Survival of fallen and returned rooftop nesting Least Tern chicks

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ABSTRACT. Beach habitat is increasingly degraded and disturbed, and many species of Larids (gulls, terns, and skimmers) have adapted to nesting on gravel rooftops. In the southeastern United States, the most common rooftop nester is the Least Tern (Sternula antillarum), and rooftop tern colonies are generally as productive as beach colonies. One problem with rooftop nesting is that chicks often fall from the roofs and will likely die if not rescued. Fallen chicks can be taken to wildlife rehabilitators and if they survive, be released on their own, but they will not receive the substantial pre- and post-fledgling parental care that Least Tern parents provide. We explored the success of placing chicks back on rooftops until they fledge and are able to travel to a staging beach. To determine long-term survival of these birds, from June 2011- July 2019, we uniquely banded 168 fallen Least Tern chicks in the Tampa Bay, Florida (USA) region and placed them back on the rooftops. From 2011-2022, we resighted banded birds on beaches, piers, and rooftops throughout Florida during the breeding season. We used the Cormack-Jolly-Seber model in Program Mark to estimate survival of juveniles and adults. The base model, where time was held constant for apparent survival and of both age classes and recapture rates, was the most parsimonious. We resighted 50 out of the 167 banded adult Least Terns a total of 347 times from 2012-2021. Apparent survival for fallen juvenile Least Terns was 0.387 ± 0.049 and 0.819 ± 0.032 for adult terns. There are no other studies of survival for juvenile Least Terns, but a closely related species had a slightly higher apparent survival. Adult survival in our study was comparable to that found in other similar Least Tern studies. This indicates that putting fallen Least Tern chicks back onto rooftops is a sound management strategy and should be explored for other species of seabirds.

Survie d’oisillons de Petite Sterne nichant sur les toits, tombés et remis au nid

RÉSUMÉ. En tant qu’habitat, les plages sont de plus en plus dégradées et de nombreuses espèces de Laridés (goélands, mouettes, sternes et becs-en-ciseaux) se sont adaptées à la nidification sur les toits de gravier. Dans le sud-est des États-Unis, l’oiseau nicheur le plus commun sur les toits est la Petite Sterne (Sternula antillarum), et les colonies qui s’y établissent sont généralement aussi productives que celles qui sont établies sur les plages. L’un des problèmes de la nidification sur les toits est que les oisillons tombent souvent et risquent de mourir s’ils ne sont pas secourus. Les oisillons tombés peuvent être transportés à un centre de réhabilitation de la faune et, s’ils survivent, être relâchés, mais ils ne recevront pas les soins parentaux importants avant et après la nidification que les parents de Petite Sterne prodiguent. Nous avons étudié la possibilité de remettre sur les toits les poussins tombés jusqu’à ce qu’ils s’envolent et soient capables de se rendre sur une plage. De juin 2011 à juillet 2019, pour déterminer la survie à long terme de ces oiseaux, nous avons bagué individuellement 168 Petites Sternes tombées dans la région de la baie de Tampa, en Floride (États-Unis), et les avons remises sur les toits. De 2011 à 2022, nous avons revu les oiseaux bagués sur les plages, les jetées et les toits dans toute la Floride pendant la saison de reproduction. Nous avons utilisé le modèle de Cormack-Jolly-Seber du programme Mark pour estimer la survie des jeunes et des adultes. Le modèle de base, où le temps a été maintenu constant pour la survie apparente des deux classes d’âge et les taux de recapture, était le plus simple. Nous avons recapturé 50 des 167 sternes adultes baguées 347 fois entre 2012 et 2021. La survie apparente des jeunes sternes tombées était de 0,387 ± 0,049 et de 0,819 ± 0,032 pour les sternes adultes. Il n’y a pas d’autres études sur la survie des jeunes Petites Sternes, mais une espèce étroitement apparentée avait une survie apparente légèrement plus élevée. La survie des adultes obtenue dans notre étude était comparable à celle calculée dans d’autres études sur la Petite Sterne. Selon nos résultats, remettre sur les toits les oisillons tombés de Petite Sterne est une bonne stratégie de gestion qui devrait être examinée pour d’autres espèces d’oiseaux marins.

