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Observations (1997-2005) of Little Tern *(Sterna albifrons)* nesting attempts on Saipan, Commonwealth of the Northern Mariana Islands

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Abstract—Five pairs of Little Terns (*Sterna albifrons*) attempted to nest on Saipan, Commonwealth of the Northern Mariana Islands (CNMI) in May and June 1997. Nesting was observed again in 2002–2005. No young were recorded for either period. The only other recorded attempts were in 1988 and 1989. Two damaged eggs collected in 1997 had traces of contaminants 4-4'-DDE and PCB 1260, but at levels well below what is believed to affect reproductive success. We hypothesize that poor choice of nesting substrate due to limited nesting habitat was a limiting factor in the failure of all nesting. We designed and tested modifications that may help future nesting attempts to succeed.

Introduction

The Asian subspecies of Little Tern, *Sterna albifrons sinensis,* has a breeding range that covers the Pacific Rim countries including Japan, Philippines, and Indonesia. It is known that a population of *S. a. sinensis* migrates between mainland Asia including Japan, south to Australia (NSW National Parks & Wildlife Service 2003). Although not globally threatened, local populations in many countries are declining and the tern is often listed under a special management status. Conflicting uses with humans over beach habitat appear to be one of the main causes of decline (del Hoyo et al. 1996, Europa 2002).

Little Terns are not known to regularly breed in Micronesia or Polynesia although Pratt et al. (1987) list the little tern as an uncommon migrant and winter resident for Micronesia. The first nesting in Micronesia was recorded from Saipan, Commonwealth of the Northern Mariana Islands (CNMI) in June 1988 and again in April 1989 within the Saipan lagoon area. No young were observed and it is believed that the nests failed (Reichel et al. 1989). The status of little terns on Saipan during 1989-1996 is unknown because no monitoring or sightings are documented.

Little Terns were again found nesting on Saipan in 1997. Upon closer inspection of some eggs, cracks were observed in the shell. A potential cause of eggshell failure is related to elevated concentrations of DDE or other organochlorines. High levels of PCB's have been detected in the area (US Army Corps 2001) and DDT was liberally applied to most of Saipan in the late 1940's for mosquito control (US Army 1963) and probably up until 1970. In this report we describe nesting attempts from 1997–2004, present pesticide analysis of failed eggs, and suggest a cause for nesting failure.

Study Area

Saipan (15º13'N, 145º44'E) is the largest and most populous of the fourteen islands that form the Commonwealth of the Northern Mariana Islands. The west side of Saipan is characterized by a fringing reef that contains the largest lagoon (35 km^2) in the Mariana Archipelago (Amesbury et al. 1979). The lagoon averages 100 m in width, but extends to almost 3 km and is about 9 km in length. The depth of the lagoon reaches a maximum of 14 m in the Tanapag Harbor Channel, although the average is less than 3 m deep. Most of the shoreline within this reef is now developed for commercial industry, residential housing, or tourism. Lower Base, which lies in the center, is part of the former military harbor and seaplane complex. Today it functions as the commercial port area that includes a waste-oil burning electrical power plant and a former garbage dump.

Within the waters next to the power plant are found remnants of floating piers and barges dating from 1945. Terns were found nesting on two of these rusting barges, about 200 m north of the power plant. These structures are constructed of steel and are heavily rusted and eroded with very little of the decking left. They measure roughly 20m x 20 m and are located side by side in about 1 m of water approximately 50 m and 70 m from shore. During high tide a little less than 1 m of the barges remains above water, although the surface can be inundated during storm conditions.

Methods

Observations

On 27 April 1997 a group of little terns were observed using the derelict barges. Periodic observations (about 20 minutes each visit) were made daily from shore with the aid of 8–10 power binoculars. Trips were made to the barges to check for eggs on 9 & 10 May, 3 June, 23 June, 19 July, and 7 August 1997. Locations and clutch size of nests were recorded. Observations stopped 7 August 1997 after it appeared the terns were no longer actively nesting. The location of nests in observed 1988 & 1989 (Reichel et al. 1989) were also visited in 1997 to determine occupancy.

In the following years the site was visited only once per year to determine occupancy. This was due to a lack of observers on island. The Lower Base nesting area was visited once during June 1998, June 1999, June 2000, June 2002, May 2003, May 2004, and June 2005. Nesting sites recorded by Reichel et al. (1989) were not visited during those years.

Analysis of Eggs

The two damaged eggs collected were sent to the California Department of Fish and Game (CDFG)–Pesticide Investigations Unit in Rancho Cordova, California USA, to determine if chemical contamination was present and could be considered a contributing cause for the apparent hatching failure.

Length and width of the eggs were measured using dial-gauge calipers with an accuracy of ± 0.05 mm. Submerging the individual eggs and measuring the mass of displaced water to within 0.1 grams determined egg volume.

