USE OF A NESTING PLATFORM BY GULL-BILLED TERNS AND BLACK SKIMMERS AT THE SALTON SEA, CALIFORNIA

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ABSTRACT: In 2006, we constructed an elevated nesting platform at the Salton Sea, California, and monitored its use by Gull-billed Terns and Black Skimmers over three subsequent breeding seasons. Black Skimmers were the first to colonize the platform with a total of five nests in 2006. In 2007 Gull-billed Terns colonized the platform with a total of 28 nests and the number of Black Skimmer nests increased to 20. Neither species nested on the platform in 2008. Low success for both species was probably influenced by at least two factors. First, when both species nested on the platform, nest densities were higher than is typical of their colonies on larger, earthen islands, and colony success may have been reduced by overcrowding. Second, lack of access to water may have reduced chicks' ability to thermoregulate effectively in the hot environment of the Salton Sea. Refinements to the size, design, and location of artificial nesting habitats are necessary to enhance productivity of colonial ground-nesting birds at the Salton Sea successfully.

Artificial or constructed nesting habitats have often been employed to increase the number of suitable breeding sites for ground-nesting colonial birds such as terns (Lampman et al. 1996, Quinn and Sirdevan 1998, Spear et al 2007, Jenniges and Plettner 2008). Such artificial nesting habitats have been provided to (1) accommodate the growth of newly colonizing populations, (2) enhance reproductive success, (3) create novel sites that are relatively free of predators or that reduce competition for space with more aggressive species (such as gulls; Molina 2004), and (4) augment the number of alternative sites when the suitability of existing natural habitats declines with the encroachment of vegetation or when the protective isolation of islands diminishes as lake levels fall. Constructed habitats are typically located in lakes, impoundments, or other shallow and protected waters. These nesting habitats often take the more traditional form of sand, rock, and earthen islands (usually formed with bottom sediments). Floating platforms such as rafts (Dunlop et al. 1991, Lampman et al. 1996) also have been used when the deposition of dredged sediments is infeasible. When natural nesting sites are limited, rafts and barges have been used to promote the colonization of alternative nesting habitats when land-use conflicts arise and colony relocation is desired (Collis et al. 2002). In some cases breeding larids have spontaneously (i.e., without the aid of audio-visual attractants such as decoys or call broadcasters) colonized the surfaces of existing floating or fixed platforms such as moored barges (Molina pers. obs.), the surfaces of navigational buoys (Karwowski et al. 1995), or even the flat gravel roof tops of buildings (Fisk 1975, Coburn et al. 1997).

The Salton Sea is the largest terminal lake in California; this highly dynamic and productive saline ecosystem lies below sea level and lacks an outlet. Over the past decade, Gull-billed Terns (*Gelochelidon nilotica*) and Black Skimmers (*Rynchops niger*) breeding at the Salton Sea have experienced the loss of isolated nesting sites (islands) with declines in water level (Molina 2004). Since 2001, the continued decline of water levels has resulted in additional losses of the traditional nesting islands of Obsidian Butte, Morton Bay, and Elmore Desert Ranch by increasing mammalian predators' access to these sites and further intensifying waterbirds' demand for undisturbed nesting and resting sites (Molina 2004, 2007).

There is no precedent in California for breeding Gull-billed Terns and Black Skimmers nesting on habitats other than earth- or gravel-based islands (Molina 2008a, b) or rafts that mimic islands (Molina 2007). However, Gull-billed Terns (Molina and Erwin 2006), Least Terns (*Sternula antillarum*; Krogh and Schweitzer 1999), and Black Skimmers (Coburn et al. 1997) have spontaneously colonized elevated sites such as flat gravel roofs in coastal Louisiana and Florida. Given the propensity of larids in general to use artificial sites in other parts of North America, in 2006 we constructed a fixed and elevated platform at the south end of the Salton Sea to address the decline in the number of suitable colony sites and to enhance nesting for the Gull-billed Tern and its close nesting associate, the Black Skimmer. In this paper we report the number of breeding pairs, nest attempts, and young of Gull-billed Terns and Black Skimmers on this novel habitat and summarize the phenology of its use in 2006, 2007, and 2008. We also discuss the disadvantages and potential refinements of artificial nesting habitats at the Salton Sea.

