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Historical review of information on terns nesting in Bermuda, with prospects for re-establishing some of the lost species

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Photo: Lynn Thorne

Historical review of information on terns nesting in Bermuda, with prospects for re-establishing some of the lost species

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Abstract The Bermuda Islands, a 57-km² atoll-like archipelago located at 32°19'N, 64°45'W, are the only truly oceanic islands in the northwestern Atlantic. Accounts of seabirds nesting at the time of settlement in the early 17th century suggest that several tern species, including the Brown Noddy (*Anous stolidus*), Sooty Tern (*Onychoprion fuscatus*), Bridled Tern (*O. anaethetus*), Least Tern (*Sternula antillarum*), Roseate Tern (*Sterna dougallii*), and Common Tern (*S. hirundo*), might have been nesting on the islands. By the time that scientific documentation began in the mid-19th century, only the Roseate and Common Terns were confirmed to have survived, but overzealous collecting extirpated the Roseate Tern. The Common Tern survived into the 20th century and with legal protection has continued to nest on small rocky islets in sheltered sounds and harbors; one pair of Roseate Terns recolonized in 2018. This paper reviews historic records of terns, together with recent observations of transient migrants and nest-prospecting vagrants, including data from a 69-yr study of Common Terns (DBW unpubl. data), combined with data of other observers. These records provide some indication of the species that nested in Bermuda in pre-colonial times and which might be most amenable to restoration using modern conservation techniques. They also shed some light on the processes and timespans for recolonizations of remote oceanic islands by seabirds following their extirpation by humans.

Keywords Bermuda, extirpation, history, recolonization, terns

Resumen Revisión histórica de la información sobre la nidificación de gaviotas (Sterninae) en Bermudas, con perspectivas de restablecer algunas de las especies perdidas—Las islas Bermudas, un archipiélago similar a un atolón de 57 km² y ubicado a 32°19'N, 64°45'W, son las únicas islas verdaderamente oceánicas en el Atlántico noroccidental. Los relatos sobre la nidificación de aves marinas en el momento del asentamiento, a principios del siglo XVII, sugieren que varias especies de gaviotas como *Anous stolidus*, *Onychoprion fuscatus*, *O. anaethetus*, *Sternula antillarum*, *Sterna dougallii* y *Sterna hirundo* podrían haber estado nidificando en las islas. En el momento en que comenzó la documentación científica a mediados del siglo XIX, se confirmó que sólo habían sobrevivido *S. dougallii* y *S. hirundo*; pero la recolección excesiva extirpó la primera de estas especies. *S. hirundo* sobrevivió hasta el siglo XX y con protección legal ha seguido nidificando en pequeños islotes rocosos y en puertos protegidos; un par de *S. dougallii* recolonizaron el área en 2018. En este artículo se examinan los registros históricos de gaviotas, junto con las observaciones recientes de especies migratorias transitorias y vagabundas con posibilidades de nidificar; incluidos los datos de un estudio de 69 años de *S. hirundo* (datos no publicados de DBW) y combinados con datos de otros observadores. Estos registros proporcionan alguna indicación sobre las especies que nidificaban en las Bermudas en tiempos precoloniales y que podrían ser más predisuestas a la restauración utilizando técnicas modernas de conservación. También arrojan algo de luz sobre los procesos y los plazos para la recolonización de islas oceánicas remotas por parte de las aves marinas tras su extirpación por los humanos.

Palabras clave Bermudas, extirpación, gaviotas, historia, recolonización

Résumé Revue historique des informations sur les sternes nichant aux Bermudes et perspectives de réinstallation de certaines des espèces ayant disparu — Les îles Bermudes, un archipel de 57 km² en forme d'atoll situé à 32°19'N, 64°45'W, sont les seules îles véritablement océaniques de l'Atlantique Nord-Ouest. Les mentions d'oiseaux marins nichant au moment de la colonisation au début du XVIIe siècle indiquent que plusieurs espèces de sternes, dont le Noddi brun (*Anous stolidus*), la Sterne fuligineuse (*Onychoprion fuscatus*), la Sterne bridée (*O. anaethetus*), la Petite Sterne (*Sternula antillarum*), La Sterne de Dougall (*Sterna dougallii*) et la Sterne pierregarin (*S. hirundo*) pouvaient nicher sur ces îles. Au milieu du XIXe siècle, lorsque les relevés scientifiques ont commencé, il a été confirmé que seules la Sterne de Dougall et la Sterne pierregarin avaient survécu, mais un excès de zèle dans la collecte a fait disparaître la Sterne de Dougall. La Sterne pierregarin a survécu jusqu'au XXe siècle et, avec l'instauration d'une protection légale, continue à nicher sur de petits îlots rocheux dans des bras de mer et des ports abrités ; et un couple de Sternes de Dougall s'est de nouveau installé en 2018. Le présent article passe en revue les données historiques sur les sternes, les observations récentes de migrants de passage et

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d'individus erratiques prospectant de potentiels sites de nidification, ainsi que les données d'une étude d'une durée de 69 ans sur la Sterne pierregarin (données de DBW non publiées), combinées aux données d'autres observateurs. Ces informations fournissent des indications sur les espèces qui nichaient aux Bermudes à l'époque précoloniale et dont le retour pourrait être favorisé à l'aide de techniques de conservation modernes. Elles apportent également un éclairage sur les processus et les délais de recolonisation des îles océaniques lointaines par les oiseaux marins après leur disparition due aux activités humaines.

