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Photo: Noah Frade

Abundance and distribution of Roseate Terns (*Sterna dougallii*) in the Virgin Islands

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Abstract The North Atlantic population of the Roseate Tern (*Sterna dougallii dougallii*) is distributed across the northeastern coast of the United States and Canada, Europe, the Caribbean, and North Africa. In northeastern North America, the species was classified as Endangered in 1987 by the United States Fish and Wildlife Service, and it is the focus of national recovery plans in both the United States and Canada. In Europe, the Roseate Tern is considered a species that requires special conservation measures under Annex I of the European Union Birds Directive, and an action plan for recovery was initiated in 1987. Roseate Terns in the Caribbean have been less well studied, but anecdotal data suggest that the species is also declining in that region. Using survey data collected over the last three decades, we report on the abundance and distribution of the largest local population of Roseate Terns in the Caribbean, which breeds within the dual-territory archipelago of the Virgin Islands (United States Virgin Islands [USVI] and British Virgin Islands [BVI]). Our results reveal that breeding sites were not consistently occupied in every survey year. However, Kalkun Cay, Shark Island, Saba Island, and Leduck Island in the USVI, and Cockroach Island, Green Cay, Cistern Point, and the Seal Dog Islands in the BVI were identified as key breeding sites. The total breeding population in the Virgin Islands fluctuated between 745 and 2,750 breeding pairs over the survey period, a population size that is globally important for this species as a whole. We observed a gradual decline in the Virgin Islands breeding population. Conservation for this species should focus on a continued cross-territory survey effort, habitat enhancement at the most populated breeding sites, and research into the effects of broader climatic and oceanographic patterns on this breeding population.

Keywords Roseate Tern, seabird surveys, site fidelity, *Sterna dougallii*, Virgin Islands

Resumen Abundancia y distribución de *Sterna dougallii* en las Islas Vírgenes—La población del Atlántico Norte de *Sterna dougallii dougallii* está distribuida a lo largo de la costa noreste de los Estados Unidos y Canadá, Europa, el Caribe y el norte de África. En el noreste de América del Norte, la especie fue clasificada como Amenazada en 1987 por el Servicio de Pesca y Vida Silvestre de los Estados Unidos y es el foco de planes nacionales de recuperación tanto en los Estados Unidos como en Canadá. En Europa, esta especie se considera que requiere medidas especiales de conservación en virtud del Anexo I de la Directiva sobre aves de la Unión Europea, y en 1987 se inició un plan de acción para su recuperación. En el Caribe, *Sterna dougallii* ha sido menos estudiada, pero los datos anecdóticos sugieren que también está disminuyendo. Reportamos sobre la abundancia y distribución de la mayor población reproductora local de esta especie en el Caribe, que se reproduce dentro del archipiélago de dos territorios de las Islas Vírgenes (Islas Vírgenes estadounidenses [USVI] e Islas Vírgenes Británicas [BVI]), con el uso de los datos de muestreos recopilados en las últimas tres décadas. Nuestros resultados revelan que los sitios de cría no estuvieron ocupados de manera constante durante los años muestreados. Sin embargo, Kalkun Cay, Shark Island, Saba Island y Leduck Island en las USVI y Cockroach Island, Green Cay, Cistern Point y las Seal Dog Islands en las BVI fueron identificados como sitios de cría clave. La población reproductora total en las Islas Vírgenes fluctuó entre 745 y 2.750 parejas reproductoras durante el período de muestreo, un tamaño poblacional que es importante a nivel mundial para esta especie en su conjunto. En esta población reproductora observamos un declive gradual. La conservación de esta especie debe centrarse en un esfuerzo de muestreo continuado a lo largo del territorio, la mejora del hábitat en los sitios de cría más poblados e investigación sobre los efectos de patrones climáticos y oceanográficos más amplios en esta población reproductora.