METHODS

In April 2006, United States Geological Survey personnel in cooperation with the U. S. Fish and Wildlife Service constructed an elevated platform at the southeast end of the Salton Sea approximately 400 meters north of the northern seawall boundary of the Sonny Bono Salton Sea National Wildlife Refuge (Figure 1). Our criteria for the platform's location were that it be (1) placed on refuge property, (2) sufficiently isolated by water over a period of years to deter access by mammalian predators, (3) observable from a distance to minimize disturbance to nesting birds, and (4) in close proximity to traditionally active colony sites such as the islands within one of the refuge's impoundments (D pond) adjacent to the northern seawall. The wooden platform measured 4.9 × 7.3 m with approximately 35 m^2 of potential nesting area (Figure 2). The platform was supported by twelve 10 cm × 10 cm × 3.7 m posts driven about 1.5 m into the sediment, with the deck, consisting of ¾-inch tongue-and-groove plywood, placed approximately 1.2 m above the water's surface. The average elevation of the Salton Sea in April 2006 was –69.2 m (–227 ft), decreasing to –69.4 m (–227.8 ft) in April 2008 (Imperial Irrigation District); water depth at this location during the study was about 1 m. The deck was covered with a layer of about 2.5 cm of mixed sand and gravel which was then covered with a 10-cm layer of crushed barnacles collected from the Salton Sea's shoreline. Three plywood