Mots clés Bermudes, disparition, histoire, recolonisation, sternes

Many populations of seabirds breeding on oceanic islands have been extirpated or severely reduced by introduced mammalian predators such as rats (*Rattus spp.*) and cats (*Felis catus*; Blackburn *et al.* 2004, Jones *et al.* 2008, Hilton and Cuthbert 2010). In recent decades, some of these seabird populations have been partially restored by programs to eliminate these predators (Howald *et al.* 2007, Ratcliffe *et al.* 2010, Brooke *et al.* 2018). Planning of such restorations requires the best possible knowledge of the original populations prior to the introduction of these predators (Brooke *et al.* 2007, Kappes and Jones 2014). Here, we review historical and recent information on terns (Sterninae) breeding in the Bermuda archipelago in the northwestern Atlantic Ocean. We compiled accounts of seabirds encountered in the period after the first human settlement in the 17th century and combined these with data on terns identifiable to species from recent decades (1840s–2010s). Our objectives were to identify the tern species that nested at the time of human settlement, to summarize their subsequent history, and to discuss conservation issues for the 21st century, including prospects for re-establishing one or more of the lost species.

The Bermuda Archipelago

The Bermuda archipelago (32°19'N, 64°45'W) is the only truly oceanic island group in the northwestern Atlantic Ocean. It is comprised of a 1,100-km² shallow platform representing the truncated summit of a volcano that erupted above sea level 34 million yr ago, but which has been eroded entirely below sea level and is now covered in a 100-m layer of carbonate marine sands and coral reefs. Water depths on the platform range 2–20 m. Dry land, totaling 57 km², occurs only around the southern rim of the platform where beach-derived fossil sand dunes rise to a maximum of 80 m above present-day sea level (Coates *et al.* 2013). The archipelago includes six large islands (now connected by causeways) and 138 smaller islands, islets, and vegetated rocks (see Fig. 1 for locations mentioned in the text). The coastline is predominantly erosional and dominated by low cliffs. Sandy beaches occur along about 7% of the coast.

Bermuda lies within the western reaches of the Sargasso Sea and the ocean surrounding it is oligotrophic. The nearest hydrographic feature is the Gulf Stream about 600 km to the west and north, which insulates the island from cold continental air masses in winter and maintains mild subtropical conditions year-round. The subtropical convergence lies about 1,000 km to the south. The monthly mean air temperature ranges from 17.1°C in February to 27.2°C in October and the monthly mean sea temperature ranges from 17.6°C in February to 28.2°C in July–August. Rainfall is fairly evenly distributed and averages about 150 cm per annum, enough to support lush subtropical vegeta-

tion on all but the smallest islets. Winds are generally light from the south during the summer months when the islands come under the influence of the Bermuda-Azores High, but southwest to northwest gales are frequent in winter before and after cold frontal passage, respectively (Bermuda Online 2019). Bermuda lies within the North Atlantic hurricane zone and experiences winds of Category 1 strength (≥ 120 km h⁻¹) about once every 7 yr in low frequency periods and once every 3 yr in high frequency periods; the frequency and severity of hurricanes are increasing (Webster *et al.* 2005).

The islands were first discovered and periodically visited by European explorers in the early 16th century, but were not permanently colonized until the early 17th century. The initial period of discovery and settlement by the Somers Isles Company is surprisingly well-documented, with non-scientific natural history accounts that give a good general description of the pre-colonial avifauna, but these do not permit precise species identifications except in a few instances (Lefroy 1877, Verrill 1901–1902). From these accounts we learn that Bermuda had no mammals other than bats before the deliberate introduction of hogs (*Sus scrofa*) in about 1560. The hogs were soon eliminated or corralled after settlement. Old World murids, the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*), arrived accidentally in 1614, and the brown rat (*Rattus norvegicus*) arrived about a century later. Apart from these there are no resident mammalian predators of seabirds other than domestic dogs and feral cats, which arrived with the earliest European visitors. Pre-colonial avian predators were restricted to hawks and owls, an endemic crow and an endemic night-heron, all now extinct, and probably the Magnificent Frigatebird (*Fregata magnificens*). Abundant native land crabs (*Gecarcinus lateralis*) may also have been a threat to the nestlings of smaller seabirds.

For about two centuries following the demise of the Somers Isles Company in 1684 (Lefroy 1879), very little natural history information was recorded. Scientific documentation only began in earnest during the Victorian period in the mid-19th century, but by that time most of the pre-colonial avifauna had been extirpated by introduced mammalian predators (rats, cats, and dogs), human harvesting for food, hunting for sport, or scientific collecting. As far as human activities are concerned, the situation is vastly different today. There is no subsistence harvesting; conservation laws provide total protection for birds (Mejías 2017) and are strictly adhered to (DBW pers. obs.).

Methods

We reviewed all published and unpublished accounts of the natural history of Bermuda to shed light on the identities of terns that might have nested in Bermuda in historic times (17th–18th

centuries). This information has been collated with recent records of breeding birds, transient migrants, and those occasional vagrants that exhibited behavior suggestive of nest prospecting (for examples, see Results). Recent records include those made by DBW during a 69-yr study of Common Terns, combined with those of other observers of birds in Bermuda since the 1920s (Bradlee *et al.* 1931, Beebe 1937, Moore 1941, Bourne 1957, Amos 1991, Dobson 2002) and relevant records from the annual bird reports (1990–2016) of the Bermuda Audubon Society.

