



CHANGES TO THE NATURAL HISTORY OF ISLANDS IN
THE CHAGOS ATOLLS, CENTRAL INDIAN OCEAN,
DURING HUMAN SETTLEMENT (1780–1969),
AND PROSPECTS FOR RESTORATION

Charles R. C. Sheppard



Smithsonian Institution
Scholarly Press

ATOLL RESEARCH BULLETIN

**CHANGES TO THE NATURAL HISTORY OF ISLANDS IN
THE CHAGOS ATOLLS, CENTRAL INDIAN OCEAN,
DURING HUMAN SETTLEMENT (1780–1969),
AND PROSPECTS FOR RESTORATION**

Charles R. C. Sheppard

Atoll Research Bulletin No. 612 ♦ 29 November 2016



Smithsonian Institution
Scholarly Press

Washington, D.C.

All statements made in papers published in the *Atoll Research Bulletin* are the sole responsibility of the authors and do not necessarily represent the views of the Smithsonian Institution or of the editors of the bulletin. Articles submitted for publication in the *Atoll Research Bulletin* should be original papers and must be made available by authors for open access publication. Manuscripts should be consistent with the “Author Formatting Guidelines for Publication in the Atoll Research Bulletin.” All submissions to the bulletin are peer reviewed and, after revision, are evaluated prior to acceptance and publication through the publisher’s open access portal, Open SI (<http://opensi.si.edu>).

Published by SMITHSONIAN INSTITUTION SCHOLARLY PRESS
P.O. Box 37012, MRC 957
Washington, D.C. 20013-7012
www.scholarlypress.si.edu

The rights to all text and images in this publication are owned either by the contributing authors or third parties. Fair use of materials is permitted for personal, educational, or noncommercial purposes. Users must cite author and source of content, must not alter or modify the content, and must comply with all other terms or restrictions that may be applicable. Users are responsible for securing permission from a rights holder for any other use.

ISSN: 0077-5630 (online)

**CHANGES TO THE NATURAL HISTORY OF ISLANDS IN
THE CHAGOS ATOLLS, CENTRAL INDIAN OCEAN,
DURING HUMAN SETTLEMENT (1780–1969),
AND PROSPECTS FOR RESTORATION**

CHARLES R. C. SHEPPARD¹

ABSTRACT

The Chagos Archipelago (British Indian Ocean Territory, or BIOT) has 55 islands totalling approximately 5,000 ha spread over approximately 50,000 km² of the central Indian Ocean. From the first human settlements, which occurred in the late 1700s, and for the following century, all of the larger islands were converted into coconut plantations. During this period the disturbance to and elimination of the native flora and fauna in Chagos atolls was especially profound because these islands were used solely for the production of coconut and its products. Regarding vegetation, many times more species were introduced than were native, and several introduced species subsequently became invasive. The bird colonies, turtles and the land crabs were hugely reduced due to human consumption, land disturbance and the introduction of rats and other inappropriate and often free-ranging animals, such as pigs.

The condition of the reefs, however, remains excellent, such that the area was declared a no-take marine reserve in 2010. For some years, BIOT was the world's largest marine no-take conservation area. This status was achieved mainly because of its reefs; the islands are still heavily dominated by increasingly derelict, rat-infested coconut plantations and lack birds on most previously planted islands. However, on the smallest islands, many no larger than a few ha in size, there are both native plant communities and huge numbers of breeding seabirds. These relatively undisturbed fragments are acting as the core of current conservation efforts to restore some of the larger islands to their pre-plantation condition. This paper documents, as far as is possible from the relatively sparse archival documents, the course of events and extent of the terrestrial changes that took place in this archipelago before modern concepts of conservation emerged and remarks on the present, planned and funded restoration efforts that can be based on such knowledge.

INTRODUCTION

The five islanded atolls of the Chagos Archipelago are spread out over an area of about 50,000 km² in the central Indian Ocean, within the area known politically as British Indian Ocean Territory, or BIOT (Figure 1); BIOT was formed in 1965 (BIOT, n.d.). The total area of the atolls, and the number of islands they support or their degree of submergence, is summarized in Table 1.

There have been considerable advances in the understanding of the reefs of these atolls (Sheppard et al., 1999, 2012, 2013 for reviews), whose quality and condition led to their declaration in 2010 as a vast no-take marine reserve, until recently the world's largest (FCO, 2010). In contrast to the large expanse of reefs in excellent condition, the tiny islands (all but a few less than 200 ha) were for the most part greatly changed during two centuries of inhabitation and use; Carr et al. (2013:271) stated it thus: "Since man colonised the islands, the impact on the fragile environment has been catastrophic, as was the case on islands world-wide." The changes wrought on the islands were the result not only of introductions but also of conversion of the natural flora of the islands to coconut plantations, a process so successful that for a time the Chagos atolls were among the most productive of what were known as the "oil islands" (Scott, 1961).

¹ School of Life Sciences, University of Warwick, Coventry, CV1 7AL, UK.
Charles.sheppard@warwick.ac.uk

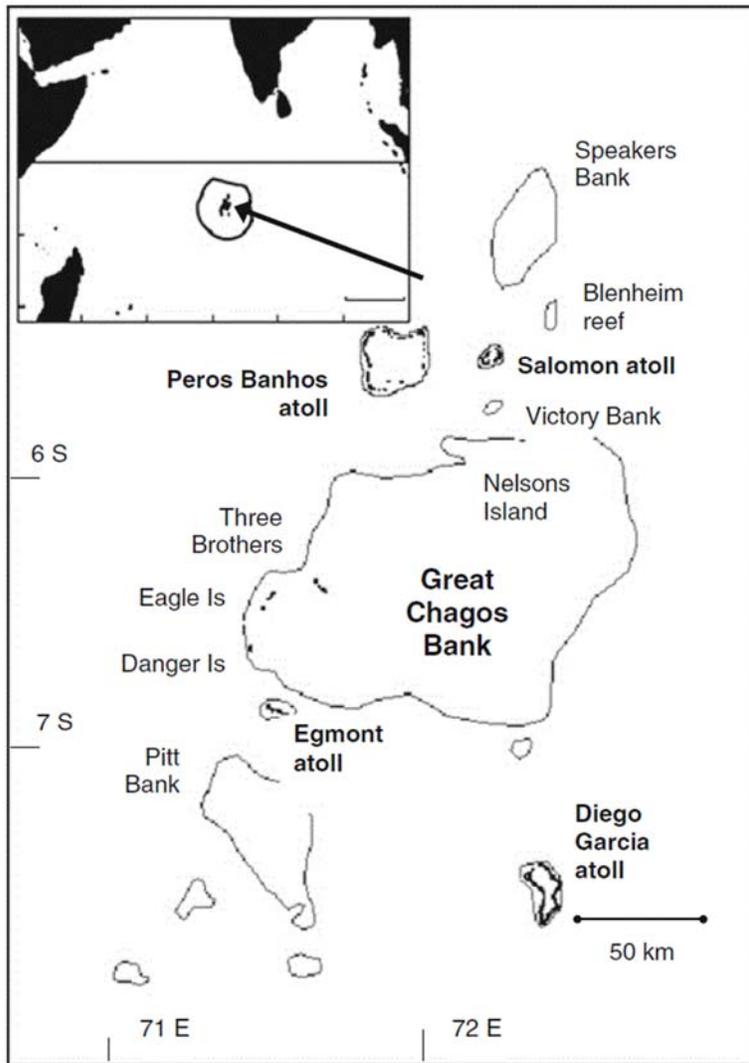


Figure 1. Map of the Chagos Archipelago (British Indian Ocean Territory). Inset shows the location of the archipelago in the Indian Ocean. Contour line is 200 m depth.

