Seabird populations of the Chagos Archipelago, Indian Ocean: an evaluation of IBA sites

ANDREW MCGOWAN, ANNETTE C. BRODERICK and BRENDAN J. GODLEY

Abstract Indian Ocean seabirds are subject to numerous threats, and populations are thought to be at a fraction of historical levels. We carried out a rapid assessment of the seabird breeding populations of the Chagos Archipelago, a UK Overseas Territory, during early March 2006. We surveyed 26 islands covering the four island groups of the Archipelago. A total of 17 species of breeding seabird were recorded. Since the last survey in 1996, nine species showed reductions in the number of breeding pairs, with brown noddy *Anous stolidus* and lesser noddy *Anous tenuirostris* showing reductions of *c.* 22,000 and *c.* 27,000 pairs, respectively. These reductions, coupled with apparent sooty tern *Sterna fuscata* colony relocations, are central to our suggested changes to the Important Bird Areas (IBAs) criteria in the Archipelago and we propose two new sites for IBA status. We discuss our findings within a regional conservation context and provide recommendations for the implementation of an annual monitoring scheme of Chagos seabird populations to allow appropriate conservation management.

Keywords Chagos, conservation, IBAs, Indian Ocean, monitoring, seabirds.

This paper contains supplementary material that can be found online at http://journals.cambridge.org

Introduction

The islands of the Indian Ocean are among the most biologically diverse regions on earth and provide a haven for the region's breeding seabird species (Conservation International, 2006). There are still many data deficiencies for seabird populations in the Indian Ocean. Populations are thought to be at a fraction of their historical levels and subject to widespread and numerous terrestrial (Feare, 1976, 1978; Courchamp *et al.*, 2003; Baker *et al.*, 2004) and marine threats (Klaer & Polacheck, 1997; Willmann, 2001; Ramos *et al.*, 2002; van der Elst *et al.*, 2005).

Biogeographically, the Chagos Archipelago lies at the southern end of the Laccadives-Maldives-Chagos ridge, covers an area of 60,000 km^2 and consists of a series of islanded atolls, several drowned atolls, and submerged banks (Sheppard & Seaward, 1999). All islands within the archipelago have been uninhabited since the late 1960s with the exception of Diego Garcia, which supports a US military facility of *c.* 3,000 personnel (Sheppard & Seaward, 1999). The last extensive survey of the breeding seabirds in Chagos was in 1996 (Symens, 1999) and since then only the birds of Diego Garcia have been surveyed (Carr, 1998, 2004, 2005). Ten Important Bird Areas (IBAs) are currently designated on Chagos (BirdLife International, 2004), all of which support significant seabird/waterbird congregations (Symens, 1999; Carr, 2004).

The lack of up-to-date information for seabirds in the Chagos Archipelago is a fundamental barrier to the detection of threats, construction of management plans, and implementation of conservation actions. Here we present the results of a survey of the Chagos Archipelago and synthesize the best current information on the breeding seabird populations in the Archipelago and interpret these within both a regional and global conservation context.

Methods

The seabirds of the Chagos Archipelago were surveyed over 1–15 March 2006 by AMcG. In total, breeding seabirds were counted on 26 islands covering most island groups (Appendix). Rapid assessment surveys were conducted between 08.00 and 18.00 and the amount of time spent on each island was 0.75–4 h, dependent on the size of the island and the number of seabirds present. During the course of a survey the perimeter of the island was mapped using a global positioning system (GPS) for calculation of perimeter distance and island surface area. As birds were not marked, we endeavoured to survey islands that were in close proximity to one another on the same day to reduce the potential problem of double counting.

For all islands we estimated the number of breeding pairs of each seabird species present by using apparently occupied nest-sites (AONs; Bibby *et al.*, 1992) and followed the criteria for an AON for each species from Symens (1999). For the smallest islands only, direct counts of all AONs were made for each seabird species present but for the majority of islands a different approach was required and the survey techniques employed are detailed below.

Boobies (Sulidae), frigatebirds (Fregatidae) and tree-nesting terns (Sternidae)

As the vast majority of boobies, frigatebirds and tree-nesting terns nest in the vegetation in close proximity to the sea's

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edge a series of plot counts was conducted around the entire coastline of each island. All plots were at the interface between the vegetation line and either the open sand, rocky substratum or sea's edge depending upon the nature of each island. At each plot we counted the number of AONs of each seabird species in a 10 m (along the coastline) × 5 m (inland) plot and repeated counts every 100 m around the entire coastline of each island. We derived individual island population estimates for each species by dividing the total circumference of each island by 10 and then multiplying this value by the mean number of AONs per plot. Any major seabird colonies, mainly lesser noddy *Anous tenuirostris*, that had been identified as occurring outside the area surveyed, were visited and direct counts of AONs made and added to island totals. The areas occupied by these colonies were subtracted from the island circumference estimate for that species. Colonies that had been identified as occurring in the interior of an island, mainly frigatebirds and some lesser noddies, were also visited and direct counts of AONs made and added to island totals.