Results

Records of Terns from the Early Settlement Period (1609–1800)

"Egge Birds" and "Sandie Birds".—Two accounts from the period shortly after the first human settlement of Bermuda in 1609 described "egge birds" (see Appendix 1). These birds nested in very large numbers in sandy bays, especially on Cooper's Island, starting to lay on 1 May. They were described as being as large as "a good pigeon" and laid eggs "near as big as hennes egges" (Lefroy 1877:17). They were extremely tame and fearless,

and hundreds or thousands of eggs could be collected every day until midsummer (Appendix 1). A third account referred to "sandie birds," which may have been the same species (Appendix 2).

These accounts were subsequently assumed to apply to the Common Tern and Roseate Tern (*Sterna dougallii*), as those were the only species recorded nesting in the 19th and 20th centuries (Bradlee *et al.* 1931). Unfortunately, there is virtually no fossil or sub-fossil evidence that might shed light on the specific identity of these birds: terns are rare throughout the fossil record (S. Olson pers. comm.), and the only specimens obtained in Bermuda are a mandible from a dredged Holocene deposit, attributed to either a Common Tern or a Forster's Tern (*Sterna forsteri*), and a wing bone attributed to a Sooty Tern (*Onychoprion fuscatus*) from a late Pleistocene fill-deposit (DBW unpubl. data). We nevertheless conclude that the early accounts of "egge birds" must have applied to the Sooty Tern, based on the sheer numbers described, the size of the birds and their eggs, their fearlessness and tameness, and their nesting behavior. Another species that might fit the descriptions in these accounts is the Royal Tern

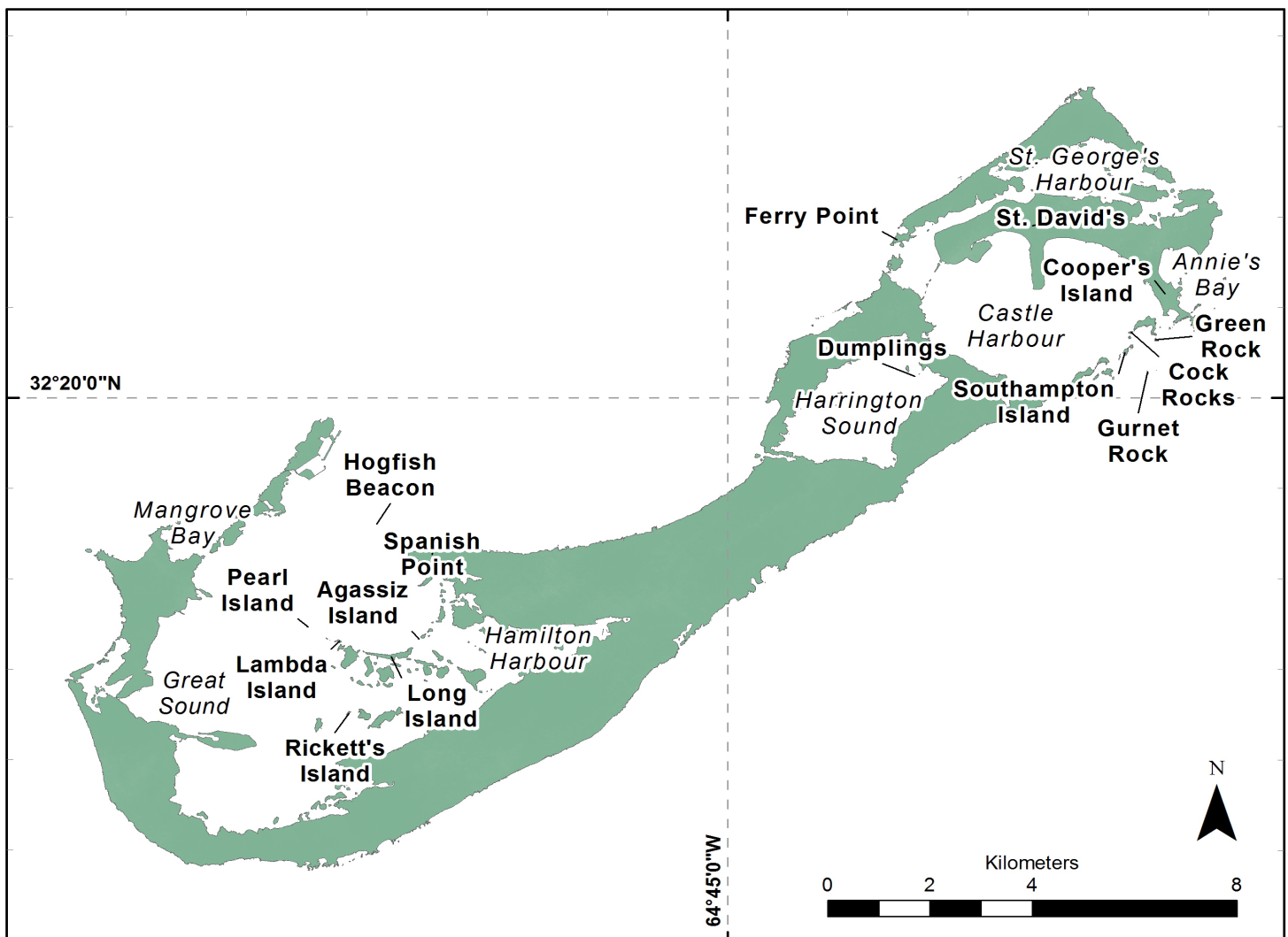


Fig. 1. Map of Bermuda showing locations mentioned in the text. North Rock (not pictured) is an isolated rock pinnacle 11 km north-west of St. David's.