Given recent funding opportunities, the ability now exists to restore and conserve these islands. As part of this, investigations were made into how much change did in fact take place; this paper describes the changes made to the natural history of the islands during that period of coconut production before the establishment of BIOT. The intensive conversion of the islands was done first under slavery and then under free labor conditions. Much attention to BIOT in the past decade has focused on politics, its use today by the U.S. military facility and the way in which the civilian evacuation from the coconut plantations took place after the establishment of BIOT. A recent book focuses on political and economic aspects of the archipelago up to the establishment of BIOT (Wenban-Smith and Carter, 2016), but it devotes little attention to environmental matters. The following adds information on the past environmental conditions with a view to informing future restoration attempts.

The total area of the archipelago's approximately 55 islands is about 4,700 ha, of which 2,700 ha is on one single island in Diego Garcia Atoll, on the west of which is the U.S. Navy Support Facility (the perceived need of which was the reason for the creation of BIOT). Most islands are minute (Figure 2) and many are very difficult to access, so that the smallest ones were never cleared and replanted with coconut trees; thus today they provide a useful illustration of the region's pre-settlement fauna and flora. Several of these small islands are still in spectacular condition, with native vegetation, including hardwood trees, and many open spaces occupied by dense colonies of over a dozen species of breeding seabirds. Because their flora is thought to be largely unchanged from pre-

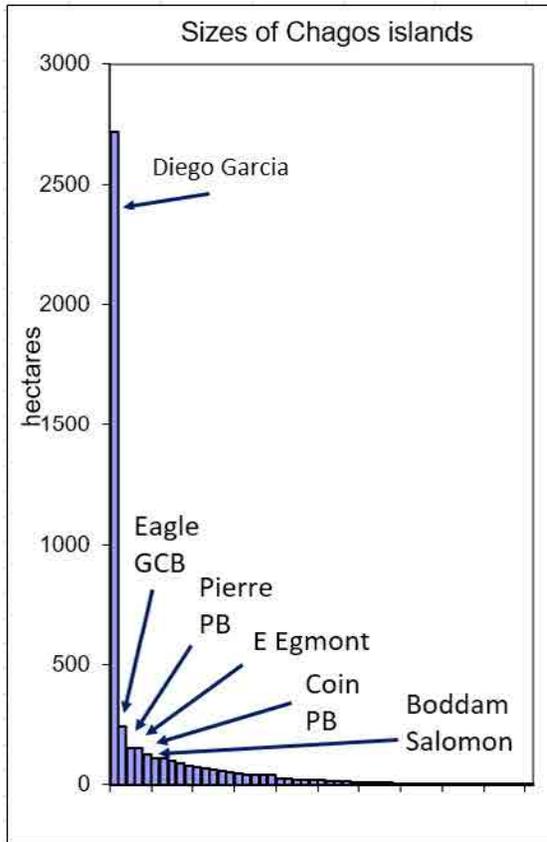


Figure 2. Sizes of the approximately 55 islands. On the right of the x-axis most islands scarcely register on this figure. For purposes of human support, hydrology and food supply issues, and infrastructure, UNESCO terminology is that “large” islands are > 200,000 ha, “small” islands are < 20,000 ha, and “very small” islands are < 10,000 ha. In this archipelago, Diego Garcia is less than half of the very small island size, and the remainder are each less than 5% of the very small island category. GCB=Great Chagos Bank, PB=Perhos Banhos Atoll.

settlement days, these small, pristine islands are currently being used to guide restoration of the larger, damaged islands (Figure 3).

Exploitation, by catching turtles and gathering fallen coconuts, commenced in the late 1700s (Wenban-Smith and Carter, 2016), soon followed by active conversion to coconut plantations. An impediment to understanding what the island flora and fauna was like on the larger islands before man’s alterations is the poor and scattered documentation about the habitat destruction that took place during plantation days, though sufficient is available to show its large extent. However, a better understanding of the extent of island changes that did in fact take place will serve better to aid restoration attempts that are now underway and which are being planned; the aim is to return some of these tiny fragments to a much more diverse condition similar to that which used to exist.

It is important to emphasize from the outset that the conditions and practices in the Chagos atolls up to the 1960s were little different to those affecting most other tropical islands in the world. Even as late as the end of the last century, Thaman (1990:1) said with regard to Pacific islands, “...deforestation in the Pacific is proceeding at a frightening rate,” and this continues in many places, making any attempts at reversion and restoration increasingly difficult and possibly speculative.

ENVIRONMENTAL CHANGES IN PLANTATION DAYS

Coconut trees themselves were of course present before the period of settlements, and some areas of Diego Garcia especially were already covered with “vast numbers of coconut trees,” presumably self-seeded (M. Barreault, quoted in Wenban-Smith and Carter, 2016:34). However, as recorded by several of the earliest literate visitors, such as magistrates and ships’ captains, in the late 1700s the larger islands starting with Diego Garcia Atoll began to be cleared of their native vegetation to grow coconut plantations (Stoddart, 1971a), creating a trade made profitable to owners at first because the labor to achieve these came from slavery.