Key Words: banding; capture-recapture models; Least Tern; movements; roof-top nesting; Sternula antillarum; survival

INTRODUCTION

Many species of Larids (gulls, terns, and skimmers) nest on gravel rooftops, likely in response to loss of beach habitat and disturbances (Fisk 1978, Soldatini et al. 2008, Palestis 2014). One of the most common rooftop nesting species is the Least Tern (Sternula antillarum), a small, colonially nesting seabird that historically bred on open sandy beaches along the coast and large interior rivers in North America and then wintered in Central and South America (Thompson et al. 2020). In the southeastern United States, the most common rooftop nester is the Least Tern (Sternula antillarum), and rooftop tern colonies are generally as productive as beach colonies.
United States, rooftops and other elevated structures can provide critical habitat, supporting approximately half of the colonies (Jackson and Jackson 1985, Savereno and Murphy 1995, Krogh and Schweitzer 1999, Forys and Borboen-Abrams 2006).

Researchers have documented that rooftop colonies can be productive (Gore and Kinnison 1991, Butcher et al. 2007) and the same rooftops often support colonies for many years (Forys and Borboen-Abrams 2006). Rooftops have the advantage of fewer human disturbances and terrestrial predators, but many rooftops lack parapets and Least Tern chicks frequently fall (Krogh and Schweitzer 1999). Some building owners will allow fencing of the rooftop, however, immature terns learning to fly will often be able to fly off the rooftop, but not back to it.

Although some fallen chicks die upon impact, others survive the fall but die due to predation and vehicle impacts. Fallen chicks can be taken to wildlife rehabilitators and if they survive, be released on their own, however, Least Terns parents provide substantial pre- and post-fledgling parental care allowing young terns time to learn where to forage and how to capture prey (Thompson et al. 2020). An alternative is to place the Least Tern chick back on the roof, using either a ladder or other access to the roof, or with a long pole with a box at the end. If surviving fallen chicks are returned to the rooftop, it is possible parents would be able to recognize the chicks through their calls and resume parental care. Individual parental recognition of chicks through calls is documented in other species of terns (Stevenson et al. 1970, Shugart 1978). Ultimately, the question is whether these fallen chicks survive and are able to enter the breeding population. Least Terns are state listed as “threatened” in Florida due to a historical and anticipated, continued population decline (Florida Fish and Wildlife Conservation Commission 2013).

There is no published research on movement or survival of rooftop-fledged Least Terns or other tern species following their departure from the natal rooftop. Similarly, the conservation benefits of returning fallen chicks to rooftops is unknown. The objective of this study was to estimate the apparent survival of Least Terns chicks that fell off a rooftop and were returned to the roof using a long-term banding and resight study.

**METHODS**

**Field work**

We monitored gravel rooftops in the counties comprising the Tampa Bay region of southwestern Florida (Pasco, Pinellas, Hillsborough, Manatee, and Sarasota). Pinellas County has the most rooftop-nesting Least Terns in the southeastern United States (Forys and Borboen-Abrams 2006). At nearly all Least Tern rooftops, some fledging Least Terns were found on the ground because they got too close to an unprotected roof’s edge and fell or because they were able to fly horizontally off the rooftop but had not gained the strength to fly vertically back up to the roof. During the breeding season, we walked each parking lot 1–7 times/day looking for chicks that had fallen from the roof. From 2011–2019, when a healthy fallen chick was discovered, we measured its wing chord and if it was greater than or equal to 10 cm (a length we have associated with near fledging), we banded it with a numbered steel band and a unique combination of 3 Darvic color bands. We called a bird “healthy” if it was alert and able to walk and use its wings with no obvious injuries. The majority of chicks found were healthy. After banding the chicks, we either put the chick back on the rooftop through a trap door or from the ground by using a long pole with a box on the end. We also re-roofed younger chicks but did not give them a unique combination of four color bands due to the inadequate length of their tarsi, and they are not part of this survival study.

Banded Least Terns were resighted during and immediately after the breeding season both by official surveyors and the general public. Through the Florida Shorebird Alliance, all beaches and rooftops in Florida are surveyed at least every three weeks during the breeding season (Florida Fish and Wildlife Conservation Commission 2023). Immediately after the breeding season, but before migration, beaches that have historically supported large numbers of Least Terns were surveyed more frequently.

**Fig. 1.** Map of the Tampa Bay Region, showing the number and location of the rooftops where juvenile Least Terns (*Sternula antillarum*) fell, were banded, and were placed back on the roof.
Table 1. The number of juvenile Least Terns (Sternula antillarum) that fell off rooftops, were banded, and placed back on the roof in the Tampa Bay Region, by building and year (note: no chicks fell in 2016).