Eggs were opened by removing a disc of eggshell from the air-cell end of the egg. The contents were removed from the egg and placed in chemically clean glass jars with Teflon lined lids. The contents were then frozen at -20º C until analysis. Egg contents were dried and macerated with anhydrous granular sodium sulfate and extracted with petroleum ether. An aliquot was eluted through a florisil column with 200 mL of petroleum ether, followed by 200 mL of 6 percent diethyl ether in petroleum ether, and finally 200 mL of 15 percent diethyl ether in petroleum ether. The eluates were concentrated to 10 mL and analyzed by gas chromatography using a Varian® model 3600 gas chromatograph with dual ECD detectors and a 30 meter DB-1 capillary column and a 30 meter DB-17 capillary column. Detected organochlorine residues were reported as parts per billion (ppb) fresh weight. Concentrations of organochlorine compounds identified during analysis were corrected to a fresh egg weight basis using the methods described in Stickel et al. (1973).

Empty eggshells were triple rinsed with distilled water and allowed to air dry for at least four months. After drying, shell thickness was measured at numerous points along the equator of each egg to within 0.001 mm, using a Starrett® digital, bench-mounted micrometer. A mean thickness was calculated for each egg and was used in all subsequent evaluations of shell thickness. All shell fragments and membranes from each egg were weighed on an electronic balance accurate to within 0.001 grams.

We were unable to locate any pre-1945 egg sets for this species. Pre-1945 sets represent base-line data before DDT came into common use as an insecticide. Summary measurement data of pre-1945 California Least Tern *Sterna antillarum* eggs and individual shell measurement data for Little Tern eggs collected from Japan in 1949 and 1956 were supplied by the Western Foundation for Vertebrate Zoology (WFVZ).

Results

Observations

On 28 April 1997, a group of 12–15 Little Terns was observed at Lower Base on derelict barges. On 9 May 1997 a trip to the barges revealed four active nests with a total of ten eggs. One nest was located on the inshore barge, while the three remaining nests were on the outer barge. Nests consisted of no nesting material but were simply eggs laid on the rusting metal where some of the original barge decking remained. On a return trip to photograph the nests on 10 May, two of three eggs in one nest were discolored from spoilage of the contents and the shells were indented and cracked. These two were collected for analysis.

The barges were observed periodically to record hatching success, but no obvious fledgling or juvenile activity was recorded. A return visit on 3 June 1997 found only two nests with eggs on the outer barge. One of these was in a new location and appeared to be different clutches. On 23 June 1997 an increase in adult activity was noted and a visit revealed five nests with a total of 12 eggs (Table 1). All five nests were in a tight grouping on one side of the outer barge, unlike the previous nests that had been scattered. No young were observed. A visit on 19 July 1997 found no eggs, no young, and observed no display of parental defensive behavior. During the first week of August, twelve adults observed roosting on the barges flew off upon approach without displaying defensive behavior. It was then assumed that nesting had ceased and shore observations were discontinued.

No terns were observed at the barges during one-day visits at the end of June 1998, 1999, and 2000. On 5 June 2002, terns were again present, with two pairs nesting. One nest was observed on the inner barge and one on the outer barge. A maximum of six adults were observed at one time. An investigator who visited the barges in mid-June found eggs and egg shells which appeared "cooked" (N. Johnson pers. comm.). No fledglings were observed and it is believed that no hatching occurred. In May 2003, May 2004 and in June 2005 terns were present at the barges. It appeared on all occasions that two pairs were nesting on the outer barge. It is unknown if they were successful.

Table 1. Nesting sequence and location for the Little Tern, *Sterna albifrons*, at Lower Base, Saipan, 1997

Nest #	Location	9 May	3 June	23 June	19 July
1	Inner barge	2 eggs	none		
2	Outer Barge	2 eggs	none		
3	Outer Barge	3 eggs	none		
4	Outer Barge	3 eggs	3 eggs	none	
5	Outer Barge		2 eggs	2 eggs	none
6	Outer Barge			2 eggs	none
7	Outer Barge			2 eggs	none
8	Outer Barge			3 eggs	none
9	Outer Barge			3 eggs	none

Table 2. Mean Eggshell Thickness and Chlorinated Hydrocarbon Contaminant Concentrations (fresh weight) for Eggs of the Little Tern, *Sterna albifrons,* Saipan, 1997.

Little Tern Eggs	4-4'-DDE (ppb)	PCB 1260 (ppb)	Mean Shell Thickness (mm)
1	15.84	306	0.159
2	12.35	228	0.157

EGG ANALYSIS

The contents of both eggs collected in 1997 were partially dried. One egg contained a fully developed and feathered chick. The other egg did not appear to have a developing embryo. Only 4,4?-DDE and PCB 1260 residues were isolated from the contents of the eggs (Table 1).

The shell thickness (Table 2) for the two eggs was within the normal range for this species and fell within the range for both, Little Tern eggs collected from Japan between 1949 and 1958 (0.126-0.162 mm), and the pre-1945 California Least Tern eggs (0.122-0.163 mm).