Ground-nesting terns (Sternidae)

We endeavoured to minimize disturbance at ground-nesting tern colonies. Sooty tern *Sterna fuscata* colonies were generally large and expansive, with a high density of birds, and therefore we adopted a species-specific approach. Firstly, the perimeter of the colony was walked and mapped using a GPS. Next, the number of visible AONs in a 5 m radius circle were counted at five or six points on a transect line through the colony (mean distance between plot counts = 105.1 ± SE 12.4 m; range 17–292 m; n = 40 inter-point distances from three colonies) because the density of nests is known to vary throughout a colony (Feare *et al.*, 1997). The number of plot counts was dependent on the size and shape of the colony. Mean number of AONs per m^2 was calculated for each colony and this value was multiplied by colony surface area to give an overall estimate of breeding pairs. Colony surface area was calculated from GPS mapping data using the software *MatLab* (Mathworks, Cambridge, UK). We did not conduct plot counts in the sooty tern colony on Grande de Coquillage because the risk to eggs and chicks was deemed too great. To attain an estimate for this sooty tern colony we mapped the colony as above and then used an average AON per m^2 from the other three colonies. For all other ground-nesting tern species colonies were small and direct counts of AONs were made.

Shearwaters (Procellariidae)

In Chagos two species of shearwater, Audubon's shearwater *Puffinus lherminieri* and wedge-tailed shearwater *Puffinus pacificus*, nest in mixed colonies (Symens, 1999). To derive estimates for the number of breeding pairs of each, we used a similar approach to that used for sooty terns. Firstly, we visually estimated the percentage of the surface area of the island that had burrows present and then conducted a series of plot counts (range 4–9 points) within the colony. All plot counts took place along the fringes of the colony because of the dangers from collapsing burrows. At each plot we counted the number of burrows of each species in a 10 × 5 m plot and used an occupancy rate of 45% (Symens, 1999) to derive an estimate of AONs per m^2 for each point. Burrows were assigned to a species on the presence of large pre-fledging chicks. The mean number of AONs per m^2 for each species, for all plots, was multiplied by colony surface area to derive an island population estimate.

We did not survey the main island of Diego Garcia and used breeding pair estimates for this island from Carr (2005). To assess the regional and global significance of the island populations and IBA criteria we used data from the literature on biogeographical and global population sizes. Terns are classified as waterbirds, rather than seabirds, for the purposes of the Ramsar Convention (Delaney & Scott, 2002) and therefore Asian and global estimates of the number of breeding pairs of each tern species were taken from published literature on the number of estimated individuals (BirdLife International, 2004) and halving this value. Global estimates of the number of breeding pairs of each seabird species, excluding terns, were also taken from BirdLife International (2004). As far as we are aware there are no Asian population estimates currently available for any seabird species. Species' names and classification follows BirdLife International (2004).

Results

All 17 species recorded breeding in 1996 (Symens, 1999) were recorded in 2006 (see full data set by island in Appendix). We directly compared the breeding numbers of each seabird species for islands that were surveyed in both 1996 and 2006. In 2006 nine species showed a decrease in the number of breeding pairs (mean relative reduction in population = 57.6%, range 13.3–90.1%) compared to 1996 (Table 1). The largest absolute decreases occurred in both species of noddy, with brown noddy *Anous stolidus c.* 22,000 pairs fewer (78%) and lesser noddy *c.* 27,000 pairs fewer (91%). There were also large relative decreases in the number of pairs of masked booby *Sula dactylatra* (354 pairs, 67.4%) and Audubon's shearwater (399 pairs, 68.6%). Three of the species (bridled tern *Sterna anaethetus*, roseate tern *Sterna dougallii*, and white-tailed tropicbird *Phaethon lepturus*) that showed large relative decreases (46–80%) have very small (≤ 20 pairs) population estimates.

Eight species showed an increase in the number of breeding pairs since 1996 (Table 1), with a mean relative increase in population size of 492.5 ± SE 293.9% (range 12.6–2,262.1%).

