# NESTING SUCCESS OF CALIFORNIA LEAST TERNS AT THE GUERRERO NEGRO SALTWORKS, BAJA CALIFORNIA SUR, MEXICO, 2005

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ABSTRACT: We studied a nesting colony of the Least Tern in the saltworks at Guerrero Negro, Baja California Sur, between 31 May and 23 July 2005. We marked the nests as they appeared and counted nests, eggs, and chicks daily. In a comparison of two periods of laying (31 May–13 June and 17 June–19 July) average clutch size of 15 nests (2.06 and 2.00 eggs/nest, respectively) did not differ, suggesting that in the year of our study food was not a limiting resource. We observed 36 chicks, 31 from the first period and five from the second. Incubation in the second period was interrupted by natural predation of nine nests (eight by coyotes and one by ravens). The hatching and fledging success of eggs laid during the first period were 100%, higher than for those laid in the second period (16% and 26%, respectively); the low values of the second period are attributable to a longer time during which the colony was exposed to predation. Though in an artificial habitat, the colony was not affected by human disturbance and enjoyed a high success rate overall. The problem of coyote depredation could be prevented with a fence, increasing the terns' success further.

The California Least Tern (*Sternula antillarum browni*) breeds from central California to the southern Baja California Peninsula (Thompson et al. 1997). Prior to the 1970s, Least Tern populations in California decreased because of loss of nesting habitat on beaches to human development and recreation (Massey 1974). Listing of *S. a. browni* under the United States and California endangered species acts in the early 1970s led to management such as nest-site protection and predator control, and these have yielded population increases in California (Thompson et al. 1997). In California, many aspects of Least Tern reproductive biology, such as site fidelity, habitat requirements, and reproductive success (e. g., Massey 1974, Atwood and Massey 1988) have been studied, as well as the species' response to management (Swickard 1974, Massey and Atwood 1981).

On the Baja California Peninsula, even though most of the coastline remains unaltered (Kramer and Migoya 1989), habitat loss and disturbance have caused partial or total reproductive failure of the California Least Tern in some areas (Palacios 1992, Mendoza 1994, Ibarra and Carmona 1998). Information on the birds' reproductive success, however, is available for only the northern and southern extremes of the peninsula (Palacios 1988, 1992, Mendoza 1994, Ibarra and Carmona 1998, Cuellar 2003). Although Least Tern breeding on the peninsula has been reported since 1927, the only data available for the entire peninsula are locations of nesting sites (Bancroft 1927, Lamb 1927, Massey 1977, Massey and Palacios 1994, Palacios and Mellink 1996).

The Least Tern's nesting at Ojo de Liebre (Scammon's) Lagoon has been known since 1927 (Bancroft 1927). But its reproductive success in the central peninsula had not been studied until we addressed the question in the Guerrero Negro saltworks (central Pacific coast of the peninsula) in 2005 nesting.

## STUDY AREA AND METHODS

The Guerrero Negro saltworks are a part of the El Vizcaíno Biosphere Reserve and are also operated by Exportadora de Sal (ESSA); they are closed to the public. Salt production involves pumping seawater from the Ojo de Liebre Lagoon along a system of connected ponds covering 27,773 ha. Water levels and salinity are kept fairly stable at all times, as a requirement of the industrial process. The first ponds of the system (S1-A and pond 1) receive water pumped from the lagoon, and their salinities are similar to those of the lagoon (ca. 33 practical salinity units); salinity values then ascend gradually from one pond to the next. The brine yielded by evaporation is pumped to a series of crystallization ponds where the salt precipitates and is collected. Although salt is produced year round, salt is collected from each pond for only one week every six months, At other times the ponds are undisturbed.

The colony we studied settled on a sand substrate with patches of salt flats. The colony is surrounded by low dunes and a margin of crystallization ponds (pond number 26: 27° 56′ 42″ N and 114° 02′ 24″ W). There is no vegetation on the nesting area, although patches of alkali heath (*Frankenia* spp.) and saltbush (*Atriplex* spp.) grow nearby and were used by the chicks to hide and to protect themselves from the sun and wind. The colony is approximately 4 km from the closest fishing areas.

Once we located the colony, we searched for nests daily (between 07:00 and 08:00), from 31 May until 23 July 2005. We counted the number of eggs in each nest and placed numbered wooden markers alongside each nest. We noted each egg's date of hatching and, in case of failure, the probable causes on the basis of nearby tracks. Using these data, we calculated two indicators of reproductive success: hatching success (proportion of chicks hatched out of the total number of eggs laid) and nesting success (proportion of nests that produced at least one chick; Erwin and Custer 1982). We also compared differences in clutch size and reproductive success between the two nesting periods by using a Kruskal–Wallis nonparametric test ($\alpha$ = 0.05 in all cases; Zar 1999).