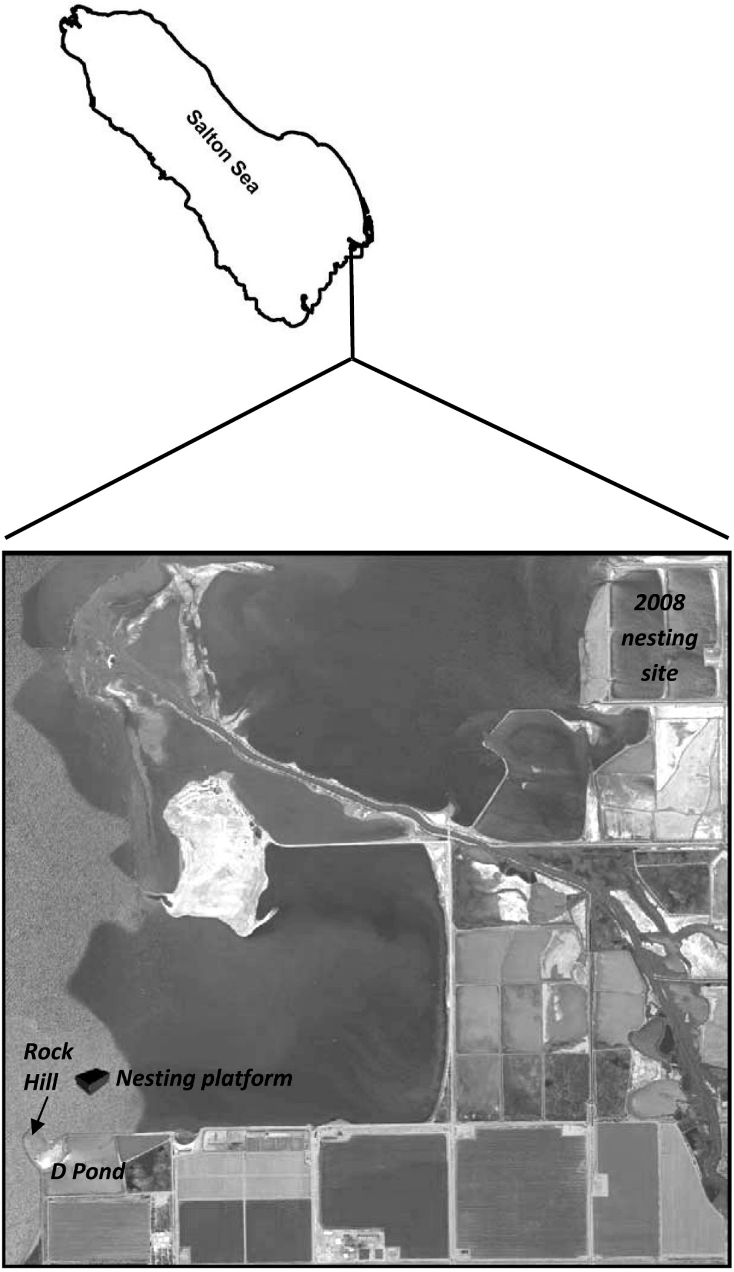

Figure 1. Geographical location of the study area and nesting platform.

Figure 2. Nesting platform at completion and close up of nesting substrate. Note solar panel at upper center and Gull-billed Tern decoys at left.

Photos by Mark Ricca

ramps measuring 3.6 × 1.2 m and extending below the water's surface were attached to the north, south, and east ends of the deck to facilitate the return of nonvolant young to the deck. The platform was equipped with visual and audio attractants in the form of 20 Gull-billed Tern decoys (Mad River Decoys, Waitsfield, VT) and a solar-powered sound system (MurreMaid, Bremen, ME) to continuously broadcast the Gull-billed Tern's vocalizations (Kress 1983). A motion-activated camera was initially installed but removed in mid-May 2006 along with ten decoys to increase the amount of potential nesting area. The solar-powered sound system was inoperable in 2007 and removed from the platform prior to the 2008 breeding season. All of the re-entry ramps were damaged or destroyed during high winds in April 2006, and subsequent attempts at repair and redesign were unsuccessful.

We monitored the presence or absence of terns and skimmers sitting or standing on the platform from at least early April through August of each year at roughly weekly intervals. In 2006 multiple censuses were made in most weeks, but there were gaps in observations of up to 14 days in July and August. In 2007 and 2008, we censused the platform at least every other week, often more frequently. Less regular observations continued into mid-October in 2006 and mid-September in 2007 and 2008. Because of larids' semi-precocial nature and sensitivity to disturbance, studies of birds nesting on rafts or elevated sites such as roof tops and our platform confront inherent difficulties because disturbance by investigators often reduces a colony's success (e.g., Krogh and Schweitzer 1999). Therefore, we observed from elevated locations from either the overlook at Rock Hill (about 500 m southwest of the platform) or from the refuge's northern seawall boundary (Figure 1). Our observations were distributed throughout the daylight period. The duration of observations ranged from 15 to 30 minutes, and for each observation we recorded the peak number of adult Gull-billed Terns and Black Skimmers on the platform as well as the platform's use by other species. We briefly visited the platform once or twice each season to confirm the number of suspected nests. To minimize the potential of older chicks being flushed from the platform, our first visit of the season was timed to precede expected hatching. When feathered young were not observed when expected, we made a second visit to confirm their absence. We did not uniquely mark individual birds or systematically monitor fates of individual nests, which precluded distinguishing renesting attempts from those of new pairs or robustly estimating nesting and fledging success. Instead, we report (1) the frequency of platform use by both species over time and (2) the peak numbers of active nest attempts and observed young on any single observation to estimate nesting use and reproductive success. Because in both species both male and female invest heavily in incubation and chick-rearing duties, and pairs raise only one brood per season, we assumed that the peak number of nest attempts accurately reflected a minimum number of nesting pairs for the platform.

RESULTS

Peak Numbers and Phenology of Platform Use

In 2006, the platform's first year, we observed only one adult Gull-billed Tern briefly in early April (Figure 3). In contrast, Black Skimmers were on the platform continuously from 17 June to 13 October with an average of 9 adults present (SD = 3, n = 14 observations). In any single day's observation, the maximum number of adults was 14 on 24 June (Figure 3). Four skimmer nests were first noted on 5 July, although exact initiation dates were unknown. A fifth nest was established by mid-September, inferred from the presence of four small downy young on 13 October.

