Seabirds of the Cay Sal Bank, The Bahamas

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Abstract.—The Cay Sal Bank in The Bahamas is one of the Caribbean region's most important areas for breeding seabirds, but the colonies previously lacked solid estimates. This paper describes results of four visits between 2010 and 2012. The Santaren Channel, used to transit to and from Cay Sal Bank, contained high numbers (6.1 ± 0.4 birds per km^2) of seabirds. The Cay Say Bank has at least 117 detectable islands with 484 ha of land area; the most numerous colony was at Elbow Cay (23 ha). Audubon's Shearwaters (*Puffinus lherminieri*) were breeding at 97 pairs per ha (total: 2,200; 95% CI = 1,650-2,800 pairs), Sooty Terns (*Onychoprion fuscatus*) at 382 pairs per ha (total: 8,800; 95% CI = 6,900-10,700 pairs), Bridled Terns (*Onychoprion anaethetus*) at 38 pairs per km coastline (5,829 m coastline; total: 220; 95% CI = 145-295 pairs) and Brown Noddies (*Anous stolidus*) at 72 pairs per ha (total: 1,609; 95% CI = 1,070-2,250 pairs). The population of Audubon's Shearwaters is among the largest in the world while populations of the other species are regionally significant. Roughly 420 ha (87% of the available land) were visited; however, many of the smaller cays (43 islands with 30 ha of habitat) have still not been surveyed. Seabirds were present in low densities (0.3-20 total pairs per ha) on the other large islands, all of which contain populations of introduced black (*Rattus rattus*) or Norway (*R. norveigicus*) rats. These visits provide the first repeatable surveys of breeding seabirds at Cay Sal Bank. *Received 13 January 2014, accepted 11 August 2015.*

Key words.—*Anous stolidus*, Audubon's Shearwater, Bridled Tern, Brown Noddy, Cay Sal Bank, *Onchyoprion anaethetus*, *Onchyoprion fuscatus*, *Puffinus lherminieri*, Sooty Tern.

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Populations of tropical seabirds have declined since the settlement of islands by humans (Steadman 2006). In the Caribbean and The Bahamas, seabirds have been extirpated from most mainland areas and nest primarily on uninhabited cays and rocks (van Halewyn and Norton 1984; Pregill *et al.* 1994; Schreiber and Lee 2000; Bradley and Norton 2009). The Cay Sal Bank in The Bahamas (hereafter, "the Bank") is a large, uninhabited atoll with thousands of breeding seabirds. The land and waters of the Bank contain healthy, relatively intact ecosystems including beach strand, rocky shore, scrubland coppice, and *Coccothrinax* coppice communities on land (Correll and Correll 1982; E. Freid, pers. commun.) and sea grass, coral reef and hard bank in the water (Bruckner 2011). Loggerhead sea turtles (*Caretta caretta*) nest in high density on islands with significant beaches (Addison and Morford 1996).

Previous estimates of the seabird populations on the Bank were pooled over the area and lacked confidence intervals. The most important populations were reported at Elbow Cay on the western edge, with numerous Audubon's Shearwaters (see Tables 1 and 2 for scientific names), Sooty Terns and other seabird species (Buden and Schwartz 1968; Sprunt 1984; Buden 1987; White 1998). The area is designated an Important Bird Area but is not otherwise protected (Moore and Gape 2008). During the *Deepwater Horizon* spill in 2010 (Mariano *et al.* 2011; Haney *et al.* 2014), concern that oil might enter the Straits of Florida and impact The Bahamas led to the organization of three expeditions to the Bank to assess the status of the marine and terrestrial habitats and document any damage from the oil. In 2012, a trip was organized to count and survey the seabird populations on the Bank.

Table 1. Counts of the seven most common species encountered during transit between Grand Bahama and Cay Sal Bank, 26-31 May 2012.

Date	Location	Area Surveyed (km^2)	Audubon's Shearwater (*Puffinus lherminieri*)	Brown Booby (*Sula leucogaster*)	Magnificent Frigatebird (*Fregata magnificens*)	Laughing Gull (*Leucophaeus atricilla*)	Bridled Tern (*Onchyoprion anaethetus*)	Sooty Tern (*Onchyoprion fuscata*)	Brown Noddy (*Anous stolidus*)
26 May	New Providence Channel	6.3	1	1	0	0	4	6	3
27 May	Santaren Channel	16.8	28	0	1	1	27	28	16
27 May	Cay Sal Bank	3.5	0	0	0	4	0	1	1
30 May	Cay Sal Bank	7.8	0	4	2	2	1	4	19
31 May	Florida Current	14.1	2	0	0	0	5	1	4

METHODS

Study Area

The Bank is 75 km north of Cuba, 145 km east of Florida and 200 km south of Bimini. It has six larger islands (15-131 ha) and at least 112 smaller islets and rocks (Fig. 1). All rocks and cays with land area above high tide were measured using the area measurement tool within ArcGIS Explorer software using the 'Imagery with Labels' basemap (Environmental Systems Research Institute 2014).

