Conservation and Management in

British Indian Ocean Territory (Chagos Archipelago)

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Summary

The British Indian Ocean Territory (BIOT) Marine Protection Area (MPA) was proclaimed in April 2010 and follows on from the BIOT Environment (Protection and Preservation) Zone established a decade earlier. It includes all sea and islands within the EEZ except for the southernmost atoll of Diego Garcia to its 3 nm boundary. All commercial fishing ceased within this area in 2010 when existing licences expired. The calculated area is 639,661 sq. km[1], (excluding Diego Garcia which is 470 sq. km, and which is 0.07% of the MPA zone).

This document outlines science needs and links these to management needs. It is very simple compared to conventional management plans. It needs to be simple because of funding and access limitations, and it can be simple, because most sectoral pressures do not exist there.

Most scientific knowledge of the area to date has come from a series of scientific visits conducted over several years. Funding for continuation of these into the near future is secured. Scientific knowledge was summarised in a multi-author review published in early 2012 [2].

Science informs management and understanding of an area. The work proposed is placed in several sections, for convenience. Some is what scientists and administrators 'need to know', for providing fundamental management information, and the rest is what would be 'nice to know', recognising that the latter often becomes the former when, as repeatedly occurs in Chagos, new ecosystems such as mangroves or seagrass beds are discovered.

The islands and their adjacent shallow reefs are relatively well documented, and in some cases the Chagos reefs are now amongst the best understood anywhere. They are also recognised as being in exceptionally good condition, and it was in recognition of this, and the need for global reference and 'reserve' sites, that led to the establishment of the protected area. Very much less is known about adjacent benthic habitats such as seagrass beds and sand substrates. Equally poorly known are the very much larger pelagic and benthic deep water zones, including knowledge of their fish stocks, other than limited fisheries data collected prior to the reserve's establishment. For much of the area, there is insufficient data of status before the reserve's declaration.

The success of many protected areas is sometimes judged by determining improvements since creation, but this is mostly inappropriate in the case of Chagos for two reasons. Firstly, insufficient data exist preceding the reserve's establishment to do this for many organisms and habitats, and over most of the area, so that such a comparison is impossible. Secondly, in the few areas where earlier data have been adequate it is seen that the marine condition is already excellent, sometimes unsurpassed, so little significant 'improvement' can realistically be expected. Examples include reef corals and fishes. For these, the difference between conditions in Chagos and those elsewhere in the Indian Ocean may be used to better

[1] This has recently been recalculated, using the same boundaries. Earlier estimates refer to approximately 550,000 sq. km.

[2] Sheppard CRC + 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: marine and Freshwater Ecosystems*. http://onlinelibrary.wiley.com/doi/10.1002/aqc.1248/full. Vol 22: 233-261.

judge its success and effectiveness. On islands the position is rather different. There, environmental degradation resulting from 200 years of exploitation is known and can be improved upon with active management strategies, where judgement of success can be measured by several indicators such as improvement in vegetation type and bird density.

Summary of science, monitoring and management recommendations

Marine, fisheries and island science, and monitoring. (Sections B.1 – B.3)

a. Coral cover monitoring. Monitor every 2 years plus after new mass mortalities.
b. Juvenile coral monitoring, coral and soft corals demographics. Every 5 years.
c. Continuous sea temperature monitoring. Bi-annual replacement of instruments.
d. Sea level and wave monitoring.
e. Reef fish biomass monitoring. Every 5 years plus after any coral mortality.
f. Monitoring coral growth changes.
g. Develop non-destructive monitoring methods for pelagic predators (sharks, tuna). Derive estimates of pelagic fish biomass. Annually for 5 years, then as research dictates.
h. Establish more complete recording of yacht based fishing and Diego Garcia recreational fishery. Continuous.
i. Document the composition of each seizure of illegal fishing boats. Every seizure.
j. Monitor shark and sea cucumber densities. Every 5 years.
k. Monitor marine mammals. Initial survey needed.
l. Monitor internationally important breeding seabird populations. Twice per year.
m. Monitor turtle nesting populations on Diego Garcia and in northern atolls. Monitor growth rates of the Hawksbills at Turtle Cove, Diego Garcia.
n. Monitor coconut crab densities in Diego Garcia and northern atolls. Every 5 years.
o. Measure, shoreline erosion using various techniques including GIS and GPS. Every 2 years.
p. Terrestrial invasive plant species research, and arthropod research. Ongoing.