Palabras clave fidelidad al sitio, Islas Vírgenes, muestreos de aves marinas, *Sterna dougallii*

Résumé Abondance et répartition de la Sterne de Dougall (*Sterna dougallii*) aux Îles Vierges — L'aire de répartition de la population de Sterne de Dougall de l'Atlantique Nord (*Sterna dougallii dougallii*) s'étend sur la côte nord-est des États-Unis et du Canada, la Caraïbe, l'Europe et l'Afrique du Nord. Au nord-est de l'Amérique du Nord, l'espèce a été classée dans la catégorie En danger en 1987 par le Fish and Wildlife Service des États-Unis et fait l'objet de plans de rétablissement nationaux aux États-Unis et au Canada. En Europe, elle est considérée comme une espèce nécessitant des mesures de conservation spéciales au titre de l'Annexe I de la Directive « Oiseaux » de l'Union européenne. Un

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plan d'action en faveur du rétablissement de l'espèce a été lancé en 1987. La Sterne de Dougall a été moins bien étudiée dans la Caraïbe, mais des données ponctuelles indiquent qu'elle est également en déclin dans cette région. À l'aide de données recueillies au cours des trois dernières décennies, nous décrivons l'abondance et la répartition de la plus grande population nicheuse locale de Sterne de Dougall de la Caraïbe, qui se reproduit sur les deux territoires de l'archipel des Îles Vierges (Îles Vierges américaines [USVI] et Îles Vierges britanniques [BVI]). Nos résultats révèlent que les sites de reproduction n'étaient pas occupés de manière constante chaque année pendant la période d'étude. Cependant, Kalkun Cay, Shark Island, Saba Island et Leduck Island dans les Îles Vierges américaines, ainsi que Cockroach Island, Green Cay, Cistern Point et Seal Dog Islands dans les Îles Vierges britanniques, ont été identifiées comme étant des sites de reproduction clés. La population nicheuse totale dans les Îles Vierges a varié au cours de la période d'étude entre 745 et 2750 couples nicheurs, une taille de population d'une importance mondiale pour cette espèce prise dans son ensemble. Nous avons observé un déclin progressif de la population nicheuse des Îles Vierges. La conservation de cette espèce devrait être axée sur des efforts continus de suivi sur les deux territoires, l'amélioration de l'habitat dans les sites de reproduction les plus peuplés, ainsi que des recherches sur les effets des tendances climatiques et océanographiques plus larges sur cette population nicheuse.

Mots clés étude des oiseaux marins, fidélité au site, Îles Vierges, *Sterna dougallii*, Sterne de Dougall

The Roseate Tern (*Sterna dougallii*) has a wide, scattered distribution across the Atlantic, Indian, and Pacific Oceans, as well as Australasia (Nisbet *et al.* 2014). Nisbet and Ratcliffe (2008) describe two subspecies: (1) *Sterna dougallii dougallii*, distributed in the North Atlantic including North America, the Caribbean, the islands of Venezuela, Europe, and Africa; and (2) *Sterna dougallii gracilis*, located in the Indian Ocean and Australasia. Several accounts have also attempted to distinguish two distinct breeding populations in the Americas: (1) one made up of individuals breeding in the northeastern United States and Canada and (2) one made up of individuals breeding in the southeastern United States, the Bahamas, and the Caribbean (hereafter "Caribbean population"). Justification for distinguishing these two breeding populations include differences in colony-site fidelity, nest-site selection, foraging behavior, clutch size, chick growth rates, and reproductive success, as well as apparent morphological differences (USFWS 2010).

The North Atlantic Roseate Tern population has suffered declines across its range. In the United States, the northeast breeding population was classified as Endangered in 1987; the population declined from ~8,500 pairs in the 1930s to ~2,500 pairs in the 1980s, by which time breeding was concentrated in a handful of sites with 85% of the population breeding on just two islands (USFWS 2010). The European population also experienced declines over the same time period. Breeding populations across Great Britain, Ireland, and France declined by 83% in less than 20 yr, dropping from 3,304 pairs in 1968 to 561 pairs in 1987 (Mitchell *et al.* 2004). These declines led Cabot (1996) to describe the species as the least numerous seabird of the temperate North Atlantic and classify it as one of the 11 European breeding bird species that are near-threatened. In recent years, after concerted conservation management actions in North America and Europe—including the Roseate Tern's inclusion in Annex 1 of the 2009 European Union Birds Directive as a species requiring special conservation measures (Lloyd *et al.* 2010)—these populations have begun to recover (Cadiou 2010, USFWS 2010).