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**Statistical analysis**

We created annual capture histories for each uniquely banded individual and pooled all the rooftops together. If a bird was resighted any time during a breeding season (April–September), it was considered to be alive that year. We used open-population, live-encounter Cormack-Jolly-Seber (CJS) models (Lebreton et al. 2009) in program MARK (White and Burnham 1999) to estimate apparent annual survival \( \phi \) (probability of surviving from year \( t \) to year \( t + 1 \)) and recapture rate \( \rho \) (probability of detecting a bird that is alive).

Because juvenile (first year) and adult terns are widely recognized to survive at differing rates (Scheckler et al. 2019), our most general model included two age classes according to time since marking: one for the interval after the first encounter (banding as a pre-fledgling until the subsequent breeding season) and another for all subsequent breeding seasons, and recapture rate was constant. Hereafter, we will refer to the younger age class as “juveniles” and the older age class as “adults.” To ensure this approach worked, we tested model goodness-of-fit for our general model by using the median c-hat procedure implemented in program MARK, which is appropriate when the most general model is not fully time-dependent (Cooch and White 2019).

We ran five additional versions of the general model. We created a three-age-class model that separated juveniles, birds in their second year, and older birds. Previous research indicates that the majority of fledglings do not return to their natal breeding areas until they are at least two years of age and perhaps stay on their migratory grounds. These second-year birds may have a different survival rate than breeding age adults (Massey and Atwood 1981, Atwood 2023). For both the two- and three-age-class models, we ran additional versions, which altered the resighting variable, to see if the incorporation of time (year) or age classes improved the ability of the model to explain the data. All models were ranked by Akaike’s information criteria adjusted for small sample sizes (QAICc; Burnham and Anderson 2002). We estimated annual survival rates for each age class from the most parsimonious model.

**RESULTS**

From 2011–2019, 168 healthy Least Tern juveniles were found on the ground, uniquely banded, and placed back on the roof (Fig. 1). One was found dead on the roof at the end of the season and was removed from the analysis. Juveniles were banded from 16 different rooftops (Table 1), and the number of chicks banded at each building and each year varied greatly because Least Terns often switch buildings every few years and the rate of chicks falling is greatly influenced by the shape and size of the roof, the number of chicks, protective fencings, and other factors. The majority of juveniles were hatched on 8–10 m tall warehouses in industrial complexes. The most juveniles were banded in 2011 (60) and in 2016 no healthy juveniles fell from a rooftop (Table 1).

We resighted 50 out of the 167 banded adult Least Terns a total of 347 times from 2012–2022. Seven of the terns were resighted while nesting, 3 on beaches in Pinellas County, 1 on a beach 150 km to the north in Levy County, and 3 were at rooftop colonies in Pinellas County (Fig. 2). The remainder of the banded terns were resighted on beaches or other artificial structures such as piers, docks, and channel markers while not nesting. Over half of the resightings, both in terms of individuals resighted and number of resightings total, were from a single narrow causeway beach (Gandy) adjacent to a bridge that is centrally located in Tampa Bay. A large number of several species of terns aggregate here before and after the nesting season (Fig. 2). A boat dock in the waters between the barrier islands and the Pinellas peninsula had the second most resightings (24 total). Although most of the resightings were in the Tampa Bay region, we did resight an individual 220 km to the south at Marco Island.

The median c-hat value of our general model was close to 1 (\( \hat{c} = 1.025, \text{SE} = 0.01 \)) indicating little overdispersion. The results of the CJS analysis using Program Mark indicated that among the six versions of the model, the one that used the two age classes for both survival and recapture was the most parsimonious (Table 2). Apparent survival for juveniles was 0.387 ± 0.049 and 0.819 ± 0.032 for adults. The recapture rate for juveniles was 0.239 ± 0.056 and 0.483 ± 0.046 for adults.
Fig. 2. The resighting locations of 50 Least Terns (*Sternula antillarum*) adults banded as chicks on rooftops in Tampa Bay, Florida. Resightings were classified as either occurring while nesting (rooftop or beach colony) or staging (beach or man-made substrate such as a dock or channel marker). Over half of the resightings came from Gandy Beach.