General needs and management activities. (Section B.4)

a. Prioritise, with several agencies and with 'Big Ocean Network', methods of improved detection of illegal fishing. Ongoing.
b. Develop research support facilities on board the BIOT Patrol Vessel and on shore in Diego Garcia. By end 2012.
c. Co-ordinate independently funded and government funded research projects. Ongoing.
d. General mapping and database work to consolidate all aspects. Satellite mapping and exploration of the >90% of Chagos still unexplored. Established by end 2013, then ongoing.
e. Develop plan for island vegetation/bird restoration and habitat management, using existing island priority list. By end 2012. As priority, rehabilitate mangroves on Moresby and Eagle islands by end 2013 and then ongoing maintenance.
f. Removal of debris from island beaches, especially potential turtle nesting beaches. Periodic.
g. Move the Strictly Protected Area north-western corner in Peros Banhos westwards to encompass two more islands.

A. Introduction and Background

During the last two decades, over one hundred scientists have been engaged in researching island and marine habitats of the British Indian Ocean Territory (BIOT). They have developed an understanding that the archipelago's reefs remain in exceptionally good condition, notwithstanding episodic impacts from warming (from which recovery here has been far faster than in most other countries), and hence the reefs are unlike most other parts of the tropical oceans where reef degradation is common, even within protected areas. The islands were farmed for coconuts in the past and their wildlife was heavily exploited, but several species such as turtles, crabs and birds have also seen marked improvement in status over the last 40 years. Scientific exploration of Chagos has so far led to over 200 scientific papers (listed in http://www.chagos-trust.org/sites/default/files/images/bibliography.pdf). Research is ongoing, and the scientific information formed the solid basis behind the declaration of Chagos as the world's largest no-take marine protected area. Building on the successes to date, at least four more scientific expeditions over the next two years have been funded, with more interest being generated.

A.1 Previous management

A management plan developed for Chagos in 2003 [3] recognised Chagos as being in exceptional condition and outlined the need for a more structured approach to its long-term protection. Its recommendations for implementing numerous conservation measures also went some way to meeting the UK Government's international conservation obligations and objectives. The plan suggested that many of the classic impediments and sectoral issues that commonly hinder preservation of natural systems world-wide could be accommodated by three main actions:

1. Creation of extensive, fully protected areas,
2. Creation of a scientific advisory group and a programme of regular monitoring,
3. Creation of a practical mechanism for information gathering – namely the continued availability of a ship from which to police the zone.

At the same time, a *BIOT Environment (Protection and Preservation) Zone* was declared, consisting of the area within a 200 nautical mile (nm) boundary with the exception of all islands out to a 3 nm boundary (**Annex 1 and 2**). Fishing within much of the area continued.

The first proposed action called for 30% of the entire area to be protected. This was felt to be essential, and more than this had not been achieved anywhere else in the world over such a large area. In the event, this was vastly exceeded when, in 2010, the whole archipelago to the 200 nm limit (the same outer boundary as the previous *Environment Zone*) was declared a no-take protected area, with the exception of Diego Garcia. Fisheries licences were not renewed, the last one expiring later in 2010.

Diego Garcia atoll, which contains the military facility and is the only inhabited part, has been excised from the reserve to a 3 nm boundary. The reserve thus covers over 99% of the total area, and 51 of the 55 islands, although only 50% of the total land area. However,

[3] Sheppard CRC, Spalding M. 2003. *Chagos Conservation Management Plan*. BIOT Administration, FCO, London. 52 pp.

Diego Garcia's own environmental regulations are extensive with a substantial proportion being strictly protected, and with a comprehensive set of Strict Nature Reserves and regulations (summarised in Section C and in extensive Annexes) developed in recognition of its important role in the archipelago.

The second recommendation from 2003, establishment of a scientific advisory group coupled with regular monitoring, was also implemented. The advisory group was *ad hoc* from 2003 to 2011, comprising some long standing members but with advisors on issues as they arose. Its final output was a recommendation of what work was needed from that point onwards (**Annex 3**).

In 2010, a workshop held at the National Oceanographic Centre in Southampton (**Annex 4**) endorsed the concept of enhanced protection; its Executive Summary stated:

> There is sufficient scientific information to make a very convincing case for designating all the potential Exclusive Economic Zone of the British Indian Ocean Territory (BIOT, Chagos Archipelago) as a Marine Protected Area (MPA)…

Following this, the science advisory group changed and became formalised.