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TABLE 1 Estimated number of breeding pairs of each of nine waterbird and eight seabird species occurring within the Chagos Archipelago in 1996 (from Symens, 1999) and 2006 (with % population change from 1996 to 2006), and in Asia and globally. For full 2006 data set and species' Latin names, see Appendix.

Species	No. of breeding pairs 1996	No. of breeding pairs 2006	Population change (%)	Asian population[1] (% of Asian population occurring on Chagos Islands)	Global population[1] (% of global population occurring on Chagos Islands)
Waterbirds					
Great crested tern	60	52	-13.3	20,000 (0.52)	
Roseate tern	20	4	-80.0	5,000 (0.16)	82,000 (0.01)
Black-naped tern	29	69	137.9	15,000 (0.92)	
Little tern	4	6	50.0	25,000 (0.05)	410,000 (<0.01)
Bridled tern	15	6	-60.0	500,000 (<0.01)	
Sooty tern	73,000	82,208	12.6	2,000,000 (8.22)	22,000,000 (0.75)
Brown noddy	28,533	6,433	-77.5	750,000 (1.72)	
Lesser noddy	29,505	2,682	-90.9	1,000,000 (0.54)	1,200,000 (0.45)
White tern	521	603[2]	15.7	500,000 (0.24)	1,100,000 (0.11)
Seabirds					
Audubon's shearwater	582	183	-68.6		30,000 (0.61)
Wedge-tailed shearwater	3,400	2,863	-15.8		1,500,000 (0.19)
White-tailed tropicbird	13	7	-46.2		25,000 (0.03)
Brown booby	29	685	2,262.1		100,000 (0.69)
Masked booby	525	171	-67.4		100,000 (0.17)
Red-footed booby	7,165	8,156[2]	13.8		300,000 (2.72)
Great frigatebird	12	164	1,266.7		170,000 (0.10)
Lesser frigatebird	85	239	181.2		100,000 (0.24)

[1]From BirdLife International (2004)
[2]Estimates include values for main island of Diego Garcia from Carr (2005)

Both frigatebird species showed large relative increases (lesser frigatebird *Fregata aerial* 154 pairs, 181%; great frigatebird *Fregata minor* 152 pairs, 1,267%), although the largest relative increase was of brown booby *Sula leucogaster* (656 pairs, 2,262%). Sooty terns increased by *c.* 9,000 pairs (12.6%).

In a direct comparison of the islands surveyed in 1996 and 2006, all the island groups experienced decreases in species richness of breeding seabirds. Lesser noddy was lost from the Salomon island groups along with roseate tern, which was also lost from Diego Garcia. Peros Banhos lost four breeding species (Audubon's shearwater, wedge-tailed shearwater, white-tailed tropicbird and brown booby), and the Great Chagos Bank lost bridled tern and great crested tern *Sterna bergii.* Despite experiencing species losses, all island groups, with the exception of the Great Chagos Bank, gained new breeding species. The Peros Banhos group gained lesser frigatebird and bridled tern, which was also new for the Diego Garcia group. The Salomon Islands have been colonized by red-footed booby *Sula sula* since 1996. In terms of the absolute number of breeding pairs only the Peros Banhos island group showed an increase (7,867 pairs, 9%), whereas the other island groups all showed declines ranging from 4% (181 pairs, Diego Garcia) to 81% (45,278 pairs, Great Chagos Bank; Fig. 1). The large apparent decreases are predominately being driven by two species, lesser noddy and brown noddy, from three islands in the Great Chagos Bank (North Brother, Sea Cow and South Brother).

We surveyed eight of the 10 IBAs (the islands of Danger and Nelson in the Great Chagos Bank were not visited). Of the IBAs surveyed, four islands (Sea Cow, South Brother, Middle Brother and Ile Longue) failed to meet the requirements for IBA status (Table 2). The remaining four islands met the IBA status objectives but with alterations to their current criteria. Barton Point Nature Reserve on Diego

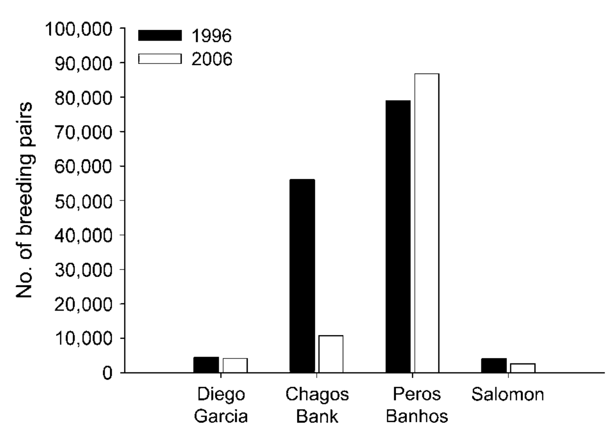

FIG. 1 Total number of breeding pairs of seabirds on the four main island groups (see Appendix for full dataset) in 1996 (from Symens, 1999) and 2006 (this study).

