Grenadines Seabird Project

Seabird Nesting Productivity, Harvest, and Invasive Species

Report

Environmental Protection in the Caribbean (EPIC)

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Summary

Seabird colonies have been declining in the Grenadine islands but the causes remain uncertain. The goal of this study was to assess the influence of suspected causes on seabird nesting performances, namely human harvest and rat predation. This report documents preliminary findings from the field season conducted at five islands from 18 May to 6 August 2015. Six species nested on the monitored islands. More nesting attempts were recorded but hatching success estimated with nest survival models was also higher in 2015 (range = 0.18-0.71; N = 81 nests) than in 2014 (0.06-0.81; N = 44) for most species. Colony size could only be compared for Laughing Gulls and did not change between 2014 and 2015. Interviews, collected from 21 stakeholders, suggest that harvest is not as important to livelihoods as it used to be. Finally, despite anecdotal observations reported by residents, rats have not been detected on the monitored islands. These very preliminary analyses would suggest that other causes, such as habitat degradation or climate change, may be more impactful.

Background

The Grenadine islands harbor 5 Important Bird Areas (i.e., areas of regional and global importance for breeding colonies; Culzac-Wilson 2008). Yet Caribbean seabird populations have been declining, including in the Grenadine islands (Bradley and Norton 2009, Lowrie et al. 2012), and causes remain unknown. Environmental Protection in the Caribbean (EPIC) initiated a *Conservation of Key Marine Bird Habitat* program that aims to determine major threats to individual nesting colonies and implement community-based conservation actions. Suspected threats are human harvest and predation by introduced species (Collier 2014), such as rats, but may also include pollution, habitat degradation, and climate change (Lowrie et al. 2012).

The seabird breeding season coincides with the dry season, when food sources are more limited for terrestrial animals. Introduced species such as rats then switch to seabird eggs and chicks as an alternative food source (Caut et al. 2008). Because seabirds typically have a low reproductive output and delayed sexual maturity, additional mortality caused by introduced species have long-term negative impacts for the population. Other life history traits of most seabird species are their colonial nesting behavior and high fidelity to nesting sites. These traits make seabirds particularly vulnerable to catastrophic events, such as hurricanes and human harvest. Historically, seabirds were exploited for their eggs, feathers, and meat (Lyver 2000), resulting in population declines. Not as prevalent today, harvest remains a widespread, though illegal, activity that has the potential to jeopardize population viability (Fontaine et al. 2011). Surveys conducted by EPIC in the Grenadine islands accumulated evidence (e.g., piles of seabird carcasses, buckets of seabird eggs, burned vegetation) that fishermen and other recreationists collect and sell seabirds and their eggs (Lowrie et al. 2012). However, cultural and socioeconomic implications of harvesting are unknown.

The overall goal of this study is to determine the cause(s) of seabird decline in the Grenadines. Specifically, the objectives are to assess:

(1) The nesting success of five species of seabirds.
(2) The presence of invasive species (particularly rats) in breeding territories.
(3) Trends in seabird (adult, chicks, and eggs) harvest through interviews.

METHODS

Study Sites and Species

The interviews were administered in the main town of Sauteurs, Grenada, whereas fieldwork (seabird nest and predator nesting) occurred at five uninhabited islands within the maritime tri-island of the state territory of Grenada, namely Les Tantes 'north', Les Tantes 'east', Diamond Rock, Sandy, and The Sisters (Fig. 1).

Figure 1. Location of the study islands in the state territory of Grenada, Caribbean Sea. Adapted from Wikipedia map.

The Grenadines are oceanic islands that formed from the convergence of the subduction of the North American tectonic plate under the Caribbean plate. They represent 130 km^2 of land surface. Shorelines are generally irregular, blocked by shallow shelves and coral reefs. The Grenadines are exposed to northeast prevailing winds and temperatures average 24°C year-round. Islands experience seasonal drought and rainfall with average annual precipitation of 7-10 cm. Vegetation cover is dominated by seasonal deciduous plants with open canopies generally exceeding 6 m, including Indigoberry (*Randia aculeata*) and succulent herbaceous shrubs such as Sea Grape (*Coccoloba uvifera*), which grow on rocky substrate. None of the islands are inhabited, but they are visited by fishermen and other recreationists who sometimes set camps.