Though the Caribbean population has been studied less extensively, in 1987 the United States Fish and Wildlife Service classified it as Threatened (USFWS 2010). Van Halewyn and

Norton (1984) cited ~4,000 breeding pairs in the Caribbean, while more recently Bradley and Norton (2009) estimated a range of 3,571–7,095 pairs, and Nisbet *et al.* (2014) estimated the total Caribbean population to be 6,000–7,000 pairs (although the authors state that this range could be too low in light of evidence that tropical Roseate Terns do not breed every year). The largest local breeding population in the Caribbean occurs in the Virgin Islands, which comprise the adjacent (approximately 1 km apart at the closest point) island territories of the United States Virgin Islands (USVI) and the British Virgin Islands (BVI). The Virgin Islands are located in the western Leeward Islands, which are part of the Lesser Antilles.

Here we compile and summarize data collected from both the USVI and BVI to report on the distribution and abundance of Roseate Terns breeding across this region over the last three decades. In turn, we examine local population trends and identify sites in this region that may be of particular importance to Roseate Terns.

Methods

Between 1987 and 2010, nest counts of Roseate Terns across the entire USVI (excluding St. Croix) were conducted annually by USVI Division of Fish and Wildlife (DFW). During these years, when logistically possible, the entire BVI territory was surveyed concurrently. Between 2014–2016, annual surveys were conducted in the USVI and BVI by DFW and the Jost Van Dykes Preservation Society; in 2015 only the BVI was surveyed. In total, we present data from surveys conducted in 27 yr in the period 1987–2016 (Fig. 1, Table 1), including concurrent surveys in the USVI and BVI from a total of 14 different years (Fig. 2). All surveys were performed during peak breeding times (May–June), and breeding colonies were located by visual surveys from boats circumnavigating the offshore cays. If a breeding colony was present, adults would be seen in attendance or flying above the colony; in the case of larger islands where observers could not see all potential nesting sites, observers watched for adults flying in and out of the colony. When a colony was located, surveyors accessed the breeding site, if logistically possible. Surveyors walked transects through the colony, recording the number of apparently occupied nests (identified by the presence of at least