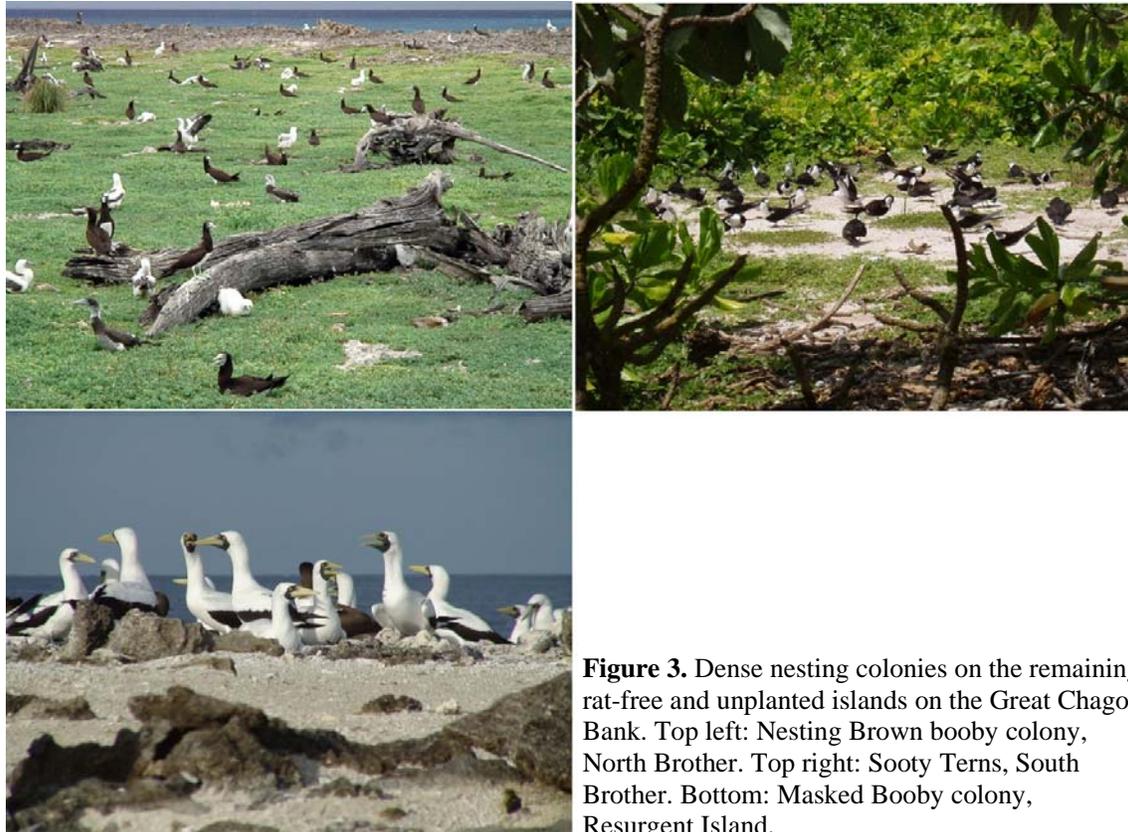


Figure 3. Dense nesting colonies on the remaining rat-free and unplanted islands on the Great Chagos Bank. Top left: Nesting Brown booby colony, North Brother. Top right: Sooty Terns, South Brother. Bottom: Masked Booby colony, Resurgent Island.

The islands of Chagos swiftly became factories for coconut production, and though a wide range of other crops were grown (see below) these succeeded only to a very minor extent (Stoddart, 1971a). Native trees were felled and, where suitable, the timber was used to help construct buildings and sheds for the various coconut products: oil, copra and coir. In all of the Chagos islands the soil is thin and poor (Posford Haskoning, 2002), and where there was none at all, numerous circular pits were commonly excavated into the limestone rock, into which was placed vegetation matter along with a germinating coconut. This, thanks to the copious labor supplied by slavery, enabled the enterprise to develop quickly and profitably.

The natural habitat, however, disappeared in the process:

...the French, who with the assistance of slave labor probably derived directly from West Africa (where they were major participants in the slave trade in this time...) soon felled the majority of the native woodland and replaced it with exceptionally productive coconut plantations wherever there was room for them. Timber continued to be exported to Mauritius from the last and most luxuriant forest on Boddam Island in the Salomon group, well into the nineteenth century, and tree stumps could still be seen there very recently. (Bourne, 1971:176)

These evidently included some huge tree specimens. As early as 1774, a variety of domestic animals including pigs were introduced into Diego Garcia to test their capacity of surviving unaided, though few did. By 1786, “the place was swarming with rats, worms and dangerous insects” (R. Price, in Wenban-Smith and Carter, 2016:55). The thin soils were shown to be incapable of sustaining crops successfully, leading to the importation of substantial quantities of soil from India and Mauritius.

Conversion of the natural habitat to a monoculture was very thorough and successful through the next century. Remaining areas of natural environment were placed under increasing pressure; by the late nineteenth century there was an “increase in the human population and amount of disturbance to the environment” (Bourne, 1971:176). Stoddart (1971a:212, 216) remarked of the largest atoll Diego

Garcia: "...almost the whole area of the atoll (6,250 out of 7,488 acres) was being cropped for coconuts" and "little attention has been paid at Diego Garcia to conservation: the atoll has simply been used as a supplier of coconut products, and to a lesser extent of dried fish and turtles, for Mauritius." Thus, as Stoddart (1971a, 1971b) repeatedly notes, few remnants of the original woodland remained in 1969, and many of the expected components of a native vegetation were entirely removed.

Certainly a few native trees still survive and these were supplemented by an ever-increasing variety of trees that were useful to the settlers, such as fruit trees and some ornamentals shipped in from Asia and Africa (Topp and Sheppard, 1999). Thus, by the time a further century had passed, in 1969, "the land vegetation of Diego Garcia consists almost entirely of coconut-dominated woodland, with some small areas of shrubs and occasional relict broadleaf trees. All parts of the atoll have been subject to continuous human interference for almost two hundred years, and man now actively controls vegetation growth in coconut plantations" (Stoddart, 1971b:127).

Introduced and Invasive Plants

Most plants present are introductions. A survey in Diego Garcia, whose 2,700 ha account for almost half of the total land area of the archipelago, recorded about 280 higher plants, of which the original native vascular flora was probably only about 45 species (16%), comprising 41 seed plants and 4 ferns (Topp, 1988; Topp and Sheppard, 1999; Clubbe, 2013). As an aside, an identical figure of 16% of the 362 plants in the eight atolls of Tuvalu are thought to be indigenous (Thaman, 2016). In the Republic of Kiribati on Christmas Island (Kiritimati) only 9% of the 174 plants are natives (Thaman and Tye, 2015), and on Banaba (formerly Ocean Island) about one-quarter are native (Thaman and Samuelu, 2016). These similar proportions illustrate the widespread extent of human introductions in tropical islands.

Dates of most introductions in the Chagos Archipelago are not documented but probably started as early as 1784 when six shiploads of soil were imported from India by the East India Company to help horticulture (R. Price and Bombay Secretariat Records Office, Secret Department, Vols. 30–39, in Stoddart, 1971a). The practice of importing soils to augment the poor, naturally occurring soils continued for perhaps a century more: Wenban-Smith and Carter (2016) refer to at least one vegetable garden made fertile by soil imported from Mauritius in the nineteenth century. This practice doubtless introduced weeds including invasive species from two continents even though the horticulture experiments themselves were generally failures. At the time of the mid-twentieth century, the plantations were infested by weeds and pests, which by then added to the causes of coconut decline (Luce-Smith, 1959).

Many plants were introduced for food. Although many survive and doubtless were invaluable in plantation days, none remained abundant or even remained alive when untended. Moresby (1837) wrote that "...maize, tobacco, cabbages, 'greens', sweet potatoes, onions, carrots, turnips, 'leaks' and garlic" existed, while an anonymous writer (in Stoddart, 1971a:215) said that "all the common vegetables cultivated in India, with limes and citrons" also occurred. Even cotton was introduced in one experiment on Egmont Atoll, which resulted in at least one cargo of cotton exported to Mauritius in 1823 (Wenban-Smith and Carter, 2016:110). Moresby himself introduced the bread fruit tree and the yam. Sometime in the 1800s bananas were introduced, along with some other tropical fruits. Along with these introductions also came numerous associated insects, including the rhinoceros beetle, which is a severe pest of coconuts (Stoddart, 1971c). Hemsley (1887) found bananas and several other cultivated fruits along with maize in a small area near a plantation in Diego Garcia. These cultivations by themselves occupied only small areas of land; their importance lies in the introduction of plant species, those both intended and unintended, in the imported cargoes of soil.