Les Tantes are characterized by sandy shores on the leeward face, with an igneous-rocky interior and slightly elevated grass plain on their windward face. Their northern side is cliff and boulder deposits. Diamond Rock's interior is mountainous with thick vegetation. Shores on its leeward face are cobbled, and cliffy boulder structures cover its windward face. Sandy's leeward face has long sandy shores and boulder structures on its windward face. Its interior is slightly hilly with a combination of grass plains and dense tree growth. It is uninhabited, but dilapidated structures indicate previous inhabitance. Finally, The Sisters consists of three islets connected by shallow reef structures. Its coast had a cliffy boulder structure with dense tree growth to the south. Northward on the island is a plateau characterized by shrubs.

These islands harbor nesting colonies of six seabird species: Bridled Tern (*Onychoprion anathetus mesonauta*), Brown Booby (*Sula sula sula*), Brown Noddy (*Anous stolidus*), Laughing Gull (*Leucophaeus atricilla*), Red-Billed Tropicbird (*Phaethon aethereus mesonauta*), and Red-Footed Booby (*Sula leucogaster leucogaster*). Their nesting strategies differ. For example, the Red-billed Tropicbird lays one egg in a nest built under boulders, whereas Laughing Gulls lay up to three eggs in shallow nests on the ground.

Bird Counts

Two independent observers identified and counted all birds, both incubating (pairs and apparently occupied nests) and loafing (after the hatching period on 6 August 2015), using binoculars and spotting scopes. Nesting pairs and apparently occupied nests were counted in parallel with breeding monitoring.

Slightly modified methods were employed when birds could not be easily detected due to topography (inaccessibility) and dense vegetative cover:

- Modified point counts: colonies were counted using binoculars and scopes from adjacent island (800-850 m away).
- In transit: birds were counted with binoculars while observers circled the island slowly 30 m offshore of an island. This method was used to count loafing individuals for all species but one (the Red-footed Booby), and counts from the two observers were then averaged for each species.

- Flush counts: individuals were counted (by plain sight) while they were in flight following disturbance. Breeding pairs may be estimated.
- Area searches: Using plain sight, chicks found outside nest were counted while on nest monitoring route.

Nesting Monitoring

Nests were monitored from 17 May 2015 to 14 July 2015 using standardized methods outlined in Haynes-Sutton et al. (2013). During the first week, we searched for nests at known nesting colony sites until confident all nests were found. Identified nests were marked with flagging and we recorded GPS coordinates and clutch size. All nests were then checked weekly for eggs or chicks. During each visit, which started around 0900, we searched for possible new nests.

For some species, monitoring procedures involved a required tactile search for eggs under the adult. Specifically, visual monitoring for Red-billed Tropicbirds was not possible as they nest in burrows (and other cliff cavities) and typically do not flush from the nest while incubating. To minimize stress, these nests were approached while making the tending adult fully aware of our presence.

We calculated an apparent nest success (i.e., simple observed proportion of successful nests) but also used the Mayfield method to estimate daily nest survival for each species. The latter approach accounts for nests that may have been missed or failed early. Knowing the species-specific duration of the incubation period, the daily nest survival was converted to a hatching success (i.e., nest for which at least one egg hatched). We could not estimate an overall nesting success because not all chicks could be followed to fledging.

Predator Presence Assessment

We recorded the presence/absence of potential predators by combining five methods. (1) A visual search for evidence of rodent scat and tracks was conducted at each site during each visit. (2) We deployed 10 corrugated plastic baited chew blocks (Fig.2) for one week on each island, using a stratified random sampling design to sample each microhabitat. (3) Three PVC tracking tunnels were also deployed, first at Sisters, Les Tantes, and Sandy (23-24 May 2015), then at Diamond on 9 June. Both types of traps only record presence of a species attracted to the bait, a mix of flour, coconut, and peanut butter in both cases. (4) A motion-activated night vision camera (Bushnell Trophy) was deployed about 3 m away from one of the PVC baited trap at Sandy (24-29 May) and at Sisters (23-30 June) to identify the species attracted to the traps. Finally, (5) interviews that were administered to local fishermen and recreationists using the islands included questions about their knowledge and observations of predators on the islands.