Discussion

From the observations made in 1997 a timeline of Little Tern nesting activities for Saipan can be made. By late April the terns had chosen the Lower Base barges as a nesting site.

In early May a first clutch had occurred with a minimum of four pairs. It appears one or more renestings or possibly new nestings had taken place by early June. In mid to late June a second wave of nesting by the entire group (minimum four pairs) was attempted in what is assumed to be a second clutch. By mid-July nesting had ceased and the season had ended. We believe that no young were hatched from the nests during 1997. This is based on no observations of young, no fledgling feed behavior, and no juveniles observed in August. Because of the continued presence of this species over several years, it is reasonable to believe that limited nesting could occur at other locations on Saipan or elsewhere in the Mariana Islands, although this species has not been recorded on islands in the chain.

The 1997 nest observations fall within the tropical nesting ranges of May–August given for Little Terns (del Hoyo et al. 1996) and coincide with the two peaks of egg laying observed in Korea during May and June (Hong et al 1998). In both Little Tern and the similar Least Tern there is a well-documented second wave of nesting (Massey & Atwood 1981, NSW National Parks and Wildlife Service 2003). Massey & Fancher (1989) describe renesting after the loss of eggs or chicks by the Least Tern and similar patterns have been noted for the Little Tern (NSW National Parks and Wildlife Service 2003). Least Terns have been known to renest up to three times in a season and have a laying interval of 4-16 days between losses of eggs (Massey & Fancher 1989). The incubation period averages 21 days for Least Terns (Baicich & Harrison 1997) and 20 days for the Little Terns (Hong et al. 1998). Chicks leave the nest within 24 hours, although fledging is about another 17-19 days (NSW National Parks and Wildlife Service 2003). Least tern parents feed chicks up to eight weeks (Thompson et al 1997).

We initially thought that chemical contamination was responsible for nesting failure, based on the observed condition of the two eggs collected and the knowledge that high levels of chemical pollutants exist in the Lower Base area (US Army Corps 2001). Though the concentrations of 4,4?-DDE in the Saipan eggs were within the range reported by Goutner et al. (1997) for Little Tern eggs in Greece, the mean concentration was higher (14.06 ppb vs. 2.79 ppb). The concentrations of both compounds were orders of magnitude below concentrations reported by Hothem and Zador (1995) for eggs of Least Terns collected from San Diego Bay, California between 1981 and 1987 (14.06 ppb vs. 936 ppb for 4,4? DDE and 267 ppb vs. 1,220 ppb for PCBs). The mean concentration of 4,4'-DDE in this study was below the "no reproductive impact" levels reported by Blus and Prouty (1979) for Least Terns from South Carolina (.063 ppm in 1972 and .033 ppm in 1975). Therefore we discounted contamination as a likely factor in nest failure.

We propose that the metal substrate the birds chose might have been too hot for successful incubation and "cooked" the eggs. Beach habitat on Saipan is extremely limited and the barges provided surface area and security from terrestrial predators. Least terns and other small terns nest in some extremely hot environments and have a variety of behavioral techniques, such as belly soaking and shading, for keeping their eggs at temperatures below those lethal for the embryo (Tompkins 1942, Grant 1982, Jackson 1994). In this case however, the birds may not have been able to cope with the thermal conducting properties of the metal decking. This has been shown to be a problem with Least Terns nesting on roof tops where high substrate temperatures have been noted to injure chicks (Jackson 1994). The temperature on the barges was not recorded, but a hand could not be held on the metal without causing burns. Other factors that weren't observed but could have played a role in nest failure include; high winds or water removing the eggs from the barges, or predation by reef herons, kingfishers, or humans.

Conservation Recommendations

To enhance the nesting habitat of this species on Saipan, we modified the barge top in late April 2003. As Little Terns are known to readily accept artificial islands (NSW National Parks and Wildlife Service 2003), two wooden boxes, 2 m x 1.2 m x 0.1 m were wired to the outer barge and filled with white beach sand. The next day each box had one tern sitting in it, apparently nesting. They were checked again one week latter and were found to still be in use by the terns. Unfortunately monitoring could not be maintained, and it is not known if these nesting attempts were successful. In April 2004, only one box remained (the other was lost in a storm) and weeds had grown up in it. The weeds were left in place and two pair observed to be nesting on the barges did not use the box. It has been observed that adults will abandon nest sites that have become too overgrown (NSW National Parks and Wildlife Service 2003). We recommend that nesting platforms be placed in March or early April just prior to the nesting season with sand in the boxes almost level with the top of the sides and free of weeds. Observations should be made only from shore and no visits to the barges be made during the nesting season. Any disturbance to the adults while nesting could expose the eggs to dangerous temperatures. A long-term solution to this problem might be solved by future harbor dredging operations with the spillage dredged up diverted to these rusting barges to form sand islands.

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