Introduced and Invasive Animals

On Diego Garcia, rats preceded permanent settlement and soon spread to other islands as each was settled and exploited. For the human populations in all Chagos atolls, rats quickly became a problem, existing in plague proportions in Diego Garcia as early as the late 1700s (Wenban-Smith and Carter, 2016). During the more developed plantation days, periodic "rat drives" using dogs in Diego

Garcia would result in about 30,000 being killed each year (Wenban-Smith and Carter, 2016). Full-time rat catchers soon became part of the pattern of employment. Most islands that had significant human habitation still have abundant rats today, though it is possible they have subsequently disappeared on one or two of the very small islands where they have not been seen in recent years (Carr, 2015). In Diego Garcia and other larger islands, the rat density remains very high for coral atolls (Harper, 2015) although there is a substantial ongoing baiting and eradication program in the western part of that atoll where the military facility is located.

With man came several domesticated animals, such that, in addition to tree clearance, the avifauna was “confronted with the destruction of their habitat and the introduction of such predators as rats, cats, and hogs, all of which appear to have been widespread by the middle of the nineteenth century” (Bourne, 1971:200). Egmont Atoll in the 1840s was overrun by 600 pigs together with dogs and cats (Scott, 1961); that atoll contains only about 300 ha of land (Table 1), so that pigs roamed freely at an average density of two pigs per ha. Poultry was abundant in probably all atolls, and was recorded in sailing notes at the time (Horsburgh, 1852; Findlay, 1882). Moresby (1837), who was responsible for the first very detailed charts of the archipelago, noted donkeys, rats, abundant pigs and poultry, feral cats and dogs.

Bees were introduced (Findlay, 1882) as were cattle and sheep, though these did not thrive (Bourne, 1886). The cattle were used for milk production, though this required fertilization of pasturage with guano obtained from the increasingly disturbed and diminishing areas of bird colonies. Donkeys introduced to carry loads and to work the coconut presses were turned loose in the early 1970s; there is still a substantial residual population in Diego Garcia and another population that persisted to the turn of the present century at least in Isle du Coin in Peros Banhos Atoll. In Diego Garcia, grazing by these feral donkeys has partly negated attempts to rehabilitate native trees in the uninhabited eastern arm.

Consequences to Native Animals

Seabirds

Conversion of the open spaces covered with grasses and low shrubs to coconut trees largely eliminated many of the bird colonies. Tree nesters declined too because the species in Chagos do not successfully nest in coconut palms (Carr, 2011a), and ground-nesting birds and burrowing species such as shearwaters suffered from both the vegetation clearances and introduced animals, and then

Table 1. Physical characteristics of the major Chagos atolls and banks. Note that several small banks with atoll cross-sections also exist, whose shallowest rim sections are < 10 m, but which have not been studied. From Sheppard et al., 1999.

Atoll	Atoll area (km²)	Land area (ha)	Number of islands	Lagoon greatest depth (m)	Lagoon mean depth (m)	Shallowest depth of rim* (m)	% rim enclosure by islands or reef flats
<i>Atolls</i>							
Diego Garcia	<200	2733	4	31	10	-	95
Salomon	38	311	11	33	25	-	85
Peros Banhos	463	920	24	80	38	-	60
Great Chagos Bank	18,000	445	8	84	50	-	<5
Egmont	40	~300	6	26	12	-	35
<i>Submerged Atolls</i>							
Blenheim Reef	40	0	0	17	8	awash	60
Victory Bank	16	0	0	33	25	5	-
Speakers Bank	680	0	0	35	44	7	-
Pitt Bank	~1,200	0	0	44	35	<10	-

* These submerged atolls have no islands but have perimeters at varying depths below mean low water springs. Awash = dries at low tides.

again from the planting of coconut trees over their nesting grounds. In Diego Garcia the ground occupied by former tern colonies was quarried for guano needed to enrich the naturally poor soils until at least the 1930s. At that time it was still being recommended that pasturage be fertilized by about 50 kg of locally sourced guano per acre each year because the natural soil was poor in many essential nutrients (Wiehe, 1939). Guano was even exported from Diego Garcia in the early part of the twentieth century (Wenban-Smith and Carter, 2016). This further indicates the size of seabird colonies in the past: thousands of birds are needed for decades or centuries to make deposits worth quarrying.

Birds and their eggs were also collected for food: “The early settlers found the frigate birds, boobies, noddies, terns, herons and tropicbirds to breed on these islands. They are considered good eating; the feathers too, make excellent bedding” (Anon., 1845, quoted in Stoddart, 1971a:216). In 1887, there were possibly 100,000 sooty terns in Diego Garcia, and the inhabitants were taking many of the terns’ eggs and feathers (Finsch, 1887).

Thus, at the final closure of the plantations in the early 1970s, Bourne (1971:175) said about the birds in Diego Garcia: “[It] is now largely devastated from an ornithological point of view by nearly two centuries of the activities of man and other introduced animals. [It is] in urgent need of conservation.”

It appears that most seabird colonies were eradicated before 1900, however: “Whereas when the islands were first described colonies of breeding seabirds, particularly terns, noddies and shearwaters, were important, these have now virtually disappeared on Diego Garcia and possibly on the other larger atolls also. The most conspicuous birds of Diego Garcia are now all introduced land birds” (Stoddart, 1971c:169). It had even been suggested that there was once quite a rich land bird community, comparable to that of Christmas Island further east in the Indian Ocean (Gibson-Hill, 1948), but if there was, it was eliminated fairly early in the plantation history. Birds were simply commodities. As late as the 1930s, booby chicks were taken to be dried in the sun for use as feathery powder puffs, after being left without food to die (Dussercle, 1936).

Turtles

Both the green and hawksbill turtles used to nest in the Chagos Archipelago in some numbers. The French were early exploiters of the meat of the greens in islands further west: “Already by 1770...turtles are starting to become rare on the island of Rodriguez...When we get more familiar with the archipelago that lies further to the north, we may hope to find islands as abundant in turtles as Rodriguez used to be” (Poivre, in Wenban-Smith and Carter, 2016). Earlier sightings of the atolls had suggested an abundance of turtles, which were considered to be good food and, in the case of the green turtle, also a cure for leprosy. Some early pioneers and then managers sought to limit the rate of turtle depletion, in measures only partially successful: these measures as well as the extensive exploitation of the animals through the 1800s are described in detail by Wenban-Smith and Carter (2016). Their population went into decline fairly early, in part because of the consumption of their eggs as well as of the adults. Green turtles used for food were kept in pens at the ends of jetties until needed; the pens can still be seen, though they are now in a state of considerable disrepair.

The hawksbill turtle was a modest but significant source of additional income; one hawksbill shell was calculated by Wenban-Smith and Carter (2016) to be worth as much as 1,000 coconuts at that time. Trade figures exist for the valuable hawksbill shell from 1900 and are shown in Figure 4. The numbers of turtles caught was prodigious (Mortimer, 2009) and the population of this species declined also. The export figures likewise show a rapid decline from the early 1900s. The number of hawksbills remaining in the entire archipelago when scientific visits first began in the post-plantation days of the 1970s was roughly the same as the number that were being caught every year in the early 1900s. Turtles take about 30 years to recover from such depletion (Mortimer et al., 2000), but they now appear to be showing some recovery.