Interviews

Interviews were administered to fishermen and recreational users (i.e., campers) who are residents of Grenada and the Grenadines after the nest monitoring period, with the final response received by 15 September 2015. Participants were questioned about their interactions with seabirds (adult, chicks, and eggs), possible encounters with invasive predators within breeding territories, and their knowledge of breeding colony locations within the study sites. Consent was obtained from all participants through signature.

RESULTS

Bird Counts

Bird counts done at the end of the hatching period revealed that Diamond harbored the largest number of seabirds, but species-specific differences exist among islands (Table 1). However, it is important to note that some species have finished breeding, which may have resulted in a low number of observed individuals. For example, for the Laughing Gull (the only species monitored twice on Sisters and Sandy) just 40 individuals were counted on 6 August 2015 with the in-transit method, contrasting with 177 individuals counted on 14 July 2015, using flush counts. In 2014, counts were only done on 18 July (Table A1; Smart 2014), so counts between years are only comparable for Laughing Gulls on Sandy and Sisters islands. The number of Laughing Gulls did not significantly change since last year on either island (χ^2_1 = 3.06, P = 0.080).

Table 1. Seabird basic counts (mean ± SE) of individuals loafing, conducted on 6 August 2015, using the in-transit method.

	Diamond	Les Tantes	Sandy	Sisters	Total
Bridled Tern	11 ± 2	11 ± 1	1 ± 1	21 ± 5	43.5 ± 6.5
Brown Booby	52 ± 0	0	0	28 ± 2	80 ± 2
Brown Noddy	75 ± 7	14 ± 1	0	49 ± 16	137.5 ± 9.5
Laughing Gull	14 ± 2	5 ± 0	20 ± 2	20 ± 2	59 ± 6
Red-Billed Tropicbird	8 ± 7	0	0	2 ± 1	9 ± 7
Red-Footed Booby*	1 ± 1	605 ± 15	0	0	606 ± 16

*Counts were done using a modified point count.

Nesting Monitoring

Overall 81 nests were recorded across species and islands (Table 2), 28 of which hatched successfully. Too few nests were available to estimate nest success on each island for each species. Bridled Terns attempted fewer nests in 2015 (N = 5) than in 2014 (N = 13), but more Laughing Gulls and Red-Billed Tropicbirds nested in 2015 (Table 3) than in 2014 (Table A2). All islands combined, Laughing Gulls and Brown Boobies seemed to have the highest and lowest daily nest survival rate and hatching success, respectively, in 2015 (Table 3).

Table 2. Number of nests monitored per species and islands.

	The Sisters	Diamond	Les Tantes North	Les Tantes East	Sandy	Total
Bridled Tern	0	0	3	2	0	5
Brown Booby	3	1	0	0	0	4
Brown Noddy	1	0	5	0	0	6
Laughing Gull	30	0	0	0	33	63
Red-Billed Tropicbird	0	2	0	1	0	3

Table 3. Productivity of five seabird species monitored during 17 May – 14 July 2015. Clutch size is expressed as mean ± SE. DSR is the daily survival rate estimated with the nest survival model, and hatching success (HS) has been calculated using DSR and the duration of the incubation period.

	# Nests	Clutch Size	# Hatched	Apparent HS (%)	Incubation (Days)	DSR (95% CI)	HS (95% CI)
Bridled Tern	5	1	2	0.20	29	0.979 (0.959 : 0.999)	0.543 (0.297 : 0.982)
Brown Booby	4	1.25 ± 0.25	2	0.50	42.8	0.961 (0.908 : 1.000)	0.180 (0.016 : 1.000)
Brown Noddy	6	1 ± 0.34	1	0.17	34.5	0.975 (0.954 : 0.997)	0.422 (0.197 : 0.892)
Laughing Gull	63	2.03 ± 0.67	22	0.35	24.5	0.992 (0.976 : 1.000)	0.714 (0.366 : 1.000)
Red-Billed Tropicbird	3	1	2	0.67	42	0.969 (0.960 : 0.979)	0.468 (0.370 : 0.589)

Predator Presence Assessment

No evidence of rat presence was recorded with PVC tracking tunnel baited traps or the wildlife camera. In addition, only two of the 21 interviewees reported having seen a rat, one at Les Tantes in 2007, and the other on Rhonde island (not one of our study sites) in 2013. However, opportunistic conversations suggested the presence of rats on Sisters, Sandy, and Diamond, but not on Les Tantes. One corrugated plastic baited trap was found at Sisters with bite and chew marks (Fig. 2), but the organism that chewed on this trap could not be identified. Because of the height of the trap (30 cm above ground), it could not be a crab. The type of marks also exclude birds; it may have been chewed by a rat or an iguana.