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TABLE 2 Current and proposed criteria for the Important Bird Areas of the Chagos Archipelago. Numbers in brackets refer to the estimated number of breeding pairs.

IBA location	Criteria of current status[1]	Proposed status criteria
Barton Point Nature Reserve, Diego Garcia	A4ii red-footed booby (16,067); A4iii >10,000 pairs of seabirds	A4ii red-footed booby (4,061)[2]; retain A4iii
Danger, Chagos Bank	A4i brown noddy (11,100); A4ii red-footed boobies (3,470); A4iii >20,000 waterbirds	Not surveyed in 2006; retain until next survey
Sea Cow, Chagos Bank	A4i brown noddy (11,500); A4iii >20,000 waterbirds	Retain until annual monitoring implemented
North Brother, Chagos Bank	A4ii Audubon's shearwater (420); A4iii >10,000 pairs of seabirds	A4ii Audubon's shearwater (183); retain A4iii
Middle Brother, Chagos Bank	A4i sooty tern 12,500; A4iii >20,000 waterbirds	Retain until annual monitoring implemented
South Brother, Chagos Bank	A4i lesser noddy 7,300; A4i brown noddy 6,100; A4iii >20,000 waterbirds	Retain until annual monitoring implemented
Nelson, Chagos Bank	A4i lesser noddy 13,700; A4i brown noddy 8,300; A4iii >20,000 waterbirds	Not surveyed in 2006; retain until next survey
Petite Ile Bois Mangue, Peros Banhos	A4i lesser noddy 12,000; A4iii >20,000 waterbirds	A4i sooty tern (20,424); A4iii >20,000 waterbirds
Ile Parasol, Peros Banhos	A4i sooty tern 14,000; A4iii >20,000 waterbirds	A4i sooty tern (9,186); A4iii >20,000 waterbirds
Ile Longue, Peros Banhos	A4i sooty tern 32,000; A4iii >20,000 waterbirds	Retain until annual monitoring implemented
Petite de Coquillage, Peros Banhos		A4i sooty tern (34,669); A4iii >20,000 waterbirds
Grande de Coquillage, Peros Banhos		A4i sooty tern (15,429); A4iii >20,000 waterbirds

[1]From Birdlife International (2005)
[2]Estimates include values for main island of Diego Garcia from Carr (2005)

Garcia and North Brother in the Chagos Bank failed to match the A4iii criteria (see Delaney & Scott, 2002, for details of the criteria) although the A4ii criteria for both sites was met with reduced breeding pair estimates (Table 2). The islands of Ile Bois de Mangue and Ile Parasol in Peros Banhos met the A4iii criteria and Ile Parasol also retained the A4i categorization for sooty tern but with a reduced breeding pair estimate (Table 2). Ile Bois de Mangue should be assigned A4i status for sooty tern (20,424 pairs) but it failed to meet the A4i criteria for lesser noddy (Table 2). We propose the islands of Petite de Coquillage and Grande de Coquillage for IBA status based on the A4i and A4ii criteria for the number of breeding pairs of sooty tern (Table 2).

Discussion

Of the 17 breeding seabird species that were recorded in the Chagos Archipelago nine showed a decrease in breeding numbers since 1996 and eight showed an increase. There were no clear patterns, although both species of frigatebird appear to have increased, whereas both species of noddy appear to have declined. All the island groups within Chagos both gained and lost individual species although the most striking overall losses in breeding numbers occurred on the Great Chagos Bank. Our assessment of eight IBA sites revealed that 50% failed to meet the necessary criteria, and the remaining IBA sites, although meeting IBA status, require the application of altered species specific criteria compared to that used in the original IBA designation.

It is difficult to interpret data of this type as we have two independent studies conducted 10 years apart and, although some islands were surveyed in both years, spatial coverage was not complete in either survey. We detected profound declines in both noddy species, for which Chagos is important. It would be prudent to interpret the observed changes only as indicators of possible trends. The phenology of all the seabirds in this study is likely to be a contributing factor to the observed differences between the 1996 and 2006 estimates. Unlike most temperate species, which have clearly defined breeding seasons, tropical and subtropical species tend to breed whenever conditions are favourable (Stearns, 1992) and not necessarily on a strictly annual cycle (Chapin, 1954; Chapin & Wing, 1959). Consequently, although both surveys occurred during February and March they may have taken place at different stages of the breeding cycle for some species and hence our estimates may not necessarily reflect true differences in breeding numbers. Our estimates also need to be taken as a minimum because a single count taken at the best time of year can underestimate the number of pairs of some species by up to 60%, depending on the degree of synchrony in breeding phenology (N. Ratcliffe, pers. comm.).