The third recommendation of the 2003 management plan concerned provision of a permanent ship for patrolling and research purposes. This has also been secured until 2016, although one ship was always considered to be a basic minimum.

The 2003 management plan was deliberately kept simple due to extreme logistical constraints, and simplicity remains key. Much of the detail and complexities needed in many marine and coastal management plans can be avoided. Moreover, many of the monitoring and management activities considered the norm in smaller tropical MPAs are difficult, given costs and distances involved. Much of the complexity in MPA plans for many places derives from zoning schemes (sometimes very elaborate) for various forms of use, in which recreational and commercial interests compete with conservation needs, leading to compromises which generally impede effective conservation. Since Chagos is an entirely no-take marine reserve, no such complexity is necessary.

The following plan and outline therefore is kept brief and succinct. However, many Annexes support the main text, focusing on documents possibly difficult to locate (but usually available somewhere on the internet). Most science references are contained in the review mentioned in footnote-2, and in the Chagos Conservation Trust website noted earlier.

The 2003 management plan ended its introduction with:

> The archipelago is also exceptionally beautiful. Such considerations regrettably are omitted from many scientific documents, though scenic and aesthetic considerations do form key components, and even the main basis, of many protected area designations worldwide. This archipelago merits protection for this alone… Indeed, its government correctly alludes to this aspect in several documents …

This importance of this aspect has, if anything, increased since then; its reefs at that time had been badly affected by the 1998 ocean-wide mortality caused by warming and in 2003 were only just starting to recover. That self-repair is now progressing well, according to

subsequent monitoring, while many other parts of that ocean have continued to degrade, increasing the contrast between Chagos and the rest. On islands too, birds, turtles and coconut crabs have also increased in numbers over the past four decades. Most importantly for the region as a whole, much of the emerging science shows that Chagos is a unique scientific model which can be used as a reference for management of exploited areas elsewhere.

BIOT intends that all aspects described here will be pursued. Some have been done, many are currently being done and are on-going, and many, especially logistically difficult or expensive elements are being planned or considered, and all are aspirational.

A.2 Environmental legislation and regulations

General

Diverse environmental legislation developed for BIOT over four decades. With its emphasis on Diego Garcia, this needed consolidation and updating, and this has been done, covering both Chagos as a whole and Diego Garcia in particular (**Annex 5**). Key features cover the taking of wildlife, damage to both marine and terrestrial environments, fishing and access to islands. Details on permit requirements and penalties for infringements are included in the legislation.

Diego Garcia

Section C is concerned with Diego Garcia.

Visiting boats

Visiting yachts are now the main 'users' of the BIOT marine reserve. Numbers vary seasonally, usually with none during the Southeast Trades, and commonly one or a few dozen during the rest of the year. Recent revisions have limited both the numbers and areas where they may anchor, now limited to only particular sites in two northern atolls. Prior permission from BIOT Administration is required: forms for this, and information, are available from: http://www.fco.gov.uk/en/travel-and-living-abroad/travel-advice-by-country/asia-oceania/british-indian-ocean-territory, reproduced in **Annex 6** (January 2012 versions; for updates, including possible changes in fixed penalties, the web site should be used).

BIOT environmental laws and regulations include requirements for conduct, mainly involving which activities are permitted on the islands, and fishing. These are available from http://www.fco.gov.uk/content/en/country-profile/asia-oceana/fco_cp_biot.

Annex 6 details the areas where yachts may anchor if BIOT grants permission to visit. The need for regulation in the case of anchor location is due to observations of environmental damage done in the past by some, including both consumption of wildlife and inadvertent and deliberate damage to corals and terrestrial vegetation. Further, when high numbers of yachts were permitted in the past, officers on the BIOT Patrol Vessel several times reported plankton blooms attributed to nutrient loads in the water. Reduction in numbers was deemed necessary to avoid such pollution (given that yachts do not generally move offshore to empty sewage holding tanks). These regulations are designed to minimise adverse impacts while still permitting visits by travellers. Visitors are not permitted access to, nor may they anchor in, any other location in BIOT except in emergencies.

A.3 Illegal, Unreported and Unregulated fishing surveillance and enforcement

Two main forms of illegal, unreported and unregulated (IUU) fishing have taken place in BIOT: parties encamped on islands who have collected mainly sea cucumbers but who have also taken turtles, reef fish including sharks, and birds; and boat based parties who have targeted mainly sharks but who also have been arrested with dolphin and manta rays on board.