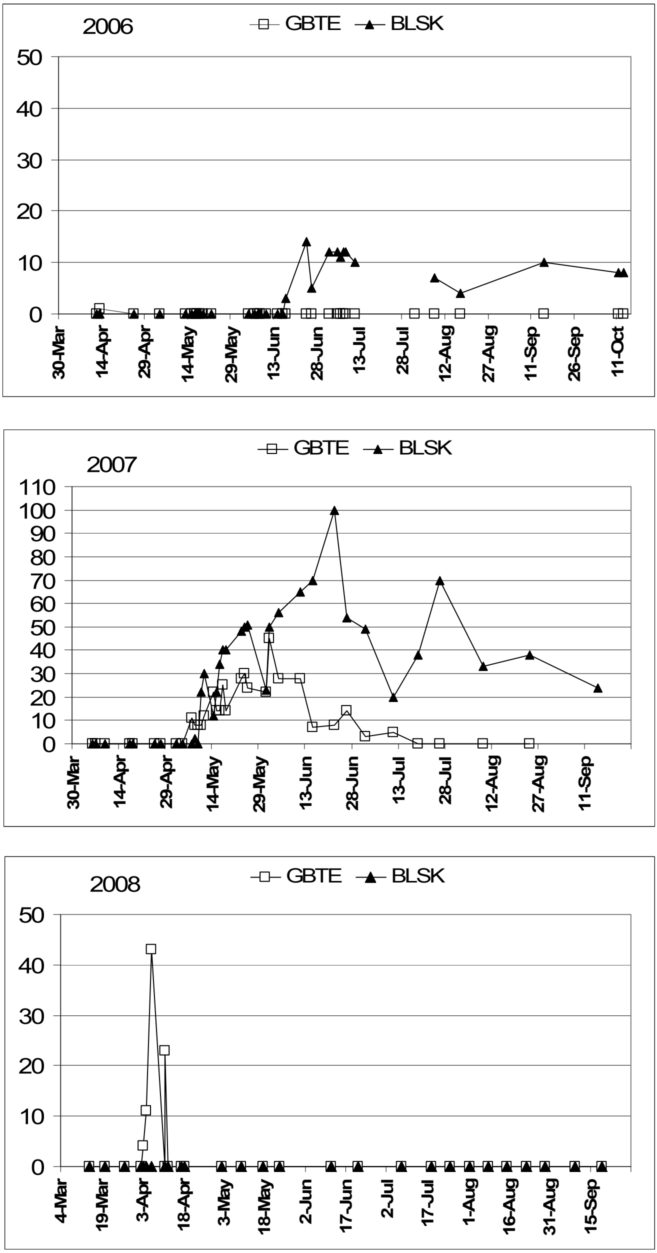

Figure 3. Phenology of platform use in 2006, 2007, and 2008 by Gull-billed Terns and Black Skimmers. Data reported are the peak numbers of adults present.

In 2007, Gull-billed Terns increased interest in the platform with an average of 17.2 (SD = 11, n = 22 observations) adults present per visit from 7 May through 11 July (Figure 3). The maximum number of adult terns was 45 on 1 June. The first Gull-billed Tern nests were established between 4 and 7 May. However, by 15 June the number of adult terns present on the platform declined to seven. Over the next 10 days, when young should have been approaching fledging age and colony activity (adults attending and feeding chicks) should have been at its peak, the number of adults on the platform remained low (Figure 3). In contrast, Black Skimmers were continuously present from 10 May to 24 August (mean number and SD = 44 ± 20 adults, n = 23 observations). In 2007 the maximum number of adults on the platform was 100 on 24 June (Figure 3) and nests were first established between 24 May and 1 June.

In 2008, Gull-billed Terns were noted on the platform in early April (Figure 3), but use was brief and limited to the period around dusk. A maximum of 43 terns was present on the platform between 3 and 11 April. The terns were always absent on return visits at first light on the following mornings. Black Skimmers were never noted to land on the platform in 2008 (Figure 3).