## RESULTS

The reproductive season ran from 31 May until 23 July 2005. Most eggs (31, 51%) were laid during the first two weeks of the season (31 May–13 June), in 15 nests. Subsequently, laying was less concentrated, with 30 eggs laid over six weeks (17 June–23 July). In the first period, average clutch size was 2.06 eggs per nest, in the second, 2.00 eggs per nest; thus the periods did not differ significantly in clutch size (Table 1).

We observed 36 chicks, 31 hatched from eggs laid during the first period, five from eggs laid during the second (Table 1). The second hatching period was interrupted by predation of nine nests, eight of those, judged from nearby

**Table 1** Breeding of the California Least Tern at the Guerrero Negro Saltworks, Baja California Sur, México, 2005

| Variables measured | First period | Second period | Both periods combined | Kruskal–Wallis value | Probability |
|---|---|---|---|---|---|
| Number of nests | 15 | 15 | 30 | | |
| Eggs laid | 31 (31 May–13 June) | 30 (17 June–19 July) | 61 | | |
| Chicks | 31 (20 June–3 July) | 5 (8 July–18 July ) | 36 | | |
| Clutch size | 2.06 | 2.00 | 2.03 | 0.17 | 0.67 |
| Hatching success | 100% | 16% | 59% | 43.05 | <0.001 |
| Nesting success | 100% | 26% | 63% | 16.79 | <0.001 |

tracks, by coyotes (*Canis latrans*), and the remaining nest apparently was raided by Common Ravens (*Corvus corax*).

For both periods combined, the hatching success was 59% and the nesting success was 63% (Table 1). During the first period hatching success and nest success were 100%, but during the second period they were 16% and 26%, respectively (Table 1).

## DISCUSSION

In 2005 Least Terns nested at the Guerrero Negro saltworks during the same interval as observed at Laguna Percebú at the extreme north of the Gulf of California (Palacios 1992) and in some years at Ensenada de la Paz in the far south (Cuellar 2003 for 1999), with the first laying at the end of May. Laying began, however, two weeks later than is typical for colonies in California (Massey and Atwood 1981) and as observed at Ensenada de La Paz in other years (Cuellar 2003 for 2000). Therefore the timing of reproduction at a given site apparently depends more on the specific conditions during a given season than on the geographic location.

At various sites on the peninsula, one of the main reasons Least Tern nests have failed has been human disturbance (Palacios 1988, 1992, Mendoza 1994). Within the Guerrero Negro saltworks, disturbance is at a minimum (Carmona and Danemann 1998), as probably reflected in the high success values we recorded, especially for the first period. Another factor that commonly diminishes success on the peninsula is tidal flooding (Palacios 1992, Ibarra and Carmona 1998), but the nests we studied were all outside the range of the tides.

At Guerrero Negro, nest failure was due largely to predation, with 60% of eggs laid after 17 June being lost to predation. Increased predation later in the season may be the result of the length of time of the colony is exposed; it has been noted that as more time passes, the probability that predators will locate the nests increases (Brunton 1999).

Predation observed in the saltworks was by native species (coyotes and

ravens). At other colonies predators often include introduced fauna (Burger 1984, Martínez 2006). The Black-crowned Night-Heron (*Nycticorax nycticorax*) is a major predator of Least Tern eggs and chicks at some colonies (Brunton 1999). Though the herons breed at Guerrero Negro (Gutiérrez-Aguilar pers. obs.). the tern colony is away from areas they frequent.

That clutch size remained constant through the season suggests that at Guerrero Negro egg laying was not limited by food, at least in the single year of our study. Clutch size is known to be affected by food availability in various species of Laridae (Harris and Plumb 1965).

Hatching success at Guerrero Negro fell between the values of 57% and 90% reported for protected colonies of this species (Swickard 1974, Massey and Atwood 1981, respectively). Even the much lower hatching success later in the season (16%) was higher than values reported for some unprotected colonies (between 4% and 12%, Zuria and Mellink 2002, Ibarra and Carmona 1998, respectively). An exception to the lower values found in colonies without active protection is at Punta Banda, where hatching success values of almost 60% (Palacios 1992, Zuria and Mellink 2002) are linked to a minimal effect of the tides.

As at many colonies, the principal problem for the Least Tern at Guerrero Negro was predation, in this case by coyotes. Coyote predation could be avoided by fencing the colony to prevent access.

The Guerrero Negro saltworks, although carefully managed for salt production, is as undisturbed as any segment of the Baja California coast. The colony's high success rates is an example of human development not conflicting with conservation. The Least Tern colony at Guerrero Negro having success similarly to that of actively protected colonies elsewhere on the peninsula indicates that with minimal effort the saltworks can contribute to the conservation of these birds.

## ACKNOWLEDGMENTS

We acknowledge A. M. Cisneros and N. Atkins for their invaluable help in the writing of the manuscript and to the authorities of Exportadora de Sal for their support, including unrestricted access to their installation.

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*Accepted 17 September 2007*