A likely general future scenario is that illegal fishing pressures throughout the ocean will increase as human populations increase, and as degradation and resource loss increases elsewhere. Increased pressure is likely to apply to Chagos too.

a. Illegal island encampments

Illegal sea cucumber exploitation has been substantial in the past[4], but this may since have been largely curtailed. Landed shore parties use snorkelling and sometimes SCUBA equipment, and those caught have been found with thousands of drying sea cucumbers. Total quantities are difficult to determine, but a report in 2006 (**Annex 7**), based on published information on imports and re-exports in Sri Lanka, and on interviews by Sri Lankan colleagues in ports, determined that probably 30-60 boats were returning to Sri Lanka from Chagos with sea cucumbers per year, up to about 2007. Of these, 3-4 were intercepted each year. Since that report, detected encampments have declined, with the last arrest in May 2005. There are no reliable figures on turtle, turtle egg or bird captures by island based illegal fishing parties.

b. Boat based IUU.

Two types of illegal boat based fishing have been documented for Chagos: infrequent, large tuna boats and frequent small IUU, usually Sri Lankan vessels. Interception of tuna boats has taken place once since the declaration of the Chagos marine reserve. Arrests of illegal small vessels have significantly increased over the last few years to twelve in 2011; this is understood to have been a small proportion of the number conducting IUU, and sharks particularly have suffered substantial declines, attributed to this[5].

c. Large MPAs and Enforcement

Enforcement in the Chagos marine reserve has, as its principal challenges, the detection of illegal fishing vessels and the setting of fines. The primary, direct means of detection available to BIOT is through its Patrol Vessel, an ocean going ship with crew of eighteen (and capacity for 14 additional persons such as scientists). Other detections via military facility have been passed on to BIOT in the past both formally and informally, and this procedure should be regularised. With rapidly evolving technology, there are several different methods of remote detection applicable to enforcement of the marine reserve. Fines

[4] Price ARG, Harris A, Mcgowan A, Venkatachalam AJ, Sheppard CRC. 2010. Chagos feels the pinch: assessment of holothurian (sea cucumber) abundance, illegal harvesting and conservation prospects in British Indian Ocean Territory. *Aquatic Conservation: marine and freshwater ecosystems* 20:117-126.

[5] Graham N, Spalding MD, Sheppard CRC. 2010. Reef shark declines in remote atolls highlight the need for multi-faceted conservation action. *Aquatic Conservation: marine and freshwater ecosystems* 20: 543-548.

are currently set to be small enough to be worth paying for boat recovery, but may not be sufficiently effective. It may become economically unfeasible for boat owners to continue risking fishing in the archipelago as more boats are intercepted, in which case numbers might drop. The current system of fines is possibly not a great enough deterrent, given their continuing presence in the reserve. This aspect is under frequent review by BIOT Administration.

Being investigated concurrently is how arrests can be matched with legislation, using models used in other coral reef areas, and exploring their potential applicability in the BIOT marine reserve. In Florida, for example, unlicensed ships arrested with fish on board are required to prove that the fish were not caught in the Florida marine protected area; failure to do so will lead to prosecution. In the Hawaii Marine National Monument, *any* fishing boat occurrence is illegal unless its intentions have been reported beforehand. These models are undergoing consideration with BIOT Administration.

d. The *Big Ocean Network*

In recognition of the particular management challenges which arise from the large sizes of Chagos and other very large marine protected areas or reserves, for example the Papahānaumokuākea Marine National Monument in the northwest Hawaiian Islands and the Phoenix Islands Protected Area, an information network has developed between the six current largest such areas. Members of the *Big Ocean Network* have protected area sizes exceeding 250,000 km^2 (http://www.bigoceanmanagers.org/). It is clear that the issues of surveillance for such large and usually remote areas differ fundamentally from that of more typical small protected areas and reserves (median global MPA size is less than 10 km^2). Enforcement is a main focus of the regular meetings of the 'Big Six'. This is an evolving subject, with aspects such as remote detection changing rapidly.