Number of years recorded breeding

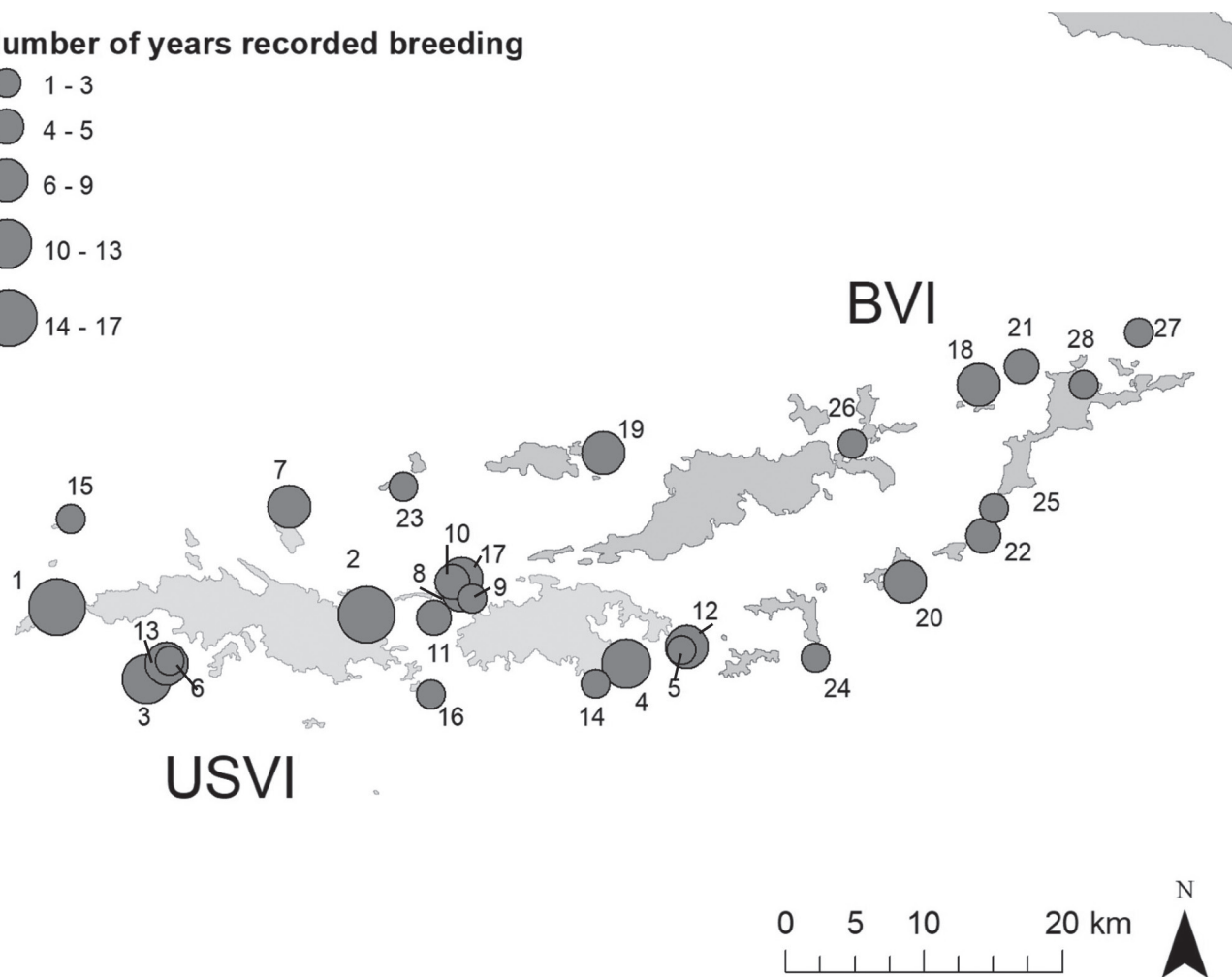
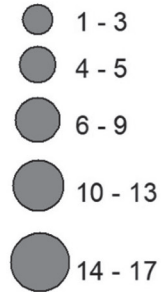


Fig. 1. Number of years breeding was recorded at 28 Roseate Tern breeding sites in the Virgin Islands. In the period 1987–2016, the USVI was surveyed in 26 yr and the BVI was surveyed in 15 yr. Numerical island labels correspond to site numbers in Table 1.

one egg or chick, or an incubating adult) as well as the number of adults flushed from the colony (at least two observers counted the flying birds and the highest count was recorded). Every effort was made to accurately survey the colonies while limiting human presence to avoid unnecessary disturbance. If it was not logistically possible to access a colony (i.e., if the island was inaccessible or if the colony was located on an inaccessible part of the island, such as a cliff edge), at least two observers counted the number of adults flying above the colony and calculated breeding pairs using a conversion factor to obtain a breeding pair index and to correct for non-breeding birds that occur in seabird colonies. We used the conversion factor 2.2, previously reported by Lowrie *et al.* (2012), which was the mean value determined by dividing the number of flushed adults by complete nest counts at three Roseate Tern colonies located elsewhere in the Caribbean. Throughout our surveys, we noted that the colonies observed were very easily disturbed and that a boat cruising around the edge of an island was enough to flush all birds from the colony. Thus, we are confident that estimates based solely on flushed adults accurately represent the number of breeding

birds present. We calculated the number of years within the survey period that each breeding site was used, as well as the average (\pm SE) population size of the colony at each site during years that breeding occurred (i.e., values of 0 were not included in the calculation of mean colony size across years). We also calculated the maximum number of successive years during which a breeding site was occupied for sites in the USVI in the years 1987–2010, and for sites in the BVI in the years 1993–1998. These time periods represent the longest continuous data sets for each territory. Additionally, we calculated the total breeding population for the entire Virgin Islands region for the years in which the USVI and BVI were concurrently surveyed. To identify population trends, we applied a linear regression to the breeding numbers recorded in each survey year.