Other species that occasionally rested on the platform when it was unoccupied by terns and skimmers were two Black-necked Stilts (*Himantopus mexicanus*), two Great Blue Herons (*Ardea herodias*), several Double-crested Cormorants (*Phalacrocorax auritus*), mainly on the platform's underlying cross beams, and, in 2008 only, as many as 26 Brown Pelicans (*Pelecanus occidentalis*).

Nesting Activity

The platform was used for nesting in two of the three years of our study by at least one of the two target species. In the first season of its availability (2006), the Black Skimmer was the only species to nest on the platform, establishing at least five nests. The number of active nests peaked at four (0.11 nests/m^2) on 5 July. The peak number of five young was observed on 13 October; their size and development ranged from one nearly fledged chick to four small, downy chicks. In 2007, Gull-billed Terns colonized the platform with a total of 28 nests. A maximum of three tern chicks, all small and downy, was observed between 1 and 15 June, but no young or eggs were present on a visit on 3 July. In 2007, the number of nest attempts by Black Skimmers also increased from the previous year. The number of active skimmer nests peaked at 11 (0.31 nests/m^2) on 27 July. A maximum of eight young (four large and feathered, four small and downy) was observed on 27 July. The number of active tern and skimmer nests taken together peaked at 32 (0.9 nests/m^2) on 1 June. In 2008 neither species nested on the platform.

DISCUSSION

Black Skimmers immediately colonized the nesting platform in 2006 with at least four pairs (representing <1% of the Salton Sea's breeding population in that year) and increased to 20 pairs in 2007 (representing ~7% of the annual population). In contrast, at least 28 pairs of Gull-billed Terns (representing nearly 22% of the annual breeding population) initiated nesting on the platform in 2007. The lack of nesting by either species on the platform in 2008 may have been due to the proximity of a Great Horned Owl (*Bubo virginianus*) nest, active from early May through June, at Rock Hill. This owl is known to disrupt nesting colonies of Common (*Sterna hirundo*) and Least Terns in Maryland (Erwin et al. 2007). Gull-billed Terns and Black Skimmers colonized other breeding sites at the Salton Sea in 2008: terns nested on earthen islands (available since 2006) in a series of impoundments about 3 km to the east of the platform, and late that season skimmers nested on a small, newly available raft in the adjacent D pond (Figure 1). Terns also nested on a natural islet about 2.7 km to the southwest of the platform, a site where the species has nested occasionally since 1992 (Molina 2004). At the Salton Sea, Gull-billed Terns typically initiate nesting between late April and early May and Black Skimmers generally do so between late May and early June (Molina unpubl. data). In the year that each species colonized the platform, 2006 for the skimmer and 2007 for the tern, the timing of nest initiations on the platform was later than at other sites used in those years, suggesting the platform was less attractive than other sites and used by pairs whose earlier attempts had failed or by late nesters that could not find space elsewhere.

The ratio of young to nest attempts, which may be a useful indicator of colony success, was low for both species, particularly the tern. In 2007, the number of adult Gull-billed Terns diminished rapidly at a time when chicks near fledging age and a corresponding high level of nest-site attendance by adults were expected (Figure 3). These observations, accompanied by adult terns' delivering food to the platform infrequently, all indicated poor colony success. The causes of the low success for both species are conjectural. The concomitant increase in the larger, more aggressive skimmer at a vulnerable period (hatching) for the tern may have caused nest failure, chick deaths, and early abandonment of the site. Other factors possibly contributing to low colony success were (1) the platform's size potentially constraining nest densities above the optimum and (2) its unprotected location with respect to wind-driven waves on the surface of the Salton Sea coupled with the region's harsh environment.