Being investigated concurrently is how arrests can be matched with legislation, using models used in other coral reef areas, and exploring their potential applicability in BIOT and other very large protected areas and reserves. In Florida, for example, unlicensed ships arrested with fish on board are required to prove that the fish were not caught in the Florida marine protected area; failure to do so will lead to prosecution. In Hawaii, *any* fishing boat occurrence is illegal unless its intentions have been reported beforehand. These models are undergoing consideration with BIOT Administration.

Thus enforcement is a main focus of the regular meetings of the 'Big Six'. This is an evolving subject, with aspects such as remote detection changing rapidly. Meetings are at least once per year, and representatives from NGOs engaged with the Chagos MPA and/or BIOT Administration attend and contribute.

B. Science, Monitoring and Management

There are 60,000 km^2 of shallow marine substrate in BIOT, in unknown proportions of coral reef, seagrass or other limestone substrate. The commonly used term 'marine management' is misleading; it does not mean 'managing' (manipulating) the marine environment, but means managing the activity of people using it. Except for the case of dealing with illegal activities, such management does not apply in Chagos at present.

Section B.1 to B.3 outline the science and monitoring needed to understand the state of the system, while B.4 states those activities where direct management activities and facilitation are possible.

Monitoring is necessary for numerous reasons, including provision of data for fulfilling international agreements and for recording changes in habitats in a time of rapid global environmental changes. In the latter case, in broad terms for BIOT, most changes underwater are the result of climate changes, which cannot be controlled by BIOT's government (Footnote-2). On the islands, changes are principally the process of recovery from the time of copra plantation, when native vegetation, turtles, birds, coconut crabs etc. were all severely reduced. On islands, active intervention does have considerable scope for environmental improvement, for example restoration through removal of rats or invasive plant species.

The five atolls of the Chagos archipelago contain some fifty-five islands, of which Diego Garcia at 2719.5 hectares is ten times larger than any other island and forms over half of the total land area. Most islands have been impacted to a greater or lesser degree by human occupation, visitation and exploitation, the two most deleterious and long lasting effects being habitat destruction when most islands were converted to coconut monoculture, and the concomitant introduction of rats. Those few islands that escaped most of the environmental havoc provide a template for ecological restoration. Island restoration is now a mature business worldwide and techniques and technology exist to vastly improve the terrestrial biological value of the Chagos islands. Data also now exist to prioritise the islands for restoration.

Considerable knowledge exists of the plants, birds, turtles, rats and insects. Several other terrestrial taxa remain poorly studied so that their global importance remains unknown. No endemic land dwelling species are known, though endemic sub-species of insects and possibly birds do occur. The two breeding turtles, hawksbills and greens, are listed as Critically Endangered and Endangered in the 2011 IUCN Red List of Threatened Species; while the coconut crab is considered Data Deficient but is known to be rare in most places outside Chagos. Of the birds, the breeding seabirds are of international importance and ten islands have been designated as BirdLife International recognised Important Bird Areas (IBAs) and two further islands are currently under consideration as IBAs.

If settlement of people does take place in the northern islands at some future time, the management plan will need to be substantially revised to mitigate human impacts. For example, new plans would need to address all human activities to avoid, minimise or delay any habitat and resource deterioration. Zoning of activities especially would be a core component if the degradation usually associated with human habitation is to be avoided.

It is a mistake to separate too carefully the concepts of science from that of management based on science: all existing knowledge now available to assist management came from past scientific expeditions. The listed activities will apply in all foreseeable scenarios, some continuing existing work and some being new in response to recently increased capacity or new discoveries.

Funding (see Section D) has already been secured for annual sets of measurements until 2014, for all activities that can be conducted from the BIOT Patrol Vessel. Other projects are also under development that are exploring the use of other research vessels e.g. NERC deep sea exploration vessels and possibly private vessels.

Several management and monitoring recommendations come from the document submitted to BIOT in 2010 (**Annex 3**). They are designed both to effectively inform BIOT with regard to the Territory, and enable it effectively to manage the area as a no take marine reserve, and to ensure BIOT can fulfil its potential as a globally important scientific reference site.

(Footnote references are given for some specific items only: a summary of the science can be found in footnote-2.)

B.1 General marine science and monitoring

a. Coral cover monitoring

Coral cover has been monitored periodically since 1996. It is a simple, rapid measure of reef health and, though far from comprehensive by itself, it complements many other research activities as well as providing a rapid measure of condition. Monitoring since 1996 includes records of the severe reduction from the 1998 mortality[6] and subsequent recovery. This information has shown Chagos to be exceptionally resilient; cover recovery rates are largely unparalleled elsewhere in the world, thus making the Chagos a globally important scientific reference site.