(*Thalasseus maximus*), which also nests at high densities on sandy substrates, sometimes in colonies of thousands (Buckley and Buckley 2002). However, while the Sooty Tern is highly pelagic and could have attained the vast populations described in the historic accounts, the Royal Tern is an inshore species that could not have reached such large numbers in oceanic Bermuda. The Royal Tern is also substantially larger than a domestic pigeon (*Columba livia*), and its eggs are much larger than those that would have been laid by domestic hens of the 17th century (which were about the size of modern-day bantams; Dohner 2001).

"Noddies".—Two early accounts referred to "noddies," one distinguishing them from "sandie birds" and the other distinguishing them from "boobies" (Appendix 1). These birds were not described and their identity is conjectural. The colloquial term "noddies" was formerly used for many small seabirds in the Caribbean and elsewhere (A. del Nevo pers. comm.). In Bermuda, it might have referred to the Brown Noddy (*Anous stolidus*), the Black Noddy (*A. minutus*), or perhaps the Roseate Tern or the Common Tern, both of which were found nesting in Bermuda in the 19th century (see "Recent Records" section below). Black Noddies nest in trees, and Brown Noddies usually nest in trees or on cliffs or rocks, but there was no mention of tree-nesting seabirds by the early settlers. Whatever species "noddies" might have referred to, it appears that at least one other tern species in addition to the Sooty Tern was nesting in Bermuda at the time of human colonization in the early 17th century.

Recent Records of Terns (1847–Present)

Roseate Tern.—Adults, eggs, and chicks of Roseate Terns were collected at Gurnet Rock in 1847–1849, but most of the specimens were lost at sea (see Appendix 2). John Bartram collected two specimens at Gurnet Rock on 30 April 1861 that were later confirmed by Reid (1877, 1884) as Roseate Terns. Subsequently, Bartram confessed that his own collecting must finally have eliminated them as a breeding species, because Reid (1877) saw none during his own stay in Bermuda in 1874–1875. Bartram recorded in 1863 that the local inhabitants were using a colloquial name, "redshanks," for terns, implying a long-established familiarity (Wingate 1965). One other Roseate Tern specimen was collected by Louis Mowbray at Cooper's Island in 1905 (Bradlee *et al.* 1931). An unlabeled Roseate Tern specimen found by DBW in the Bermuda Aquarium Museum is probably this specimen collected by Mowbray in 1905; it is now in the American Museum of Natural History, New York.

There were no other published records of Roseate Terns before DBW's observations began in the 1950s. During the last 60 yr, this species has been an annual but scarce spring transient, with some individuals remaining well into the summer and occasionally feeding with Common Terns and visiting their nesting islets. In each year from 2012 to 2017, a single Roseate Tern associated with the Common Terns nesting on Rickett's Island in Hamilton Harbour, frequently chasing them in 2012, and displaying to them with fish in 2017. In 2018, a pair of Roseate Terns nested on Pearl Island, the first documented nesting in Bermuda since 1849. A nest with one egg was found on 7 July; the egg hatched on 24 July and the chick fledged and left the islet on 19 August. Three features of this nesting pair indicated that they were

derived from the population breeding in the Caribbean and Bahamas: the adults had bills > 50% red at the time of egg-laying in early July, the nest was on an open substrate, and the clutch contained only one egg (DBW, E. Hetzel, and M. Mejías unpubl. data). Other Roseate Terns seen in May and June in recent years, including the bird mentioned above that displayed to Common Terns in 2017, had black bills and were apparently derived from the population breeding in the northeastern United States (Nisbet *et al.* 2014).

There are only two confirmed autumn records of Roseate Terns to date: an adult seen in Castle Harbour and Great Sound on 16–17 September 1996 (DBW pers. obs.), and two individuals at Ferry Point following Hurricane Wilma on 29 October 2005 (Bermuda Audubon Society 2006). The paucity of autumn records is surprising in view of the fact that Roseate Terns from the northeastern United States all pass within about 400 km west of Bermuda during their southward migration (Mostello *et al.* 2014, Nisbet *et al.* 2014).

Common Tern.—Both John Wedderburn (Jones *et al.* 1859) and Hurdis and Hurdis (1897) confirmed that a few Common Terns were breeding along with the Roseate Terns on Gurnet Rock in 1848 (see Appendix 2). Recent research has revealed that the Bermuda nesting population of Common Terns differs genetically from other populations around the North Atlantic (Szczyz *et al.* 2012), which strongly implies that it survived through the late 19th and early 20th centuries. However, direct evidence that it did so is scanty and inconclusive (Appendix 2). Common Terns were found nesting on islets in Harrington Sound and Hamilton Harbour in 1940–1945 (Appendix 2). DBW was first introduced to nests of this species in Harrington Sound in the early 1950s by his childhood peers who, amazingly, were still using the colloquial name "redshanks" that was first reported by Bartram in 1863. This strongly implies an unbroken record of local familiarity with the species as a breeder from the mid-19th century. Starting in 1950, DBW monitored the small population in Harrington Sound and Hamilton Harbour in 14 of the 23 yr before his main study began in 1973. Some recent information from DBW's research has been published by Nisbet *et al.* (2010) and Szczyz *et al.* (2012). There were 15–30 breeding pairs in the 1970s–1980s, but currently (2018), there are only four productive (male-female) pairs and three unproductive (female-female) pairs (DBW unpubl. data). The population is under active management but remains critically endangered (Mejías 2017).