Our results, in conjunction with those from the 1996 survey, clearly highlight the need for a monitoring programme to be initiated to elucidate trends and potentially identify the causes of changes in populations. Implementation of systematic monitoring was identified as a key component in the Chagos Conservation Management Plan (Sheppard & Spalding, 2003) but no further action has been forthcoming. The lack of basic life history information for seabirds breeding in Chagos makes it difficult to explain the contrasting fortunes of the 17 species surveyed. The implementation of an annual monitoring scheme would allow essential basic information to be gathered and is crucial for the conservation of the Archipelago's seabirds.

Beyond methodological concerns there are many potential causes of changes in the breeding seabird species of the Chagos Archipelago, including predation (Kepler, 1967; Feare, 1979; Warham, 1990; Megyesi & Griffin, 1996; Martin *et al.*, 2000), human exploitation (Feare, 1976, 1978; Symens, 1999) and natural events such as the El Niño Southern Oscillation (N. Dunlop, pers. comm.). However, we believe that at-sea changes in food supply offers the most likely explanation. Food availability now or since 1996 for seabirds in the Indian Ocean is not known. However, sea surface temperatures have been continually rising (Goreau *et al.*, 2000) and corals declined by almost 90% in 1998 in some parts of the Indian Ocean (Goreau *et al.*, 2000). This temperature rise triggered exceptional ecological changes (McClanachan *et al.*, 1999) and has most likely decreased prey availability for some species of seabird. Furthermore, overfishing of a wide variety of marine species has taken place in the Indian Ocean over the last 10 years (Willmann, 2001; van der Elst *et al.*, 2005) and will almost certainly be driving changes in the number and type of prey available to seabirds. Nevertheless, without some form of systematic monitoring in the Chagos Archipelago it will not be possible to distinguish between and identify the likely causes of population changes.

The overall importance of the Chagos seabird populations is already recognized by the 10 designated IBAs (BirdLife International, 2004) and we propose two further sites based on our findings (Table 2). Although four IBAs failed to meet IBA criteria we advocate that all sites retain their IBA status until an annual monitoring scheme has been underway for several years. From a regional perspective the Chagos Archipelago is important for several species, with the number of breeding pairs of six of 17 breeding species reaching the 1% population thresholds that indicate regionally important populations (Table 1). As our findings are only based on breeding pairs, the Chagos populations of sooty tern, red-footed booby and Audubon's shearwater would be large enough to trigger the 1% global population thresholds if chicks and non-breeding individuals were included. The Asian population of sooty tern is estimated at 1–4 million breeding pairs (Rocamora *et al.*, 2003; BirdLife International, 2004) and Chagos accounts for 2–8% of the regional population. Similarly, based on estimates of the breeding numbers of red-footed booby in the Seychelles and other Indian Ocean island groups (Rocamora, 2003), the entire Chagos population (*c.* 11,500 pairs, including values from 1996 for islands not surveyed in 2006) would account for *c.* 20% of the Asian population and 2.7% of the global population. With a global population of 30,000 pairs (BirdLife International, 2004), our estimates of the breeding Audubon's shearwaters in Chagos, and those of Symens (1999), account for 0.6–1.9% of the global population. These three species alone warrant the need for annual monitoring. Coupled to these species, Chagos is also regionally important for black-naped tern, lesser noddy (previously globally important) and brown noddy.

The important regional and global status of breeding seabirds in Chagos and potentially worrying declines of some species mandates further action. The lack of concerted ongoing monitoring is a cause for concern and we strongly recommended that the UK government implement an annual monitoring scheme, particularly on those islands hosting seabird colonies with IBA status, to allow effective conservation management of this important aspect of the UK's biodiversity.

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Appendix

The appendix for this article is available online at http://journals.cambridge.org

Biographical sketches

Andy McGowan is active in both fundamental and applied research related to marine turtles, cooperative breeding in avian systems, dispersal, animal migration, and avian roosting behaviour. Annette Broderick and Brendan Godley co-ordinate the work of the Marine Turtle Research Group at University of Exeter, with research into the ecology and conservation of marine turtles in many locations around the globe.