The only organism recorded through the wildlife camera was a green iguana (*Iguana iguana*) on June 30 2015 on Sisters. The iguana caught on camera was in the vicinity of the trap but was not investigating it. Field observations confirmed the presence of iguanas on both Sisters (N = 2) and Les Tantes 'East' (N = 1), although opportunistic interviews suggest that they are also present on the other three islands. Similarly, the direct observations of a goat (*Capra aegagrus hircus*) on cliffs and of goat scats on Diamond corroborated interviewees' observations of goats on Diamond, although Les Tantes 'East' was also mentioned in interviews. Of the 18 respondents to the query "*List all the predators of seabird that you recall encountering while in the Grenada Grenadines*", 10 listed iguanas, 5 wrote goats, and 2 even cited opossums.

Figure 2. Corrugated plastic with chew and bite marks of unknown organism at Sisters.

Interviews

A total of 21 residents were interviewed in 2015, all of whom listed fishing as their primary or secondary occupation. For 65% of them, seabird harvest is not a tradition, nor is it part of Grenadines' culture, but 14% of interviewees who view it as a tradition explained that it is more of a family activity. When asked to "*List all the predators of seabird that you recall encountering while in the Grenada Grenadines*", 13 of 18 respondents said humans. Although none of the respondents (three interviewees skipped the question) sell seabirds or their eggs, they all reported a "most important harvest species", namely boobies (72%), pelicans (11%), gulls (11%), and terns (6%). The best island for egg/chick harvest is Sisters, listed by 67-71% of the interviewees, but all the study islands were mentioned more than once. Half the interviewees have eaten seabirds or their eggs at least once, but only 9.5% (n=2) still currently do. Similarly, 19% of those interviewed have collected seabirds, but not since 2009, and four of these five harvesters do not think that seabird harvest is important to make a living. Furthermore, 67% interviewees believe that seabirds are harvested less than in past years (others did not know) mostly because of increased gas prices. Finally, only two interviewees (9%) seemed aware of laws about seabird/egg collection, 45% were convinced that there are no rules or laws, and 45% did not know.

DISCUSSION

If the studied colonies are not as healthy as desired, they seem at least stable since 2014,. However, when compared with surveys conducted in 2009-2010, populations have decreased substantially for some species (Lowrie et al 2012). The number of nesting attempts and hatching success also seemed to have increased by a factor of 2 from 2014 to 2015, although not for all species. Of all species, boobies probably have the most alarming status because they have the lowest hatching success and are the favorite species for harvest. However, boobies have a long incubation period and our estimate may be biased low because nest monitoring ended while two nests were still at egg stage on July 14. A longer monitoring season would help determine the fate of late nests and better estimate nest success. In addition, we estimated hatching success instead of nest success because the fate of chicks could not easily be determined for species whose chicks leave the nest 2-3 days after hatching. If an additional field season can be secured, iButton temperature data loggers could be placed in the nests. Recording temperature data at close time intervals would help determine the date at which parents stop tending the nest through a clear and permanent change in temperature. Flush counts as used on other species such as quail are not the most accurate approach to estimate fledging success, but VHF transmitters require trapping on the nest before chicks leave the nest, and more regular tracking than our weekly visits have allowed.

The traps, camera, observations, and interviews all corroborated the presence of iguanas and goats. No rat was seen or detected on any of the study islands by the research team of interviewed locals. However, one trap showed bite and chew marks that could belong to a rat or iguana. The fact that recreational activity as well as nest monitoring tend to occur during the day could have resulted in reduced likelihood of detection, since rats are commonly active at night (Jones et al., 2008). Surveys also suggested the presence of opossums, the first documented note of such, which is a possible nest predator (Brown et al. 1993, Staller et al. 2005). Increasing detectability and certainty in identification would require deploying additional wildlife cameras. Alternatively, if the islands could be visited every day, baited live traps for small mammals could be used, but there is a risk of capturing a bird (Waldien et al. 2004) and other native wildlife. The last option could be large-scale surveys at night using night-vision goggles or thermal imaging devices (Boonstra et al 1994).