Results

Roseate Terns were recorded breeding at 17 sites within the USVI in the 26 yr the territory was surveyed, and at 11 sites in the BVI in the 15 yr the territory was surveyed (Fig. 1). No single site in either the USVI or BVI was used for breeding during every year

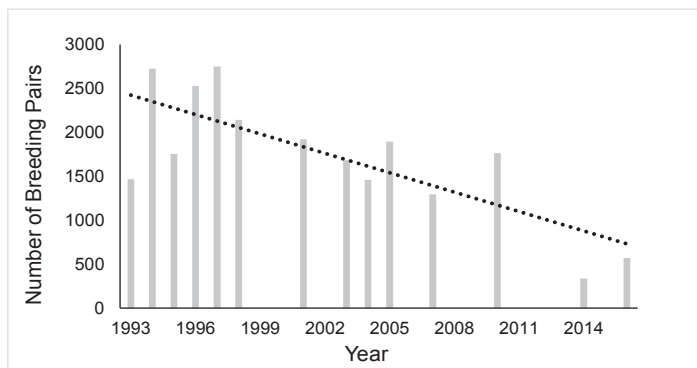


Fig. 2. Population estimates for Roseate Terns breeding in the Virgin Islands for the 14 yr in which the USVI and BVI were surveyed concurrently. The dotted line is a best-fit linear regression ($R^2 = 0.59$) which shows an overall downward trend in Roseate Tern breeding pairs around the Virgin Islands from 1993, when surveys began in the BVI, to the end of our study period in 2016.

surveyed in the period 1987–2016. During 24 yr of continuous annual surveying in the USVI, 1987–2010, only 8 of the 17 reported breeding sites were occupied for multiple years in a row. During 6 yr of continuous annual surveying in the BVI, 1993–1998, only 4 of the 11 reported breeding sites were occupied for multiple years in a row. The maximum number of years in which consecutive breeding was recorded at a site was 7, on Kalkun Cay, USVI (Table 1). The most frequently used sites in the USVI include Kalkun Cay (65% of the years the site was surveyed), Shark Island (62% of surveyed years), Saba Island (50% of surveyed years), and Leduck Island (46% of surveyed years). In the BVI, the most frequently used sites include Cockroach Island (47% of surveyed years), Green Cay and Cistern Point (both 40% of surveyed years), and the Seal Dog Islands (33% of surveyed years) (Fig. 1, Table 1). The largest colonies recorded over the survey period were located on Green Cay, BVI (200–1,755 pairs, average 746 ± 97 pairs), and Leduck Island, USVI (25–1,200 pairs, average 567 ± 122 pairs) (Table 1). Annual estimates of the breeding population in the USVI ranged 135–2,440 (average $1,142 \pm 112$) pairs, while annual estimates ranged 35–1,755 (average 608 ± 138) pairs in the BVI. During 14 yr in the period 1993–2016 when surveys were undertaken concurrently in the USVI and BVI, total population estimates for the Virgin Islands ranged 745–2,750 breeding pairs (average $1,814 \pm 154$ pairs; Fig 2).

Although concurrent surveys of the USVI and BVI were not conducted in all years, statistical analysis revealed an overall declining trend in the population of Roseate Terns in the Virgin Islands during our study period (number of pairs = $2,519 - (82 \pm 29) \times (\text{year} - 1993)$, $F_{1,12} = 17.8$, $R^2 = 0.59$, $p = 0.001$; Fig. 2).

Discussion

Our survey data from the Virgin Islands since 1987 highlight both the regional and global importance of the area's Roseate Tern population. Within the Caribbean, the Virgin Islands host the largest breeding population, making up between 11% and 40% of the total Caribbean population (based on minimum and maximum regional population estimates made by Nisbet *et al.* 2014). In global terms, the Virgin Islands also host one of the largest populations of the North Atlantic subspecies, rivaled only

by the breeding populations found on Great Gull Island, New York (1,413 pairs), and Bird Island, Massachusetts (708 pairs) (USFWS 2010, Spendelow *et al.* 2016).