Reid (1884) was the first to record large numbers of Common Terns on autumn migration (Appendix 2). In recent decades, the species has been found to be a regular migrant through Bermuda in September–November, sometimes in large numbers. However, Common Terns are very scarce during spring migration (Amos 1991, Dobson 2002, DBW pers. obs.).

Least Tern.—Least Terns (*Sternula antillarum*) were reported nesting on small islets in Bermuda from 1928 to 1943, but little specific information was published (see Appendix 2). Dredging and land-building operations during the Second World War to create an airport at the east end of Bermuda and a naval facility in Great Sound at the west end would probably have temporarily created extensive barren sandy areas, a habitat favored by this species for nesting, but there is no scientific information to suggest that nesting actually occurred.

We were initially skeptical about the records from the period 1928–1943, suspecting confusion with the Common Tern, because the number of pairs reported closely matched the number of pairs of Common Terns that DBW found nesting on the same islets between 1950 and 1973. Least Terns are transients through Bermuda from late July to September, when Common Terns are still in the final stages of nesting, so we suspected that the sighting of both species feeding together near the nesting islets could have led to an assumption of nesting without adequate proof. However, in the summers of 1984–1986, a pair of Least Terns was observed courtship-feeding and landing in search of places to make nest scrapes on Lambda, Agassiz, and Long Islands in Hamilton Harbour between late May and late July. No active nest was ever found, and the pair did not return in 1987 (DBW pers. obs.). The islets chosen for nest prospecting featured large stretches of bare rock with small sandy areas and very little vegetation. Such habitat is now rare in Bermuda and two of the three islets prospected were subject to frequent disturbance by humans and dogs.

In retrospect, it seems plausible that the Least Tern nested on pre-colonial Bermuda but died out due to excessive persecution and shortage of suitable habitat in the 19th century. It appears that the species recolonized briefly in the second quarter of the 20th century—a time when numbers on the east coast of North America were increasing rapidly (Nisbet *et al.* 2013)—but died out again as human population growth and disturbance by boaters encroached on its exceedingly limited breeding habitat after the 1940s.

Sooty Tern.—As we conclude above (see “Records from 1609–1800” section), Sooty Terns apparently nested abundantly in Bermuda in the 17th century. However, the species has not been recorded nesting subsequently; we think it likely that the breeding population was extirpated by the combination of excessive harvesting (Appendix 1) and predation by rats after 1614. There have been few records of Sooty Terns in Bermuda since scientific documentation of the avifauna began in the mid-19th century, and those were mostly hurricane-displaced vagrants (Bradlee *et al.* 1931, Amos 1991, Dobson 2002, DBW unpubl. data). However, a few spring records in recent years strongly suggest nest prospecting by individual birds. On 31 May 1994, Steven Desilva observed an adult Sooty Tern flying around Castle Harbour chasing groups of White-tailed Tropicbirds (*Phaethon lepturus*) and calling loudly. This behavior lasted for about 20 min and whenever Desilva imitated the call, the bird rushed over to him and circled the boat. On 4 June 1996, Desilva again observed an adult Sooty Tern calling loudly and chasing groups of tropicbirds along the reef line between Cooper’s Island and Gurnet Rock (pers. comm.). On 30 March 2000, DBW saw an adult flying over Green Rock in Castle Harbour, calling loudly (pers. obs.). On 20 May 2001, Eric Amos reported a Sooty Tern near Annie’s Bay, St. David’s; it was dive-bombing a commercial jet at the nearby airport (pers. comm.). On 22 May 2001, DBW saw an adult flying out to sea from Annie’s Bay. Later that day, what was presumably the same bird broke its wing while dive-bombing a Merlin turboprop aircraft idling its engines at the airport’s cargo ramp. DBW prepared the specimen for the Bermuda Aquarium, Museum and Zoo; it was an adult female with ovary 11 mm long and largest ovum 3 mm long, implying that it was at least capable of

breeding. Another Sooty Tern was seen at Cock Rocks in Castle Harbour between 16 and 29 July 2001; it was associating with a pair of nesting Common Terns and often landed beside their chicks (DBW pers. obs.).

Bridled Tern.—There were no specific records of Bridled Terns (*Onychoprion anaethetus*) from the early history of Bermuda. The first confirmed record was a flock of 24 hurricane-displaced vagrants seen in Mangrove Bay on 25–26 October 1973 (E. Amos pers. comm.). DBW has since recorded single adult Bridled Terns showing nest prospecting behavior in summer on two occasions. In 1978, a Bridled Tern associated with the Common Terns nesting on Pearl Island for the entire summer between 6 July and 12 September, calling and landing there for long periods; it also made occasional visits to Castle Harbour to feed with other Common Terns. The second record was an adult Bridled Tern that circled over Cock Rocks where Common Terns were nesting on 4 August 2000. As with the Least Tern, we consider these records indicative that the species could have been nesting in pre-colonial time, especially as it is seasonally pelagic in habit and associated with the *Sargassum* algae community that is common around Bermuda during all seasons (Haney *et al.* 1999). Bermuda’s calcareous islets and coastline are almost identical to islets in the Bahamas where Bridled Terns nest commonly, and under the influence of the Gulf Stream, the climates and littoral flora of Bermuda and the Bahamas are almost identical.