Surveys

At sea surveys were conducted en route to the Bank from either Nassau (2010) or Grand Bahama (2012), passing along the northern and western edge of the Great Bahama Bank (Fig. 1). In 2010, opportunistic observations were taken of birds and wildlife during the voyage. In 2012, birds were counted using standard transects within 200 m of either side of the boat from the midsection to a point 200 m directly forward of the bow (Camphuysin and Garthe 2004). The boat travelled at a speed of 13 kmph, so that each 10 min block covered 0.43 km^2. Detection rate was assumed to be 100% within this distance.

On land surveys were conducted using circular plots to estimate numbers of nesting seabird pairs on Elbow Cay in 2010 and 2012 (Burger and Lawrence 2000; Mackin 2004). Plots were searched at night using playback to allow detection of Audubon's Shearwaters. In 2010, 10 plots of 4-m radius were placed systematically at 98-m intervals from the northern tip of Elbow Cay south to the lighthouse, and all nests were counted. In 2012, 42 plots were placed randomly and assigned to six survey teams. For Sooty Terns, all nests within 5 m of the center were counted. For Brown Noddies and Audubon's Shearwaters, all nests within 7 m of the center were counted. On 29 May 2012, a total of 27 plots were located and searched by the teams between 21:30 hr and 23:00 hr. Values for Audubon's Shearwaters were divided by 0.79 to adjust for the detection rate (Trimm and Hayes 2005; W. A. Mackin, unpubl. data) and multiplied by 0.54 to convert defended nest sites to breeding pairs (W. A. Mackin, unpubl. data).

For Bridled Terns, which nest in cavities on the periphery of islands, a separate survey was conducted at Elbow Cay in 2012. Nests were counted in seven transects of 125 m around the perimeter of the island. These transects were spaced approximately 600 m apart. The last 25 m of each transect were recounted by the third observer to estimate detection rate. The estimate of the number of breeding pairs of Bridled Terns was produced by multiplying the average count by the ratio of the distance of coastline available at Elbow Cay divided by the transect length (125 m). For surveys at sea and on land, the mean (λ), SE [$\ddot{O}(\lambda / n)$] and 95% CI ($\lambda \pm 1.96$ SE) were calculated for Poisson-distributed (count) data (Greenwood 1996; Barker 2002).

To check for the presence of *Rattus* species, observers searched and watched for signs of rats during all

Table 2. Islands visited on the Cay Sal Bank during surveys in 2010 and 2012 with notable observations. Scientific names given for bird species not identified in the text or Table 1.

Location	Date(s)	Observations
Cay Sal Cay	5/24/2010	10-20 pairs each of Royal (*Thallaseus maximus*) and Least (*Sternula antillarum*) terns; numerous sea turtle crawls
	7/22/2010	No birds present; fate of nesting attempts unknown; abundant sea turtle eggs
	5/30/2012	Two Laughing Gull nests; numerous sea turtle crawls
Elbow Cays	5/23/2010	Audubon's Shearwater, Sooty Tern, Bridled Tern and Brown Noddy nesting
	7/22/2010	Successful nesting by all four species
	5/29/2012	Same four seabirds nesting; Short-eared Owl observed
Double-headed Shot Cays	6/25/2010	Sooty Tern, Bridled Tern and Brown Noddy nesting
	5/30/2012	Royal, Sooty and Bridled terns and Brown Noddy nesting; Short-eared Owls and Norway Rats observed
Damas Cays	5/27/2012	Sooty Tern and Brown Noddy nesting; Brown Booby, Bridled Tern and Audubon's Shearwater suspected nesting
Anguilla Cay	5/25/2010	Audubon's Shearwater and Bridled Tern nesting, first observation here
	7/21/2010	Three shearwater chicks near fledging
	5/27/2012	Black rats and Barn Owl observed
	5/28/2012	Fewer shearwaters near north end; Cuban racer collected
Cotton Cay	5/24/2010	Sandwich Tern (*Thallaseus sandvichensis*) and Laughing Gull nesting; numerous sea turtle crawls on north beaches
	5/28/2012	Royal Tern, Sandwich Tern, Roseate Tern (*Sterna dougallii*), Sooty Tern, Bridled Tern and Brown Noddy nesting; rat skull found; numerous sea turtle crawls on all beaches