Few studies of raft- or barge-nesting larids have specifically addressed the causes of mortality of young terns on these artificial sites. In a comparison of the relative proportions of Common Terns banded as fledglings in Britain and subsequently resighted in Africa, Norman (1987) found terns nesting on elevated platforms to be marginally more successful than those breeding at other sites, concluding that the main benefit of the platform was its inaccessibility to mammalian predators. Studies of raft-nesting Caspian and Common terns on Lake Ontario noted dead juveniles washed up on the mainland shore (Lampman et al. 1996), suggesting that some missing chicks, after falling into the water, were unable to navigate the ramps and return to the raft (Dunlop et al. 1991). We routinely searched along the northern seawall, the closest point on the shore and downwind from prevailing winds, for dead or live chicks displaced from the platform but never encountered any.

Nearest-neighbor distances of Gull-billed Tern nests on constructed islands at the Salton Sea are highly variable, ranging from 0.8 to 3.85 m (mean = 2.32, SD = 1.1, n = 14; Molina unpubl. data), but within the range of 0.3–20 m reported by Gochfeld and Burger (1996). Although we did not measure nearest-neighbor distances for nests on the platform, the density of concurrent tern and skimmer nests on it in 2007 (maximum = 0.9 nests/m^2) was greater than the average density of 0.09 nests/m^2 (SD = 0.06, n = 9 colony sites) for Gull-billed Tern nests on constructed islands in 1999 and 2001 (Molina unpubl. data). The nesting asynchrony of Gull-billed Terns and Black Skimmers that often promotes a degree of temporal separation at shared colony sites at the Salton Sea (Molina unpubl. data) was not observed on the platform in 2007; nest densities and the likely nearest-neighbor distances we observed for terns and skimmers combined may have exceeded the Gull-billed Tern's levels of tolerance and suggests that the platform's area may have been insufficient to support the typically sized colonies of 30–50 pairs for both species (Molina and Erwin 2006, Gochfeld and Burger 1994).

In this unprotected location, our experimental platform was challenged immediately after construction by high wind-driven waves that briefly but completely swept the platform's deck. During successive periods of wind the platform's ramps were eventually washed away and a nonvolant chick's only means of return was eliminated. The loss of the ramps also prevented routine access to water by chicks and brooding adults for thermoregulation. At the Salton Sea, colonial birds that nest in exposed locations experience ambient temperatures that often exceed 42°C and corresponding high rates of insolation. Frequent foot and body soaking are important thermoregulatory behaviors for adult larids and their young in maintaining normal body temperature via evaporative cooling. These behaviors are also performed by incubating and brooding adults to maintain the eggs and nest at adequate temperature and humidity. Unrelieved heat stress may result in adults abandoning nests; chicks that lack access to water and constant brooding may die (Grant 1982, Molina pers. obs.).

Our platform's elevated design (Figure 2) more closely approximated the snags and trees in which herons and cormorants commonly nest at the Salton Sea (Molina and Sturm 2004) rather than the islands or rafts (which more closely mimic islands) typically used by larids. Such a design may be more appropriate for nesting by species with altricial or less precocial young and in regions where breeding adults and young are not exposed to high ambient temperatures that require birds have regular access to water for thermoregulation. Even if nesting larids do not use the platform in the future, the smaller-bodied terns and skimmers may still benefit if the platform attracts resting congregations of other large waterbirds, such as the White (*P. erythrorhynchos*) and Brown pelicans and Double-crested Cormorants, away from the terns' and skimmers' island nesting sites. In past years, resting flocks of these larger species have destroyed substantial numbers of tern and skimmer eggs by trampling them (Molina 2004, 2007).

More study is required for the size and design of constructed sites to be optimized for terns and skimmers in the region. We did find that audio attractants appeared unnecessary for colonization. Although artificial nesting substrates such as rafts and islands are usually installed in protected waters

(Dunlop et al. 1991, Lampman et al. 1996, Molina 2007), our placement of the nesting platform was constrained by logistical and environmental considerations, including a paucity of such protected impoundments and a fluctuating sea-surface elevation and shoreline. If at the Salton Sea platforms can be successfully adapted to mimic islands more closely, that is, to maintain a degree of direct connectivity between the deck's surface and surrounding water (e.g., with permanent ramps or "skirts"), they will most certainly require placement in protected waters.

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