Noddies.—The Brown Noddy has been a rare vagrant in Bermuda within the last century. Three records were hurricane-displaced immatures, two in October 1969 and one on 11 October 1995; two of these died and were preserved as specimens (Wingate 1973, Amos 1991). The other two records were summer vagrants, apparently also in immature plumage. One of these remained among the Castle Harbour islands for the first 12 days of June 1988, perching on cliffs and feeding in the breaking surf close to shore (DBW pers. obs.). The second was observed perched on Hogfish Beacon on 15–17 June 2006 (Bermuda Audubon Society 2007). The Black Noddy remains unrecorded in Bermuda.

Other Tern Species.—All other tern species that breed in eastern North America, including the Gull-billed (*Gelochelidon nilotica*), Caspian (*Hydroprogne caspia*), Black (*Chlidonias niger*), Arctic (*Sterna paradisaea*), Forster’s, Royal, and Sandwich (*Thalasseus sandvicensis*) Terns, occur in Bermuda in autumn (August–November)—sporadically in most years, but occasionally in large numbers following hurricanes (Amos 1991, Dobson 2002, DBW pers. obs.). Arctic Terns pass Bermuda in large numbers during their spring migration; all the other species are rare in spring and none has exhibited prospecting behavior.

Discussion

Former and Current Breeding Species

The only tern species that currently (2018) nest in the Bermuda archipelago are the Common Tern, which is critically endangered, with only 3–4 productive (male-female) pairs that depend on intensive management, and the Roseate Tern, of which one pair nested in 2018 after a 150-yr hiatus. Historical records indicate that at least two different species nested in the early settlement period in the 17th century. One was most likely the Sooty Tern, which apparently nested in very large numbers but was

probably eliminated by the combination of excessive harvesting and introduced predators. Other birds were referred to as “noddies” and might have been Brown Noddies, Roseate Terns, or another species. Roseate Terns nested in small numbers in the mid-19th century, but were extirpated by overzealous collectors before 1874. Least Terns nested in small numbers from the late 1920s to the 1940s.

Threats

Until the early 20th century, the major threats to terns in Bermuda were harvesting of eggs and chicks for human food (see Appendix 1), collecting, supposedly for scientific purposes (see Appendix 2), and predation by introduced mammals. Rats and cats remain abundant on the large islands of Bermuda, and are probably responsible for terns breeding only on very small islets since the first reported observations in the 1840s. Rats occasionally reach some of the islets where Common Terns currently breed, but they cannot subsist there for long periods and can be controlled if they attempt to do so, provided that a surveillance program is maintained (Mejías 2017). We have found no evidence that other potential predators such as Ruddy Turnstones (*Arenaria interpres*), gulls (*Larus* spp.), American Crows (*Corvus brachyrhynchos*), or land crabs prey on terns, despite their frequent presence on the islets used by nesting terns (Mejías 2017).

We have found no evidence for major changes in the environment of Bermuda that might have affected terns prior to the 21st century. However, climate change has already had adverse effects on terns in the 21st century, and these effects are expected to increase in the future (Wingate and Talbot 2003, Glasspool 2008). Both the frequency and the intensity of North Atlantic hurricanes are increasing (Webster *et al.* 2005, Murakami *et al.* 2018). Common Terns in Bermuda have been adversely affected by three major hurricanes since 2003 (Nisbet *et al.* 2010, Szczys *et al.* 2012, DBW and ICTN unpubl. data), and the long-term survival of the population is unlikely if these trends continue. Rising sea level is not currently a threat to Common or Roseate Terns in Bermuda because many of the islets they nest on are sufficiently high. However, rising sea level might make it more difficult to re-establish Sooty Terns (see next section).

Conservation Recommendations

Based on the information summarized in this paper, we suggest that three species of terns might be good candidates for conservation efforts to restore breeding colonies. The Roseate Tern has already recolonized, but broadcasting calls recorded at other West Indian breeding colonies might benefit the breeding population by attracting additional individuals. The Sooty and Least Terns might benefit from decoys, broadcast calls, and habitat manipulation such as mooring gravel-filled nesting rafts at disturbance-free sites, or in the case of the Least Tern, creating fenced-off sand flats on protected islets (Kress and Hall 2004, Mejías 2017).

As previously discussed, we believe that Sooty Terns bred in large numbers in Bermuda in the 17th century. Although the species is primarily tropical, it has recently attempted to nest in small numbers at Cape Hatteras in North America and in the Azores (Monteiro *et al.* 1996, Nisbet *et al.* 2013), in both cases at higher latitudes than Bermuda. The fact that a prospecting

Sooty Tern was fatally attracted to an idling turboprop aircraft in 2001 and the immediate response of other individuals to imitated calls suggest that this species would respond to sound broadcasting and decoys. Unfortunately, much of the appropriate breeding habitat at Cooper’s Island was destroyed when the airport was constructed, and Cooper’s Island itself is not only near the line of approach to the runway but is also now a popular beach park. However, we propose that the Southampton Island nature reserve would make an ideal predator-free site for experimental colony re-establishment (Bermuda Audubon Society 2019).