The treatment of turtles was sometimes grim. Charles Darwin (1897:441) related in his *Voyage of the Beagle* some of his correspondence with Commander Moresby:

Captain Moresby informs me that in the Chagos archipelago... the natives, by a horrible process, take the shell from the back of the living turtle. ‘It is covered with burning charcoal, which causes the outer shell to curl upwards; it is then forced off

with a knife... After this barbarous process the animal is suffered again to regain its native element where, after a certain time, a new shell is formed; it is, however, too thin to be of any service, and the animal always appears languishing and sickly.’

Recently, new discoveries using radio-satellite trackers attached to the shells of several greens show that this species may be slowly recovering its numbers. They conduct huge migrations from now-protected beaches in the Chagos atolls to East Africa as far as Somalia (Hays et al., 2015), and they form an especially close genetic linkage with populations in the Seychelles (Vargas et al., 2015).

Coconut Crabs

In most of these islands the very palatable coconut crab *Birgus latro* is now abundant. In the mid- and late 1970s it was observed that, in broad terms, the longer an island had been uninhabited, the more abundant were its *B. latro* populations and the larger were the individuals found there (Sheppard, 1979). Islands only recently abandoned appeared in the 1970s to have none.

Birgus latro is the largest land-living arthropod in the world, reaching 4 kg in weight. Being palatable and readily caught, they are virtually extinct throughout most of their range (Schiller, 1992, section 3.1); “both the size and geographical distribution of coconut crab populations are significantly reduced and ... localized extinction has occurred in areas where coconut crabs were sympatric with humans.” In Chagos islands it was also thought that their capture would help increase the number of nuts harvested; it was estimated in the early part of the twentieth century that an adult would consume 250 nuts per year in these plantations (Gardiner and Cooper, 1907).

Their recent recovery has been marked. Genetic studies show substantial recruitment from both the Seychelles and East Africa. In 2011, the first quantitative survey in Diego Garcia found extraordinarily high numbers (Carr et al., 2013). On the uninhabited eastern side of that atoll, their average density was 300 per ha, with peak numbers in some areas of nearly 600 per ha. Personal observations suggest similar high numbers in many of the northern islands too.

Poaching of these crabs does continue, however, both on Diego Garcia and by visiting sailors in northern atolls. Numbers taken are likely to be relatively low, given the present record densities, though any significant capture could make a marked difference to the total population in such small islands.

In 1996, attempts to see whether *B. latro* could be artificially bred in the London Zoo failed despite best efforts (Barnet et al., 1999). To date, their prospective survival can only be assured for islands with strict conservation measures.

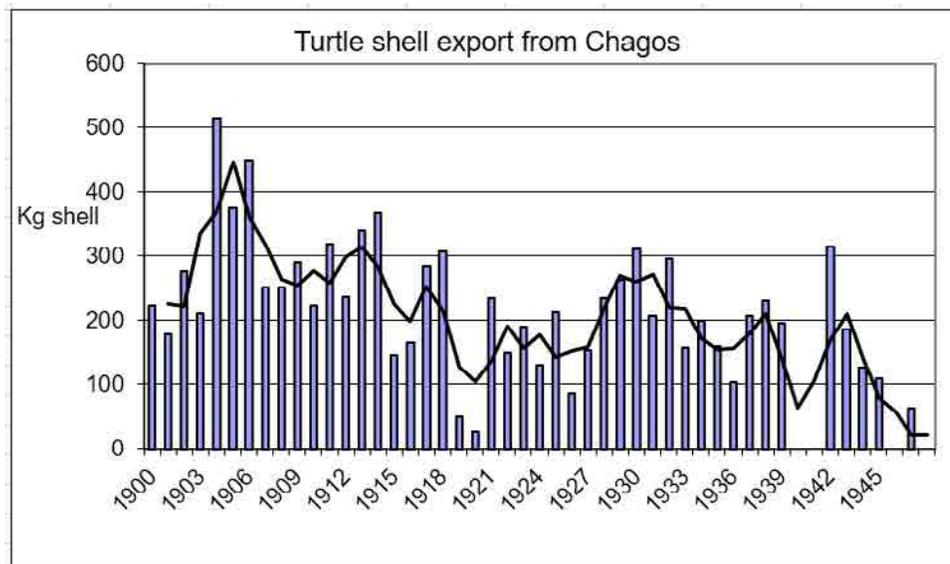


Figure 4. Exports of turtle shell from the Chagos Archipelago during the twentieth century. The black line is the running mean.

FINAL PLANTATION DAYS

Conservation never received significant attention during plantation days. A manager in the 1870s, James Spurs, took the first practical conservation measures, but “in the absence of enforcing authority or of any clear need for conservation it is unlikely that much attention was paid to it” (Stoddart, 1971a). Going by the results seen today on the ground, the same lack of conservation ethic existed throughout all atolls, so that only tiny islands escaped.

By the early twentieth century the coconut plantations were in decline in terms of quantity and quality of produce, exporting progressively less than they had done during the previous century when the “Oil Islands” were at their peak. Wenban-Smith and Carter (2016) document the numerous failures of management and lack of oversight and investment in the industry by the (usually absent) owners and management in the Chagos Archipelago’s plantations. Even though the proportion of land area used for coconut production by that time was very large, the plantations were producing less and less because of inefficient and old-fashioned cultivation practices. By the mid-twentieth century, production became “derisory” and “absurdly low”; it was only half of that obtained from even poor soils in the Caribbean and one third that from Ceylon and East Africa (Luce-Smith, 1959), places which also had far better transport links to markets.

Plantation management was commonly incompetent, which placed production in a perilous situation considering the higher costs associated with the location of these plantations, which were a long way from consumer centers. Plantations increasingly struggled throughout their last century of existence, coming close to bankruptcy three times. The plantations closed on two atolls in the 1930s both for economic reasons and because of social problems. After World War II there was an increasing tendency of the islanders to move permanently to Mauritius, so temporary workers were increasingly brought in from the Seychelles to make up the shortfall of labor. This process accelerated after the islands were purchased by a Seychellois businessman in 1962 (Wenban-Smith, 2012).

Just before the creation of BIOT and development of the Navy facility, in a letter to the Foreign and Commonwealth Office dated 24 July 1968, D. R. Stoddart said: “Diego is, of course, much altered by man, and there are few natural features remaining undisturbed. It is really an extended coconut plantation from end to end.” He says the islets in the north were more natural. He did not visit any other atoll in Chagos but added: “It does, however, seem unlikely that they will be of such biological interest as to require any measure of conservation at all...” Stoddart (2001) later said of Diego Garcia (which, as noted, contains half the archipelago’s land area) that “the atoll was by then simply a coconut plantation. I had to say there was no case in the terrestrial ecology to object to the military plans.” But contrary to this view is that of one Chagossian (Mandarin, 2016) who insisted that in the 1950s, near the final days of plantations, Chagossians respected nature and lived alongside it in a guardian role; however, details elsewhere in Mandarin’s account do rather belie that commentary.