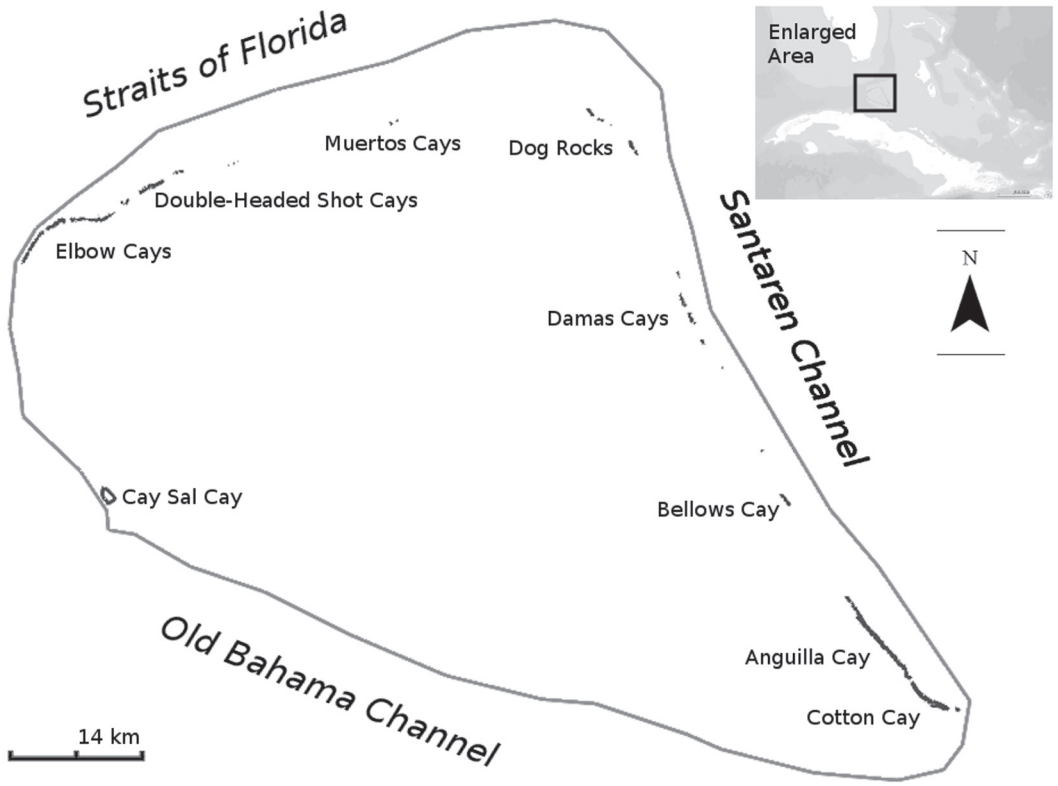

Figure 1. The islands of Cay Sal Bank, The Bahamas.

fieldwork. Six baited, spring-loaded rat traps were set on Elbow Cay and Cay Sal Cay during 1 day of work in 2010 and again at Elbow Cay in 2012. Finally, a Reconyx Hyperfire PC800 Camera Trap baited with bread was set during 1 night of work on Anguilla Cay in May 2012.

RESULTS

In 2010, it was noted that the Santaren Channel had high numbers of seabirds during transit to and from the Bank. In 2012, 37.2 km^2 of pelagic water (deeper than 100 m) was surveyed with an average of 3.5 ± 0.2 birds per km^2. Audubon's Shearwaters, Brown Boobies, Magnificent Frigatebirds, Laughing Gulls, Bridled Terns, Sooty Terns and Brown Noddies were the most common species observed (Table 1). Densities of pelagic species were highest in the Santaren Channel (6.1 ± 0.4 birds per km^2), moderate in the New Providence Channel (2.4 ± 0.4 birds per km^2) and lowest in the Straits of Florida (0.9 ± 0.5 birds per km^2).

