal wetlands in Sonora. As development encroaches, the persistence of Least Terns in the region is inseparably tied to the persistence of breeding sites such as Estero Cardonal. However, the presence of feral dogs and cats and traffic by off-road vehicles and trucks can readily lead to colony failure. To minimize disturbance to the Least Tern colony, active measures should be taken to control feral predators. In terms of public education and outreach, efforts are needed to raise awareness of the area's importance and to inform local residents about the impact of seemingly inconsequential actions, such as off-road vehicles driving in the sand dunes or pets running loose. Future monitoring efforts will be important to determine more accurately the size of this colony, its productivity and the main threats to it. Given their protected status, Least Terns can be an umbrella species important for guiding future development and protecting the unique biological attributes of Estero Cardonal.

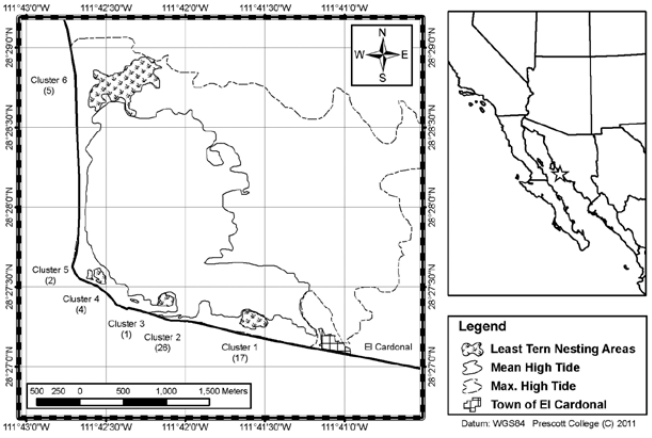

Fig. 1. Map of Estero Cardonal showing locations of six clusters of Least Tern nests (numbers of nests in parentheses),

TABLE 1
Habitat type, number of Least Tern nests, nest contents and clutch sizes for six colony clusters in Estero Cardonal, Sonora, Mexico, during 2010

Cluster	Habitat	Number of nests	Nests with contents examined	Eggs	Chicks	Clutch size			
						Mean	Minimum	Maximum	SD
1	Salt flat	17	11	20	–	1.82	1	3	0.57
2	Sand flat	26	13	21	1	1.62	1	3	0.6
3	Beach/dune	1	1	2	–	2	2	2	0
4	Beach/dune	4	1	2	–	2	2	2	0
5	Beach/dune	2	–	–	–	–	–	–	–
6	Dust flat	5	5	8	–	1.6	1	2	0.49
Total		55	31	53	1	1.71	1	3	0.57

ACKNOWLEDGEMENTS

This work was conducted by the Prescott College Kino Bay Center for Cultural and Ecological Studies, Research and Conservation Program. We acknowledge the Environmental Studies faculty at Prescott College for inspiring in their students the love of natural history and birds. Thanks to Lorayne Meltzer for providing encouragement and support, Hector Pérez Puig for field assistance, and Mark Riegner, Tom Fleischner, Douglas Clendaniel, Eileen M. Kirsch and Eduardo Palacios, for providing feedback on the manuscript.

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