Roseate Terns that breed in the tropics have been reported to be versatile in their colony site selection (Nisbet and Ratcliffe 2008). Our data supports this observation, since not one of the 28 breeding sites was used in every year surveyed (Table 1). It is unclear what might influence breeding site philopatry in our study area, but factors could include disturbance, predation, and parasitism (Duffy 1991, Monticelli *et al.* 2008). However, our extensive data set highlights that, over time, a number of sites both in the USVI and BVI have been more frequently utilized by breeding Roseate Terns than other sites; these include Green Cay in the BVI and Saba Island in the USVI, both of which are designated as Important Bird Areas by BirdLife International (Devenish *et al.* 2009). Other frequently used sites include Kalkun Cay, Shark Island, and Leduck Island in the USVI, and Cockroach Island, Cistern Point, and the Seal Dog Islands in the BVI. Yet there are no obvious reasons, either geographical or environmental, to explain why these sites have been more frequently used by breeding Roseate Terns over the past three decades.

There are some aspects of our data set that may impact the reliability of population comparisons between consecutive years. These include the differences in survey methodology (counting apparently occupied nests directly versus counting flushed adults and converting to breeding pairs), differences in the annual timing of surveys between years, whether surveys encompassed mostly incubating or mostly chick-rearing birds, and the fact that tropical Roseate Terns are reported to be intermittent breeders. Despite these limitations, however, it is apparent that the Virgin Island population has experienced a general decline over the last three decades. Causes of population decline in the Virgin Islands and across this species' range could include factors acting on the wider marine environment as well as on local breeding sites. Both local and wider-ranging oceanographic conditions can have an effect on seabird breeding behavior. For example, Ramos (2000) reported that in the Seychelles, sea surface temperature and the multivariate El Niño–Southern Oscillation index for the laying season were negatively correlated with the size of the Roseate Tern breeding population, but positively correlated with the initiation of breeding. Unpredictable food supply in tropical oceans and a lack of predatory fish to drive smaller prey species to the surface were also reported as factors for decreasing Roseate Tern breeding success in the Seychelles (Ramos 2000). Further research should be conducted to assess whether these factors affect the Virgin Islands population as well.

As ground-nesting seabirds, Roseate Terns are also vulnerable to nest predation from both native fauna, such as gulls (e.g., *Larus* spp.) and land crabs (*Coenobita clypeatus*) (Donehower *et al.* 2007, USFWS 2010), and introduced predators, such as black rats (*Rattus rattus*) and brown rats (*R. norvegicus*) (Harper and Bunbury 2015). Additionally, goats (*Capra aegagrus hircus*) and other introduced livestock can trample eggs, and human disturbance can have other negative effects on the breeding behavior of this species (SZ pers. obs.). It is likely that the Caribbean population of Roseate Terns is being negatively affected by a combination of the aforementioned factors, and

Table 1. Breeding site use by Roseate Terns within the Virgin Islands in the period 1987–2016 and average colony size (estimated number of breeding pairs \pm SE) of each colony for years when breeding was recorded. Maximum number of successive years breeding recorded is based on data from 1987–2010 for the USVI and 1993–1998 for the BVI. Site numbers correspond to island labels in Fig. 1.