Observations from visits to cays are given in Table 2. Terns were on eggs in late May of both years, while most Audubon's Shearwaters had small chicks (~1-2 weeks after hatching), similar in stage to the same species in the Exuma Cays on similar dates (Lee and Clark 1994; Mackin 2004). Chicks of all species were near or past fledging by the end of July in 2010. No sign of Black (*Rattus rattus*) or Norway (*R. norveigicus*) rats was found on Elbow Cay. Rats were detected on the other islands that were visited: Anguilla (sightings, photos), Cotton (skull), South Double-headed Shot (sighting) and Cay Sal Cays (Royal Bahamian Defense Force Marines, pers. commun.). We found three potential predators of seabirds that were new records for the Bank: Barn Owls (*Tyto alba*), Short-eared Owls (*Asio flammeus*), and the first Cuban racer (*Cubophis cantherigerus*) outside of Cuba (Krysko *et al.* 2015) (Table 2).

In available imagery, there were at least 117 islands on the Bank ranging from 40 m^2 to 131 ha in area with 484 total ha (Table 3; Fig. 1). Surveys in 2010 and 2012 estimated the density of seabirds at Elbow Cay, and the

Table 3. Island area, breeding pairs of seabirds and detection of rats on the Cay Sal Bank. Counts or best estimates of breeding pairs from ground surveys are in bold text. Estimates in plain text apply the low 95% density estimate from Elbow Cay to islands that had similar habitat but were not surveyed. Numbers denoted by "~" are conservative guesses. "S" indicates Breeding Suspected. "+" indicates that estimates are thought to be low.

	Bank Total	Cay Sal	South Elbow Cays	Elbow Cay	East Elbow Cays	Double-Headed Shots	Dog Rocks	Damas Cays	Bellows Cay	Anguilla Cay	Cotton Cay
Area (ha)	485	131	13	23	20	35	8	14	7	117	116
Islands	117	1	13	3	30	10	20	21	2	5	3
Audubon's Shearwater	4,900		1,000	**2,230**	1500	1+		S		~270	
Brown Booby	0-50			S				S			
Laughing Gull	70+	2				**48**					~20
Least Tern	20+	**20**									S
Royal Tern	276+	**20**				**206**					~50
Sandwich Tern	50+										~50
Roseate Tern	80+		S								**42**-80
Sooty Tern	24,650		4,000	**8,800**	6,065	~200		4,500			~200
Bridled Tern	1,160		170	**220**	220	~50		100		~200	~200
Brown Noddy	4,500		620	**1,600**	940	~200		750			~200
Rats Observed		Yes	No	No	No	Yes				Yes	Yes
Total Pairs	34,800	43	5,800	12,900	8,700	700		5,400		470	800
Density (per ha)	72	0.3	442	558	436	20		382		2.6	6.9

results along with population estimates are given in Table 4. The 2010 and 2012 surveys with circular plots are compared in Fig. 2. The estimate of density for Sooty Terns was higher in 2010 than in 2012, while the estimates for Audubon's Shearwaters and Brown Noddies were similar.

DISCUSSION

The waters of the Santaren Channel produced high counts of seabirds in 2010 and 2012. The densities measured in 2012 were comparable to those around productive eddies of the Gulf Stream off the southeastern USA (e.g., Cold Core Eddy = 7.3 individuals per km^2; Haney 1986). More surveys of wildlife in Santaren Channel could determine whether it is an important marine feeding area.

Elbow Cay and the surrounding islands are among the largest seabird colonies in the Caribbean. Comparable breeding populations of small *Puffinus* shearwaters (formerly *Puffinus assimilis* and *P. lheminieri*, see Austin *et al.* 2004 and Clements *et al.* 2015) have been suggested at Reunion Island (*P. bailloni*; 235 colonies; 3,000-5,000 pairs; Bretagnolle *et al.* 2000), are known at Allen Cay and Long Cay in the Exuma Cays (*P. lherminieri*; Mackin 2004) and are thought to exist in the tropical Pacific (*P. bailloni*; BirdLife International 2015). Jensen (1981) estimated a total of 1,500 pairs of Barolo Shearwater (*P. baroli*) at Selvagem Grande Island in the Portuguese Madeira archipelago in the North Atlantic Ocean (225 ha). More pairs of Audubon's Shearwaters were documented on the Bank (4,900 nests) than were known previously to nest in the entire Caribbean region, estimated at 2,700 pairs by Bradley and Norton (2009) and 3,000-5,000 pairs by Lee (2000). There are hopefully other colonies yet to be documented, but Elbow Cay is the largest known or suspected (W. A. Mackin, unpubl. data). Bank populations of Sooty Terns, Bridled Terns and Brown Noddies reported here are 8%, 13% and 11%, respectively, of the Bradley and Norton (2009) baselines. Notably, the 2010 and 2012 surveys at Elbow Cay produced different densities of Sooty Terns but not of Audubon's Shearwaters or Brown Noddies (Fig. 2). The 2010 survey plots were aligned along the long axis of the island. This allocation may have biased the estimate by putting plots primarily in the densest habitat for Sooty Terns, while the populations of the other two species were independent of this feature. The simplest explanation for the difference is that these two surveys demonstrate the superiority of randomly-placed, larger and more numerous plots.