In the North Atlantic Ocean, the Sooty Tern is currently limited to islands in the Caribbean and Bahamas, where total numbers are estimated at about 300,000 pairs and are thought to be declining (Bradley and Norton 2009); this species breeds only in very small numbers in the eastern North Atlantic (Cramp 1985, Paterson 1997). With the changing climate, breeding sites in the Caribbean and Bahamas are likely to become less suitable and the Sooty Tern population is expected to shift northwards (Nisbet *et al.* 2013). Bermuda would be the best location in the western North Atlantic for the first step in this shift. Bermuda would also be a good location for a northward shift in the population of Roseate Terns that currently breeds in the Caribbean and the Bahamas, considering this species’ historic presence and recent recolonization in Bermuda. Bermuda is at the southern margin of the Common Tern’s range, and as has already been discussed, the prospects for this species’ long-term survival there are poor. However, Common Terns in Bermuda appear to be distinct from other North Atlantic populations both genetically (Szczys *et al.* 2012) and ecologically (DBW and ICTN unpubl. data), so we recommend continuing efforts to conserve them.

Bridled Terns have been observed associating with breeding Common Terns on two occasions, but the most recent case was in 2000 and the prospects for this species establishing itself in Bermuda are small. “Noddies” were reported in the 17th century, but these casual statements give little clue to the identity of the species or the location where it might have nested. Brown Noddies are now rare visitors to Bermuda, but there is ample habitat on some secure nature reserves that might support nesting if they should colonize spontaneously. The Black Noddy has not yet been recorded in Bermuda. Most other terns from the east coast of North America are estuarine or continental-shelf feeders, and would not find sufficient feeding habitat to colonize oceanic Bermuda.

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Title Page Illustration

Roseate Tern (*Sterna dougalli*) chick; photo taken on Pearl Island, Bermuda, on 8 July 2018 by Lynn Thorne.

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Appendix 1. Accounts of Terns from the 17th to the Early 19th Centuries

"Egge Birds".—Silvanus Jourdain, a member of the shipwrecked Sea Venture party that was stranded on Bermuda in 1609–1610, wrote:

There is fowle in great numbers upon these islands where they breed that there hath been taken in two or three hours a thousand at the least: The bird being of the bignesse of a good pigeon and layeth eggs as big as hennes egges upon the sand where they come and lay them daily although men sit down among them: that there have been taken up in one morning by Sir Thomas Gates men one thousand of eggs; and Sir George Somers men coming a little distance of time after them have stayed there whilst they came and laid their eggs among them that they brought away as many more with them, with many young birds very fat and sweet. (Lefroy 1877:17)

Jourdain went on to distinguish these "egge birds" from the equally abundant Bermuda Petrel or "Cahow" (*Pterodroma cahow*), which laid white eggs in burrows, and specifically mentioned that the egge birds' eggs were "speckled and of a different colour" (Lefroy 1877:18). A second reference to terns made in 1623 by a former governor of Bermuda, Nathaniel Butler, specified the time and location of breeding:

But above all these, most deserving observation and respect, are those two sorts of birds, the one for the tune of its voice, the other for the effect; called the Cahow and the egge bird, which on the first day of May, a day constantly observed, fall a laying infinite store of eggs near as big as hennes egges upon certain small sandy bays especially in Cooper's island; and although men sit down among them when hundreds have been gathered in the morning...they have stayed among them and collected as many more. They continue this course till mid summer and so tame and fearless you must thrust them off from their eggs with your hand; then they grow so faint with laying they suffer them to breed and take infinite numbers of their young to eat which are very excellent meat. (Lefroy 1877:330)

"Noddies".—Two early accounts referred to "noddies" in addition to "sandie birds" and "boobies." In 1615, the Reverend Lewis Hughes wrote:

When the cahouze time is out other birds called noddies and sandie birds come in and continue to the latter end of August. (Hughes 1615:5)

In 1863, Bartram wrote in an unpublished Commentarium of

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his bird observations that:

The booby and the noddy used to be very common sixty years ago, and a man who died this day, 1 Dec, 1863 age 75 has often told me. . . (Wingate 1965:1)

Appendix 2. Records of Terns from the Mid-19th to the Mid-20th Centuries (1847–1945)

Roseate Tern.—The first scientific documentation of nesting terns identifiable to species was recorded in the diaries of Wedderburn (Jones *et al.* 1859) and John L. Hurdis; Hurdis's diaries spanned the period 1840–1855 and were later published by his daughter (Hurdis and Hurdis 1897). Under the heading of Roseate Tern, Wedderburn wrote:

This was the first bird new to the Bermuda list that I found in the islands. On the 30th of April 1847 I shot several specimens at Spanish Point and in Castle Harbour where they breed. I got their eggs off Gurnet Rock on the 17th of June, 1848. I have also seen a few roseate terns at the North Rock. (Jones *et al.* 1859:52–53)

In July 1847, Hurdis contracted with Salton Smith to obtain specimens of terns that were reported to be nesting on Gurnet Rock at the mouth of Castle Harbour—the most remote and inaccessible islet in Bermuda. Hurdis wrote as follows, referring to a visit on 1 August 1847:

Smith tells me . . . that the sea was rougher than he anticipated and that he had some difficulty landing a boy upon the rock. The boy twice returned with specimens of young seabirds including about a dozen terns all of which were safely got on board the dinghy. He then went for eggs and returned with some dozens in the fold of his shirt; with these he attempted to jump in to the frail bark as it rose upon a sea, but missing his footing, fell into the water and was in danger of drowning. Mr. Smith in his endeavours to save the boy was carried on to the rock, the dinghy was upset and stove and the whole of the specimens and eggs lost. (Hurdis and Hurdis 1897:32–33)

A year later, on 13 June 1848:

Mr. Wedderburn visited Gurnet Rock opposite the entrance to Castle Harbour. He found it tenanted by forty or fifty of the roseate tern of which he killed seven. (Hurdis and Hurdis 1897:66)

Another year later, on 2 June 1849:

Mr. McLeod visited Gurnet Rock this day. He tells me he saw four terns only of which he killed two but failed to recover from the sea. (Hurdis and Hurdis 1897:111)

And finally, on 21 June 1849:

Mr. Orde and Mr. McLeod visited Gurnet Rock last evening and this morning. Of terns they saw none. (Hurdis and Hurdis 1897:111)

Bartram collected two terns at Gurnet Rock on 30 April 1861, and they were later confirmed by Reid (1877, 1884) as Roseate Terns. One other specimen was collected by Mowbray at Cooper's Island in 1905 (Bradlee *et al.* 1931).

Common Tern.—Both Wedderburn (Jones *et al.* 1859) and Hurdis and Hurdis (1897) recorded a few Common Terns breeding along with the Roseate Terns on Gurnet Rock. Wedderburn wrote:

I have seen a few of these terns at Gurnet-head rock, but only succeeded in shooting a couple of them near the entrance to St. George's harbour on the 17th of June 1848. (Jones *et al.* 1859:53)

Regarding a visit by Wedderburn to Gurnet Rock on 13 June 1848, when 40 or 50 terns were counted, Hurdis wrote:

. . . a brother officer who pulled out with him said that two kinds were distinguishable, the one with very forked tails and the other with a tail not so forked. (Hurdis and Hurdis 1897:66)

The birds with tails “not so forked” were presumably Common Terns. Of that period and the decades that followed, Reid wrote:

They were sufficiently numerous in 1850 but there is no record of their having bred since that date. Not a single one was to be seen in 1874 or 1875. (Reid 1884:269)

Reid was the first to report large numbers of terns on autumn migration. He wrote the following in October 1876:

. . . during a severe NW gale in St. Georges harbour there were a great number of terns of various species about. Mr Bartram is of the opinion that there must have been at least five different kinds in the harbour. He only obtained two, the Black tern, *Hydrochelidon nigra* and the Common tern, the reappearance of which after so many years is interesting, but he killed and lost two larger terns which may have been *S. caspia* or *S. regia*. (Reid 1884, Appendix 1:1)

The checklist by Bradlee *et al.* (1931) recorded only that Mowbray took a male Common Tern on 6 September 1899. Bowditch (1904), who was present on Bermuda from 6 July to 22 August 1903, saw single terns three times off the north shore and considered it most likely that they were Common Terns. Bowditch's records are significant in suggesting that the Common Tern survived as a breeding species into the 20th century. Bradlee *et al.* (1931) stated that Common Terns had lately become more numerous; this probably referred to autumn migrants, and the increase could reflect the rapid increase in numbers nesting along the Atlantic coast of North America during that period (Nisbet

et al. 2017).

Moore was the first to confirm breeding again in the 20th century:

In August 1940 I saw several pairs, one pair accompanied by a young bird. The latter group flew regularly around a small island and cried loudly whenever I approached it. I could find no trace of a nest but the island was covered with their droppings and I think it is very likely that they had nested and reared the young bird there. (Moore 1941:73)

Moore felt it unwise to specify the exact locality, but it was most likely an islet in Harrington Sound. In 1945, 5 yr later, a United States Army officer took color photographs of a Common Tern nest with eggs and chick at a location that is clearly recognizable as one of the Dumplings in eastern Harrington Sound (F.T. Hall unpubl. data). Soon after, Bourne reported Common Terns nesting in Great Sound:

In 1942 I saw up to 4 birds together in the Great Sound, one of which had a young bird. There was a nest here with three eggs in May 1943, and I saw other odd birds in Great Sound in the same year. (Bourne 1957:102)

Least Tern.—Shortly before the discovery of nesting Common

Terns, and apparently at the same small harbor islets, there were published records of nesting Least Terns, beginning with a report from Mowbray, who wrote in a casual way:

Breeding on some of the more inaccessible islands about Bermuda. I first found birds of this species in 1928 and have since observed them in 1929 and 1930. There are about 12 to 15 pairs; both eggs and young were observed. (Bradlee *et al.* 1931:292)

This report was followed up by Beebe, who added:

At least two pairs bred in 1935 on an islet in Harrington Sound. (Beebe 1937:63)

Moore commented equally casually that Least Terns were

... seen in small numbers near their known nesting site. No increase evident. (Moore 1941:72)

Finally, Bourne referred to Bradlee *et al.*'s (1931) report and added:

... since then most visitors have reported it in Harrington Sound where I saw odd birds in 1942 and 1943. (Bourne 1957:102)