- It is recommended that coral cover monitoring continue in a compatible manner at two year intervals, or more frequently if another severe warming event occurs.

b. Juvenile coral monitoring and coral demographics of stony and soft corals.

Juvenile coral recruits have been measured since the 1998 mortality, and in 2001 were found to be the highest recorded in the world at that time. The data showed that Chagos reef resilience, or recovery potential, was very high, and the data have also been used as important inputs into models used to forecast the future of Chagos reefs[7]. Measurements were repeated in early 2012. Both slow-growing massive corals, and fast-growing fugitive species, especially soft coral species, make good indicators of long-term temperature flux.

- It is recommended that coral juvenile counts and colony demographics of key stony and soft coral species be recorded at intervals of five years (or immediately after new mass bleaching events).

c. Continuous sea temperature monitoring

Mortality from high sea temperatures is probably the most immediate threat to Chagos corals, and hence to its reef ecosystems. Thus, continuously recording temperature loggers have been deployed at various depths at sites across all atolls since 2006, in lagoons, reef passes and outer seaward slopes. Early results after two years (from Diego Garcia) were striking[8], and help explain the resilience of these atolls to warming, which warrants the continuation of this work. Existing temperature recorders will continue recording until 2015.

- It is recommended that this work continue with data loggers permanently deployed at key sites, because rising temperatures and associated anomalies are predicted to become increasingly critical factors affecting reef survival.

d. Sea level and wave monitoring

Sea level change is a sensitive indicator of change in ocean density (steric change), ocean circulation and regional climate. It is important to monitor sea level for these science reasons,

[6] Sheppard CRC, Spalding M, Bradshaw C, Wilson S. 2002. Erosion *vs*. recovery of coral reefs after 1998 El Niño: Chagos reefs, Indian Ocean. *Ambio*. 31:40-48

[7] Riegl BM, Sheppard CRC, Purkis SJ. 2012. Human Impact on Atolls Leads to Coral Loss and Community Homogenisation: A Modeling Study. PLoS One Volume 7, e36921, pp1-11.

[8] Sheppard CRC 2009. Large temperature plunges recorded by data loggers at different depths on an Indian Ocean atoll: comparison with satellite data and relevance to coral refuges. *Coral Reefs* 28:399-403.

and also for practical ones to do with determination of change in flood risk and as input to studies of coastal processes (e.g. erosion). Availability of ongoing sea level data will also be useful to many sets of fieldwork e.g. surveys of coral reefs. Some types of tide gauge (e.g. pressure-based systems) also measure waves, complementing wave information from wave models, satellites and, ideally, from wave radars.

- It is recommended that researchers make maximum use of tide gauge data available from the Global Sea Level Observing System (GLOSS) installation at Diego Garcia operated by the University of Hawaii. If considered desirable, this installation when next upgraded should be equipped to monitor waves inside the lagoon.

e. Reef fish biomass monitoring

The shallow water reef fish assemblages in Chagos were shown to be remarkably stable through the massive mortality and subsequent recovery of corals following the 1998 warm water event[9]. This is in stark contrast to many other locations in the Indian Ocean where the diversity of reef fish declined substantially and local extinctions were recorded. Research has also shown that the reef fish biomass in Chagos is 6-100 times greater than in most other areas in all tropical oceans, including small MPAs on populated coastlines. With the exception of sharks at least, Chagos is thus known to provide a good reference baseline and a management target for reefs worldwide in terms of the potential biomass and composition of reef fish assemblages.

- It is recommended that similar monitoring take place at intervals of not more than five years in order to detect changes, and that this monitoring is especially conducted after any future mass coral mortality episodes.
- It is recommended that monitoring of reef fish be extended to deeper reefs as these areas are subject to illegal fishing of large predatory fish.

f. Monitoring coral growth changes

It is important to know whether coral growth (linear extension, calcification, density) is responding to temperature increases in the Chagos. Extensive coral cores have been acquired already for other purposes, which can be used to initiate this. A corer remains in Diego Garcia to take more.

- It is recommended that funding be obtained to analyse existing cores to determine changes over long time series of coral growth.

The above are priority marine monitoring activities. Numerous additional activities are ongoing and are listed in later sections, notably B5. All are designed to determine the status of Chagos' marine condition, to detect any changes to it, and to provide information which may be used for mitigation (in a few cases) and management.