Logistics and Trade of Remote Island Living

Such transformation of island ecology was in no way particular to the Chagos islands and few people anywhere acted differently. Human settlement throughout plantation days was clearly very difficult. Visits to the smaller and more remote islands of Chagos from villages on the larger islands were also necessary when supply ships failed to arrive—sometimes because they had sunk—causing the villagers to go elsewhere to collect birds and birds’ eggs, turtles and turtle shell. This was necessary simply because supply of edible wildlife on inhabited and accessible islands had already been heavily depleted. While protein was never a problem because of plentiful fish from the reefs along with pigs, chickens and other animals, basic carbohydrate foodstuffs were always imported and paid for by the copra and, to a small extent, by selling turtle shell and bird feathers (Wiehe, 1939). Fruit was grown to a probably sufficient extent using introduced fruit trees such as pawpaw and banana.

Coconut production was in decline in Chagos islands in the twentieth century because of lack of investment in new equipment and other facets of poor management. Neglect meant that by the 1930s, rats consumed about a third of the already declining yields of coconuts, and because collections of fallen nuts and clearing of undergrowth were carried out too infrequently, many more nuts were simply lost in the increasing cover of palm litter (Wiehe, 1939).

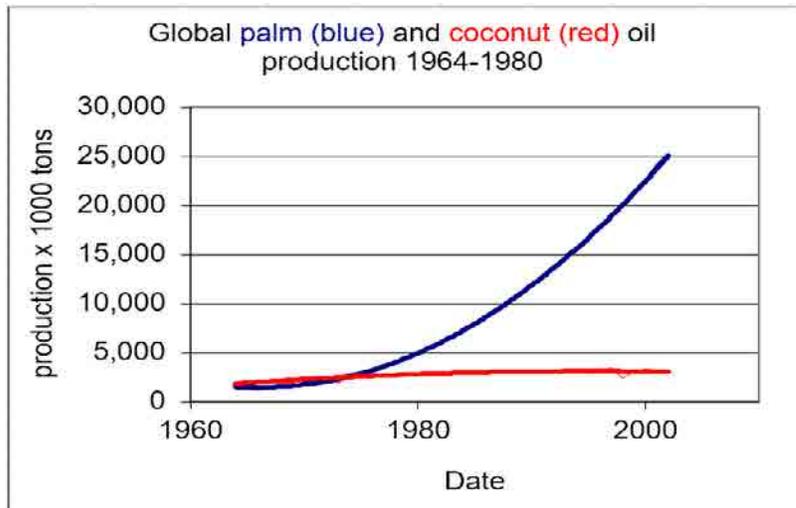


Figure 5. Global coconut oil and palm oil production, showing the increase of the latter from the early 1970s. World palm oil production in 2014/15 was 63.3 million tons, double that of 2000; world coconut oil production in 2015 was 3.43 million metric tons, similar to that in 2000 (USDA, 2014, 2015).

But the increasingly interconnected global economy was forcing a greater change too. By about 1972, palm oil from Southeast Asia had started to dominate vegetable oils throughout the world (Figure 5; USDA, 2014, 2015). Huge palm oil plantations were being developed in places such as Indonesia, which have much closer access to major trade ports, more flexible labor markets, and an infinitely greater land area on which to plant.

The problem for the people in the Chagos communities was that coconuts were the only significant industry in the islands. The islands had too little soil for more diverse agriculture, and they are small and remote. Turtle shells and bird feathers, no matter how avidly they were exploited, were never more than some cash on the side. The coconut plantations in Sri Lanka and the Caribbean became sufficient for the world’s demand of that product. Because of all these factors, the fate of this industry in Chagos was sealed.

FUTURE CONSERVATION AND RESTORATION PLANS

The islands that were too small or too rocky and dangerous to land on had always been left more or less alone. Today these unaltered islands provide the information for current restoration and conservation efforts. Despite containing only a tenth of the land area, they contain >90% of the native plants and birds. Indeed, there are ten Important Bird Areas (IBAs) among them (Table 2; Carr, 2011b), although it has been suggested that these IBAs should be grouped into fewer but larger clusters given that it has recently been found that seabird colonies move to adjacent islands from one year to the next, possibly for parasite control and avoidance (Carr, 2011b). These islands include some that were used for a very short time, but had no permanent settlements and no rats. Bird populations today are not limited by food resources from the ocean but by lack of rat-free nesting space. Several islands that are now devoid of birds are named after seabirds, which is likely to indicate that they once supported bird populations. The remaining undisturbed islands today provide evidence of pre-plantation island ecology, with remnants of Indian Ocean hardwoods and open areas, all supporting relatively large bird colonies (Carr, 2011a).

However, priorities change over time, and there is now much greater interest in restoring and conserving such islands. Clubbe (2013) has enumerated six broad categories of native vegetation that exist today, and these descriptions are a valuable precursor to developing the restoration strategy for these islands. The Chagos Conservation Trust is in receipt of funding from the U.K. government to develop management plans for each individual island. It is the information from these examples on small islands that will be used to aid restoration through vegetation manipulation and rat eradication on several of the larger islands, and this will become part of an ongoing conservation program. Three interlocking actions are needed for restoration: rat eradication, coconut and other invasive plant reduction, and hardwood re-seeding, all of which need to be undertaken simultaneously over a long period.

Table 2. Confirmed and proposed Important Bird Areas (IBA) in the British Indian Ocean Territory and their qualifying criteria. An asterisk (*) denotes a proposed IBA. GCB = Great Chagos Bank. Numbers of birds given, other than “congregations,” are breeding. From Carr, 2011b.

Site name	Qualifying criteria for IBA
Diego Garcia, islets and west	4,000 red foot booby
Danger Island, GCB	11,100 brown noddy tern; 3,470 red foot booby; congregation of >20,000 waterbirds
Sea Cow, GCB	11,500 brown noddy tern; congregation of >20,000 waterbirds
South Brother, GCB	7,300 lesser noddy tern; 6,100 brown noddy tern; some sooty terns; congregation of >20,000 waterbirds
Middle Brother, GCB	12,500 sooty tern; congregation of >20,000 waterbirds
North Brother, GCB	420 Audobon’s shearwater; >10,000 other breeding seabirds
Nelsons Island, GCB	13,700 lesser noddy tern; 8,300 brown noddy tern; congregation of >20,000 waterbirds
Ile Parasol Salomon atoll	14,000 sooty tern; congregation of >20,000 waterbirds
Ile Longue Peros Banhos atoll	32,000 sooty tern; congregation of >20,000 waterbirds
Petite Ile Boise Mangué Peros Banhos atoll	12,000 lesser noddy tern; congregation of >20,000 waterbirds
Petite Ilse Coquillage Peros Banhos atoll*	34,600 sooty tern; congregation of >20,000 waterbirds
Grande Ilse Coquillage Peros Banhos atoll*	15,400 sooty tern; congregation of >20,000 waterbirds

For the past half-century, however, coconuts have been the ecological “stable state” in these islands. This persists even in the two Chagos atolls that were abandoned over 80 years ago. Although surviving mature hardwood trees continually shed copious seeds, the trees fail to spread, and indeed, the reverse usually happens, and coconuts extend their advance. This occurs even around the two diminishing mangrove patches that remain, located on Eagle Island on the Great Chagos Bank and on Moresby Island in Peros Banhos Atoll. Mangrove trees, which thrive in salt water, are losing the competition against encroaching coconut palms, and these areas are now listed as a key priority for conservation (Clubbe, 2013). Hardwood tree regeneration elsewhere generally fails because of the layer of copious fallen palm fronds that cover the ground to as much as a meter deep (Figure 6); this choking palm litter has been aptly described as “coconut chaos” (Carr, 2011a). The contrast with the unaltered ground cover seen in Figure 3 is clear.