Interviews suggest that harvesting does occur, although much less than in the past. Three of the five interviewees who have harvested seabirds last did so in 2009. Maybe the Lowries' survey (2012) in 2009-2010 made the fishermen community aware of the impact. Alternatively, it is possible that some interviewees decided not to report their harvesting activities. This hypothesis could explain why one of the five harvesters did not specify a year of last harvest. However, most harvesters did not seem aware of any law prohibiting seabird harvest (e.g., closed seabird hunting/harvest season between 1 March and 31 August, *Birds and Other Wildlife Protection Act, 1957*), which may not be surprising given that poaching seabird has never been regulated nor policed. To this point, we have no evidence from this 2015 study that poaching significantly impacts seabird populations on the five study islands. This lack of evidence contrasts drastically with Lowrie et al.'s (2012) survey during which they observed high seabird harvesting activities, but though not directly observed, it is possible that harvest occurred at the chick stage (chicks are difficult to track after they leave the nest). The lack of awareness indicates that outreach programs could make a difference, especially since seabird harvest is an activity that seemed neither culturally nor economically important to interviewees. Some locals who harvested seabirds did it because they grew up in a family of harvesters, but most just tried “for fun”. Finally, if seabird harvesting is important to some locals (one respondent), it could probably be easily replaced by another activity. Indeed, one interviewee believed seabirds were less harvested today than in the past because people now hunt goats. Goat hunting could thus serve as an alternative and be beneficial to seabirds because it would not only reduce seabird harvest but also habitat degradation. Goats have caused the loss of seabird nesting habitat (including ground- and burrow-nesting species) and nest disturbance on many islands worldwide (Bell 1995). However, goat hunting would only work if the goat population is not restocked for further hunting opportunities.

In our attempt to quantify the impact of seabird harvest on colonies and nesting performances, the survey questions should be re-designed for future interviews. For example, all 2015 interviewees checked the lowest category for the amount (1-10 eggs/chicks) and frequency of harvest (1-5 times a year), and this remains imprecise, so we should offer an open-ended question to more accurately quantify harvest and the associated impact on the colonies.

To conclude, we may need to reassess causes for seabird declines. Habitat degradation or climate change might be more impactful, but harvest and predation effects on nesting performances still need to be quantified.

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Appendix A. Seabird data collected in 2014.

Table A1. Seabird basic counts of individuals loafing, conducted on 18 July 2014, using the in-transit method. Only one observer conducted the counts.

	Diamond	Les Tantes	Sandy	Sisters
Bridled Tern	32	21	30	6
Brown Booby	60	0	0	2
Brown Noddy	26	32	0	10
Laughing Gull	14	6	102	84
Red-Billed Tropicbird	0	15	0	0
Red-Footed Booby	0	352	0	0

Table A2. Productivity of five seabird species monitored during 16 May – 25 July 2014. Clutch size is expressed as mean ± SE. DSR is the daily survival rate estimated with the nest survival model, and hatching success has been calculated using DSR and the duration of the incubation period.

	# Nests	Clutch Size	# Hatched	Apparent HS (%)	Incubation (Days)	DSR (95% CI)	HS (95% CI)
Bridled Tern	13	1	2	15	29	0.971 (0.954 : 0.989)	0.428 (0.251 : 0.721)
Brown Booby	4	1	2	50	42.8	0.938 (0.854 : 1.000)	0.063 (0.385 : 1.000)
Brown Noddy	10	1	2	20	34.5	0.963 (0.938 : 0.988)	0.276 (0.118 : 0.666)
Laughing Gull	16	1.31 ± 0.46	14	88	24.5	0.992 (0.981 : 1.000)	0.820 (0.332 : 1.000)
Red-Billed Tropicbird	1	1	1	100	42	1.000 (1.000 : 1.000)	1.000 (1.000 : 1.000)