Site #	Colony	Latitude	Longitude	Number of Years Surveyed	Number of Years Breeding Recorded	Maximum Number of Successive Years Breeding Recorded	Average Colony Size (\pm SE)
<i>USVI</i>							
1	Kalkun Cay	18°21'00.8"N	65°03'27.5"W	26	17	7	258 \pm 54
2	Shark Island	18°20'14.2"N	64°50'41.3"W	26	16	5	313 \pm 60
3	Saba Island	18°18'19.1"N	65°00'02.8"W	26	13	5	164 \pm 45
4	Leduck Island	18°18'58.1"N	64°41'18.0"W	26	12	3	567 \pm 122
5	Flanagan Island	18°19'35.0"N	64°39'02.8"W	26	9	2	431 \pm 104
6	Flat Cay	18°18'59.4"N	64°59'23.3"W	26	8	2	87 \pm 25
7	Pelican Rock	18°20'20.9"N	64°40'33.5"W	26	6	0	241 \pm 74
8	Rata Cay	18°21'20.8"N	64°47'48.8"W	26	5	0	162 \pm 57
9	Carval Rock	18°22'11.0"N	64°47'38.2"W	26	6	3	35 \pm 10
10	Congo Cay	18°22'03.4"N	64°48'12.7"W	26	5	0	85 \pm 53
11	Two Brothers	18°20'34.4"N	64°49'02.6"W	26	4	0	32 \pm 13
12	Flanagan Rocks	18°19'34.2"N	64°39'10.0"W	26	3	0	85 \pm 20
13	Little Flat Cay	18°19'04.2"N	64°59'19.6"W	26	3	0	57 \pm 27
14	Booby Rock	18°18'08.1"N	64°42'35.3"W	26	2	0	16 \pm 6
15	Cricket Rock	18°24'29.7"N	65°02'58.2"W	26	2	0	59 \pm 53
16	Dog Island	18°17'44.4"N	64°48'57.0"W	26	2	2	198 \pm 163
17	Ramgoat Cay	18°21'18.8"N	64°47'21.5"W	26	1	0	848 \pm 0
<i>BVI</i>							
18	Cockroach Island	18°29'40.8"N	64°27'48.9"W	15	7	2	335 \pm 38
19	Green Cay	18°27'11.7"N	64°42'30.9"W	15	6	5	746 \pm 97
20	Cistern Point	18°22'50.9"N	64°30'54.6"W	15	6	2	53 \pm 12
21	Seal Dog Islands	18°30'24.9"N	64°26'03.6"W	15	5	0	246 \pm 40
22	Round Rock Island	18°23'53.6"N	64°27'27.8"W	15	4	0	104 \pm 15
23	Watson Rock	18°26'20.8"N	64°50'01.6"W	15	3	0	36 \pm 2
24	Carrot Rock	18°19'34.5"N	64°34'13.8"W	15	2	2	56 \pm 31
25	Broken Jerusalem	18°24'39.1"N	64°27'11.5"W	15	2	0	45 \pm 18
26	Little Camanoe	18°27'29.9"N	64°32'36.0"W	15	1	0	24
27	Necker Island	18°31'38.1"N	64°21'32.2"W	15	1	0	10
28	Virgin Gorda	18°28'51.1"N	64°24'14.9"W	15	1	0	5

further investigation into population trends on other Caribbean breeding sites is warranted. Shealer *et al.* (2005) reported the movement of breeding birds between the USVI and two islands within Puerto Rico, so it is possible that individuals may regularly move between islands included in our surveys and those outside the study region. Thus, changes in population counts within a smaller region do not necessarily indicate concomitant changes in the population counts of a wider region; the local population could be changing more drastically than the regional population, or alternatively, may be stable even though the regional population is fluctuating.

Current conservation measures occurring on the most frequented Roseate Tern breeding sites in the Virgin Islands include control and eradication of rats on the Seal Dog Islands, rat and

goat control on Green Cay, and habitat restoration measures on Green Cay that include the installation of nest boxes and decoys to attract Roseate Terns. The fact that some frequently used breeding sites are far from pristine (e.g., have degraded habitats, invasive predators, or both) increases the difficulty of ascertaining which environmental factors, if any, might influence the site choice and subsequent reproductive success of breeding pairs. Thus, effective management practices for the Virgin Islands population remain exceedingly difficult to implement.

Conclusions

The Virgin Islands represent a globally important breeding area for the North Atlantic Roseate Tern. Continued breeding

season surveys should be conducted consistently across both the Virgin Islands and Puerto Rico to reveal whether the general downward trend in breeding pairs continues. When possible, both historical and recently reported key breeding sites should be restored (through the eradication or control of invasive species) and appropriate habitat restoration measures (including installation of nest boxes and decoys) should be implemented. This may help improve the breeding success of Roseate Terns in this region, which in turn could help reverse the decline of this species as a whole.

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Title Page Illustration

Roseate Tern (*Sterna dougallii*); photo taken offshore near Spanish Wells, Bahamas by Noah Frade (Macaulay Library ML31079161, Cornell Lab of Ornithology).

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