Another problem on some islands comes from the *Casuarina equisetifolia* tree, also known as ironwood. It is a durable building material whose fallen needles inhibit other plant growth. It is likely that this tree is native (Topp and Sheppard, 1999) but it was certainly also planted for its timber. In 1973, believing it was reducing natural regeneration of trees, Bellamy (1979) described efforts to rid Egmont Atoll of it, which were successful.

Important to restoration efforts, however, is eradication of rats. This is possible, though expensive and complicated. In 2006 an attempt was made to eradicate rats on the relatively large Eagle Island (Hillman, 2007), but this failed. At 243 ha, its success would have potentially doubled the land area available for birds. One possible reason for the failure was because there were two largely non-intermixing rat populations: a ground-living one susceptible to bait and subordinate tree dwellers that were not, the latter of which may have provided the survivors. More recently, another approach has been trialed that tackles very small islands first, and a start has been made with three successful so far. Plans exist to extend this for each of the rat-infested islands of the archipelago.



Figure 6. Example of the coconut frond litter that covers most of the ground in all former plantation areas, to depths up to 1 m.

Criticism has been leveled that rat eradication and vegetation restoration is not natural. It is not, but neither was the planting of coconuts in the first place, and today only intervention might help restore any semblance of a pre-man condition that would allow the once huge bird populations to recover. The opportunity now exists to restore native populations by the removal of invasive species, a goal which has established itself worldwide as being a legitimate and desirable conservation achievement.

The Chagos islands perhaps provide the ideal place where we might be reasonably certain that past damages could be repaired, given a proper, integrated, and planned restoration program. These procedures have many complications, but it is now entirely possible that they can be achieved. The present governance of the area means that exploitation of any kind is not permitted, a political situation from which conservation measures might usefully benefit. Successful restoration is now, as expressed by Carr (2011b), a matter of funding and political will rather than being a “green dream,” and this funding and political will now exist to embark on a particularly important conservation program in a part of the world where it is badly needed.

ACKNOWLEDGMENTS

I thank several colleagues who have worked in in the Chagos Archipelago who read this manuscript and encouraged me to publish it, including some of Chagossian heritage; the latter especially were important. It is important also to acknowledge the late Professor David Stoddart OBE, whose prodigious bibliographic skills and diligence made my “discovery” of several obscure sources relatively easy, as did the authors of the new *History* volume, Nigel Wenban-Smith and Marina Carter. It is worth restating that absolutely no blame for the nature of previous damage should be attached to the Chagossian laborers of the time—any blame (if blame there should be in those days of ignorant exploitation) is now meaningless but would lie with the managers and owners alone.

REFERENCES

- Anonymous. 1845. *Sailing Directions for the Red Sea*. By R. Moresby and T. Elwon, Esqrs., Commanders, Indian Navy. Printed by order of the Court of Directors of the East India Company. London: Allen and Unwin.
- Barnet, L. K., C. Emms, and D. Clarke. 1999. "The Coconut or Robber Crab (*Birgus latro*) in the Chagos Archipelago, and Its Captive Culture at London Zoo." In *Ecology of the Chagos Archipelago*, ed. C. R. C. Sheppard and M. R. D. Seaward, pp. 273–284. Linnean Society Occasional Publications 2. Otley, U.K.: Westbury, for the Linnean Society of London.
- Bellamy, D. J. 1979. *Half of Paradise*. London: Cassell Ltd.
- Bourne, G. C. 1886. General Observations on the Fauna of Diego Garcia, Chagos Group. *Proc. Zool. Soc. London*, 1886:331–334.
- Bourne, W. R. P. 1971. The Birds of the Chagos Group, Indian Ocean. *Atoll Research Bulletin*, 149:175–208.
- British Indian Ocean Territory (BIOT). n.d. "Governance." British Indian Ocean Territory website. <http://www.biot.io/governance/>.
- Carr, P. 2011a. *Guide to Birds of the British Indian Ocean Territory*. Bedford, U.K.: Pisces Publications, for Royal Society for the Protection of Birds.
- . 2011b. The British Indian Ocean Territory. *British Birds*, 104:642–659.
- . 2015. The Distribution of Ship Rat *Rattus rattus* in the Chagos Archipelago. *Chagos News*, 47:20–31. <http://chagos-trust.org/sites/default/files/images/Chagos%20News%2047.pdf>
- Carr, P., J. C. Hillman, M. R. D. Seaward, S. Vogt, and C. R. C. Sheppard. 2013. "Coral Islands of the British Indian Ocean Territory (Chagos Archipelago)." In *Coral Reefs of the United Kingdom Overseas Territories*, ed. C. R. C. Sheppard, pp. 271–282. London: Springer.
- Clubbe, C. 2013. Island Restoration in Chagos. *Chagos News*, 41:13–16. <http://chagos-trust.org/sites/default/files/images/Chagos%20News%2041%20-%20Jan%202013.pdf>
- Darwin, C. 1897. *Naturalist's Voyage Round the World [or Voyage of the Beagle]*. London: John Murray.
- Dussercle, R. (1956) 1936. *Archipel de Chagos: en mission 10 Novembre 1933–11 Janvier 1934; Archipel de Chagos: en mission Diégo–Six Iles–Péros, Septembre – Novembre 1934 ; Naufrage de la Barque Diégo à l'Île d'Aigle aux Chagos ; Dans les 'Ziles là-Haut*. Port Louis, Mauritius: General Printing Company.
- Findlay, A. G. 1882. *A Directory for the Navigation of the Indian Ocean*. 4th ed. London: R. H. Laurie.
- Finsch, O. 1887. Ein Besuch auf Diego Garcia im Indischen Ozean. *Deutsche Geographische Blätter*, 10(1):30–42.
- Foreign and Commonwealth Office (FCO). 2010. "New Protection for Marine Life." Online press release archived in the UK Government Web Archive. <http://webarchive.nationalarchives.gov.uk/20121212135632/http://www.fco.gov.uk/en/news/latest-news/?view=News&id=22014096>.
- Gardiner, J. S., and C. F. Cooper. 1907. The Percy Sladen Expedition to the Indian Ocean in 1905: Description of the Expedition. *Trans. Linn. Soc. Lond., Zool.*, 12:1–56, 111–175.
- Gibson-Hill, C. A. 1948. Field Notes on the Birds of Christmas Island. *Bull. Raffles Mus.*, 18:87–165.
- Harper, G. A. 2015. An Initial Trial to Determine an Effective Rat Bait Application Rate at Diego Garcia, British Indian Ocean Territory. *Chagos News*, 47:17–19. <http://chagos-trust.org/sites/default/files/images/Chagos%20News%2047.pdf>
- Hays, G. C., J. A. Mortimer, D. Jerodiconou, and N. Esteban. 2014. Use of Long-Distance Migration Patterns of an Endangered Species to Inform Conservation Planning for the World's Largest Marine Protected Area. *Conservation Biology*, 28:1636–1644.
- Hemsley, W. B. 1887. Report on the Vegetation of Diego Garcia. *J. Linn. Soc. Bot.*, 22:332–340.
- Hillman, C. 2007. Rapid Assessment Survey of the Environment of Eagle Island – CERP 2006. *Chagos News*, 29:2–9. <http://chagos-trust.org/sites/default/files/images/ChagosNews29.pdf>
- Horsburgh, J. 1852. *India Directory, or Directions for Sailing to and from the East Indies*. 6th ed. 2 vols. London: William H. Allen & Co.