**DISCUSSION**

This study demonstrates that Least Tern juveniles that have fallen from a rooftop and are placed back on the roof can survive, and their survival increased markedly after their first year. Although several studies have measured Least Tern survival of young chicks at the colony (Dugger et al. 2000, Brooks et al. 2013, Nefas et al. 2018), no other study of Least Terns has measured survival in the first year (from fledging until the next breeding season). However, several studies of closely related species (genus *Sternula*) exist and in comparison, the juvenile survival rates are higher than the survival found in our study (Table 3). Schekler et al. (2019) studied Little Terns (*Sternula albifrons*) nesting on an artificial island in Israel using statistical methods very similar to ours and had a slightly higher survival rate (0.49 ± 0.04). Other studies of Damara Terns (*Sternula balaenarum*) in Namibia (Braby et al. 2011) and Fairy Terns (*Sternula nereis*) in New Zealand (Ferreira et al. 2005) had rates that were higher than our survival and that of the Little Tern (Damara Tern 0.59 ± 0.11; Fairy Tern 0.63 ± 0.05). All these comparison studies are of terns nesting on beaches, so it is not known if the lower juvenile survival rate in our study is due to the impact of falling off the roof, the challenges of living on a rooftop, or factors related to the species or region. Birds could have moved away from our study area, but if they moved within the state of Florida, it is likely surveyors would have recorded their presence due to the extensive monitoring efforts for this state-threatened species.

Once they reached adulthood, the banded Least Terns in our study had survival rates very similar to the two other studies of Least Tern survival (Massey et al. 1992, Renken and Smith, 1995; Table 3). The adult survival rate was also very similar to studies for other members of the *Sternula* genus (Table 3). It makes sense for Least Terns and other long-lived species to have higher adult survival than juvenile survival. Any reduction in the survival of an adult would greatly reduce lifetime productive success (Weimerskirch et al. 2001).

Our results are important because it demonstrates that putting juveniles back on rooftops is a viable management tool for Least Terns and potentially other rooftop-nesting seabirds, and it may serve as the best current estimate we have for survival rates of adult Least Terns in Florida. It is interesting to note that the adult survival in our study is similar to adult survival in stable populations, but the number of nesting pairs and colonies is currently declining in the Tampa Bay region and throughout Florida (Florida Fish and Wildlife Conservation Commission 2013). This suggests that low productivity and/or juvenile survival is more likely the major cause of the decline than adult survival. Although rooftops may offer an alternative nesting habitat for Least Terns, juvenile survival may depend on habitat quality during the post-fledging period.

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This study also demonstrates the importance of beach habitat for rooftop nesting Least Terns, particularly after nesting is over, but before migration occurs. Although Gandy Beach is likely too narrow and disturbed by people and dogs for nesting, the majority of our uniquely banded Least Terns were seen on this beach, often with banded Least Terns from outside Florida, and with other species of seabirds (Fig. 2). Staging beaches like Gandy allow juvenile birds time to improve their flying and foraging techniques before migrating south (Trull et al. 1999). Gandy Beach and other low energy beaches in Tampa Bay provide access to calm, shallow waters with good visibility. Least Terns are surface plungers that search for small fish from above the water's surface (Eriksson 1985). Previous studies have found that Least Terns and other surface plungers are more successful in calm, less turbid waters (Eriksson 1985, Haney and Stone 1988).

Our research has implications for colonial nesting seabirds, a species group predicted to face some of the greatest threats from sea-level rise and disturbances from increased storm activity (Von Holle et al. 2019) as well as from continued increases in beach recreation disturbances. Although the number of gravel rooftops is declining due to energy-efficient alternative roof materials (DeVries and Forys 2004), the need for artificial nesting structures such as raised and floating platforms is increasing due to habitat loss (Spatz et al. 2023). Knowledge about how to manage seabirds on these artificial structures may be critical as part of an overall species conservation strategy.

Future research should focus on survival of rooftop-fledged seabirds and shorebirds of multiple species in comparison with the same species fledge from colonies on intact beach habitat. Additionally, identifying the cause of lower-than-expected juvenile survival rates (i.e., threats on the roof or threats upon leaving the roof) could inform conservation strategies at artificial nesting structures. If it could be safely done, it would be interesting to band chicks on the rooftop to see if the fall decreases their apparent survival or other factors. Further research could also be done to see if rehabilitated chicks can survive to adulthood, particularly for cases when it is not possible to return the chick to its rooftop.

Acknowledgments:
We thank J. Hood for inspiring us to pursue this project and for his assistance with banding. K. Cook, B. Jenks, S. Jenks, D. Kandz, L. Margeson, D. Margeson, W. Meehan, H. Short, and many others assisted with rescuing chicks and resighting banded birds. Additional logistical and outreach support was provided by St. Petersburg Audubon, Clearwater Audubon, Audubon Florida, and the Florida Shorebird Alliance.

Data Availability:
Data are available from the corresponding author (forysea@eckerd.edu).

LITERATURE CITED