In contrast to Elbow Cay, the populations on the largest islands (Cay Sal, Anguilla, Cotton and the Double-headed Shot Cays) were sparse (Table 3). Elbow Cay lacks both rats and Cuban racers. Rats are known to depress seabird populations, particularly for smaller taxa such as these (Jones *et al.* 2008). Cuban racers are not known predators of seabirds but do prey on other small birds (Vasquez

Table 4. Results of surveys at Elbow Cay in 2010 and 2012. For Audubon's Shearwater, Sooty Tern and Brown Noddy, mean density ± SE per ha of circular plots is reported. Estimates for Audubon's Shearwaters were adjusted by dividing by detection rate (0.79) and multiplying by rate of breeding within defended nests (0.54). For Bridled Terns, counts in 125-m transects are reported with linear density multiplied by the total island coastline (5,829 m).

Year	Plots	Plot Size	Species	Density (per ha)	95% CI
			Audubon's Shearwater	109 ± 38	770-4,240
2010	10	50.3 m^2	Sooty Tern	657 ± 114	9,950-20,250
			Brown Noddy	119 ± 49	550-4,940
		153.9 m^2	Audubon's Shearwater	97 ± 13	1,650-2,800
2012	27	78.5 m^2	Sooty Tern	382 ± 42	6,900-10,700
		153.9 m^2	Brown Noddy	72 ± 13	1,100-2,250
2012	7	125 m	Bridled Tern	38 ± 6 per km	145-295

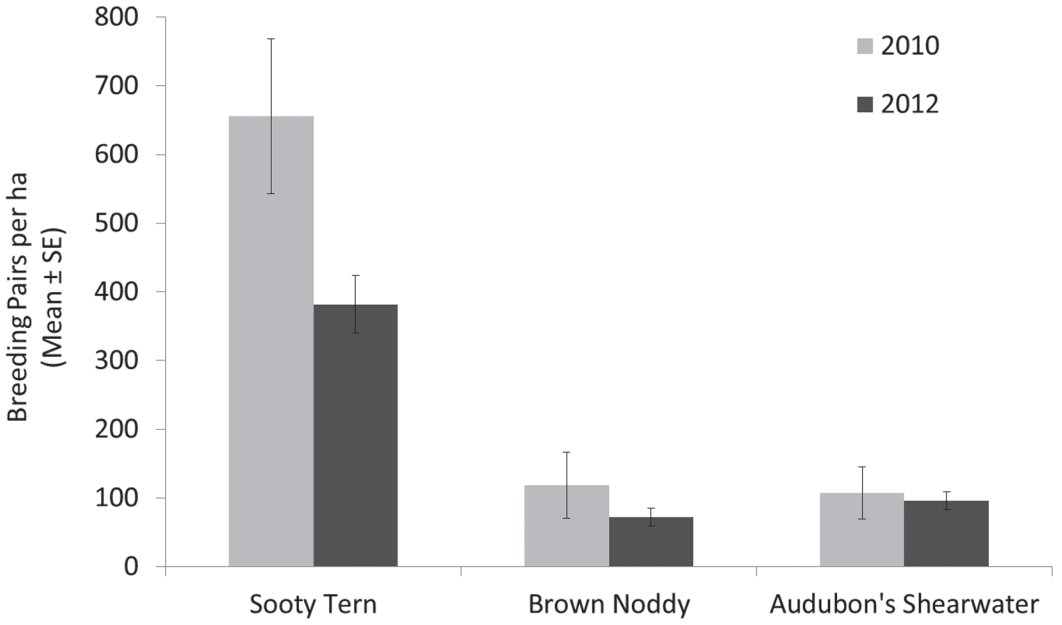

Figure 2. Densities of Sooty Terns (*Oncyoprion fuscata*), Brown Noddies (*Anous stolidus*) and Audubon's Shearwaters (*Puffinus lherminieri*) at Elbow Cay in 2010 and 2012.

et al. 2013); however, they were only found at one cay.

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