- Luce-Smith, W. 1959. *Development of Economy of Mauritius*. File CO 1036/502 in the National Archives at Kew. <http://discovery.nationalarchives.gov.uk/details/r/C2049337>
- Mandarin, F. 2016. "Living Memories: A Worker's View of the 1950s." In *Chagos: A History: Exploration, Exploitation, Expulsion*, ed. N. Wenban-Smith and M. Carter. York, U.K.: YPD Books for the Chagos Conservation Trust.
- Moresby, R. 1837. Admiralty Charts and Publications, Covering the Chagos Archipelago and Its Atolls. *Transactions of the Bombay Geographical Society*, 1:307–310.
- Mortimer, J. A. 2009. History of Turtle Exploitation in Chagos. *Chagos News*, 34:14–16.
- Mortimer, J. A., M. Donnelly, and P. T. Plotkin. 2000. "Sea Turtles." In *Seas at the Millennium*, Vol. 3, ed. C. R. C. Sheppard, pp. 59–71. Oxford: Elsevier Science.
- Posford Haskoning. 2002. *Feasibility Study for the Resettlement of the Chagos Archipelago: Phase 2B, Section 3: Soil and Land Resources*. Report prepared for BIOT Administration, London.
- Schiller, C. 1992. *Assessment of the Status of the Coconut Crab Birgus latro on Niue Island with Recommendations Regarding an Appropriate Resource Management Strategy*. Report prepared for the Food and Agriculture Organization of the United Nations (FAO). FAO Corporate Document Depository: <http://www.fao.org/docrep/field/003/ac281e/AC281E00.htm#TOC>.
- Scott, R. 1961. *Limuria: The Lesser Dependencies of Mauritius*. London: Oxford University Press.
- Sheppard, C. R. C. 1979. Status of Three Rare Animals on Chagos. *Environmental Conservation*, 6:301.
- , ed. 2013. *Coral Reefs of the United Kingdom Overseas Territories*. London: Springer.
- Sheppard, C. R. C., M. R. D. Seaward, R. Klaus, and J. Topp. 1999. "The Chagos Archipelago: An Introduction." In *Ecology of the Chagos Archipelago*, ed. C. R. C. Sheppard and M. R. D. Seaward, pp. 1–20. Linnean Society Occasional Publications 2. Otley, U.K.: Westbury, for the Linnean Society of London.
- Sheppard, C. R. C., and 40 others. 2012. Reefs and Islands of the Chagos Archipelago, Indian Ocean: Why It Is the World's Largest No-Take Marine Protected Area. *Aquatic Conservation: Mar. Freshw. Ecosyst.*, 22:232–261.
- Stoddart, D. R. 1971a. Settlement and Development of Diego Garcia. *Atoll Research Bulletin*, 149:209–217.
- . 1971b. Land Vegetation of Diego Garcia. *Atoll Research Bulletin*, 149:127–142.
- . 1971c. Terrestrial Fauna of Diego Garcia and Other Chagos Atolls. *Atoll Research Bulletin*, 149:163–170.
- . 2001. Be of Good Cheer, My Weary Readers, for I Have Espied Land. *Atoll Research Bulletin*, 494:235–272.
- <http://www.sil.si.edu/digitalcollections/atollresearchbulletin/issues/00494.12.pdf>
- Thaman, R. R. 1990. Kiribati Agroforestry: Trees, People and the Atoll Environment. *Atoll Research Bulletin*, 333:1–29.
- . 2016. The Flora of Tuvalu: Lakau Mo Mouku o Tuvalu. *Atoll Research Bulletin*, 611:1–129.
- <http://opensi.si.edu/index.php/smithsonian/catalog/book/143>
- Thaman, R. R., and M. Samuelu. 2016. Vascular Plants, Vegetation and Ethnobotany of Banaba (Ocean Island), Republic of Kiribati. *Atoll Research Bulletin*, 609:1–91.
- <http://opensi.si.edu/index.php/smithsonian/catalog/book/117>
- Thaman, R. R., and A. Tye. 2015. Flora of Kiritimati (Christmas) Atoll, Northern Line Islands, Republic of Kiribati. *Atoll Research Bulletin*, 608:1–73.
- <http://opensi.si.edu/index.php/smithsonian/catalog/book/114>
- Topp, J. M. W. 1988. An Annotated Checklist of the Flora of Diego Garcia, British Ocean Territory. *Atoll Research Bulletin*, 313:1–21.
- Topp, J. M. W., and C. R. C. Sheppard. 1999. Higher Plants of the Chagos Archipelago. In *Ecology of the Chagos Archipelago*, ed. C. R. C. Sheppard and M. R. D. Seaward, pp. 225–240. Linnean Society Occasional Publications 2. Otley, U.K.: Westbury, for the Linnean Society of London.
- U.S. Department of Agriculture (USDA). 2014. *Commodity Intelligence Report*. <http://pecad.fas.usda.gov/highlights/2014/09/SEAsia/index.htm>.
- . 2015. *Oil Crops Yearbook*. <http://www.ers.usda.gov/data-products/oil-crops-yearbook.aspx>.
- Vargas, S. M., M. P. Jensen, S. Y. W. Ho, A. Mobaraki, D. Broderick, J. A. Mortimer, S. D. Whiting, J. Miller, R. I. T. Prince, I. P. Bell, X. Hoenner, C. J. Limpus, F. R. Santos, and N. N.

- FitzSimmons. 2015. Phylogeography, Genetic Diversity, and Management Units of Hawksbill Turtles in the Indo-Pacific. *Journal of Heredity*, 2015, 1–15. doi:10.1093/jhered/esv091
- Wenban-Smith, N. 2012. Population of the Chagos, 1820-1973. *Chagos News*, 39:18–22.
<http://www.chagos-trust.org/sites/default/files/images/Chagos%20News%2039.pdf>
- Wenban-Smith, N., M. and Carter. 2016. *Chagos: A History: Exploration, Exploitation, Expulsion*. York, U.K.: YPD Books for the Chagos Conservation Trust.
- Wiehe, P. O. 1939. Report on a Visit to the Chagos Archipelago. Prepared for Mauritius Department of Agriculture. Library of the Royal Botanic Gardens, Kew, mimeographed document.