[9] Graham NAJ, + 9 others. 2008. Climate warming, marine protected areas and the ocean-scale integrity of coral reef ecosystems. *PLoS ONE* 3(8): e3039.

B.2. Fisheries-related science and monitoring

Cessation of industrial fishing was the main practical achievement of the Chagos protected area. Current authorised fishing activity in BIOT includes the legal recreational fishery in Diego Garcia (which is outside the reserve) and fishing from visiting yachts which currently is limited to fish consumable within three days. Interest by the fishing sector remains in reopening this fishery, a desire which may increase as tuna and sharks become increasingly depleted elsewhere. Data collection from this fishery was poor, especially of bycatch[10]. For management purposes, the priority is to ensure that enforcement is adequate and effective. Monitoring is required to understand the effectiveness of enforcement on species that are known to be depleted by illegal fishing (primarily sea cucumbers and sharks), the scale of recreational and illegal fishing, and to determine the value of the Chagos marine reserve to highly mobile species, particularly tuna.

a. Tuna and other highly mobile ocean predators

Commercial fishing ceased within the reserve's boundaries in October 2010. This was a highly significant step in global marine conservation as the large area provides a refuge from exploitation for mobile pelagic predators such as tuna and sharks, many of which are internationally threatened. However, debate persists on whether mobile species are sufficiently "resident" within the marine reserve boundary for this protection to have an impact on overall populations. Fundamental to resolving this largely data-free debate is the collection of information on the status of key pelagic indicator species such as yellowfin tuna and blue sharks, with respect to their distribution and movements, relative abundance, size structure, sex and maturity. Monitoring methods should also be non-destructive given their application within a no-take marine reserve. There is little relevant information on tuna for the Indian Ocean, but in an analogous large tropical archipelago in the Pacific, the median lifetime range of the two tuna species caught in BIOT waters is approximately the dimension of the Chagos marine reserve. If this range applies to Chagos too, these data would indicate that while half the tuna do indeed migrate, half may not, relying on the productivity that has recently been identified by remote sensing.

No pre-closure data on tuna (or sharks) exists of use for comparison to estimate effects of closure on tuna biomass. It should not necessarily be expected that fish numbers within the Chagos marine reserve will increase; trials carried out in early 2012 showed that exceptionally high levels exist already. Maintenance of this biomass may be the best that can be achieved, and indeed would be a major achievement. Pressures to reopen the BIOT fishery, both political and commercial, will increase with time and with continued decline in fish stocks elsewhere. A pilot study will take place in Chagos at the end of 2012.

- It is recommended that a non-destructive method for monitoring tuna, sharks and other highly mobile species is developed and implemented, building on methods adapted from those employed successfully in Chagos in shallow water in early 2012.
- It is recommended that monitoring is implemented to derive estimates of pelagic fish biomass and, if possible, trends in biomass over time.
- It is recommended that BIOT remains engaged with the IOTC to demonstrate the value of the Chagos marine reserve in the context of the status of the wider Indian

[10] Koldewey H, Curnick D, Harding S, Harrison L, Gollock M. 2010. Potential benefits to fisheries and biodiversity of the Chagos Archipelago/British Indian Ocean Territory as a no-take marine reserve. *Marine Pollution Bulletin* 60: 1906-1916.

Ocean in general and the status of commercially important species, particularly tuna and sharks.

b. Fishing from yachts

Recreational fishing from yachts is currently permitted, so it is important to determine the scale of this activity, documenting species, numbers, sizes and fishing effort (days fished, number of lines). This will help determine if fishing levels are sustainable.

- It is recommended that yachts be required to complete recreational fishing logbooks as a condition of entry.

c. Seized catches

It is important that the catch composition is documented for every seized catch, including species, numbers, sizes, and sex where external assessment is possible, as well as effort (days fishing, location) and gear characteristics (number of hooks, length of line).

- It is recommended that the composition of illegal catches is documented, using consistent and standardised methods.

d. Sharks

The relative number of reef sharks seen per scientific dive has been recorded in Chagos since 1975 (earlier footnote reference). The greatest declines occurred between 1980 and 1996, representing a 90% loss in average number of reef sharks observed. No measurable recovery has occurred to date, but if illegal fishing rates are reduced, a slow recovery of reef shark populations is likely.

- It is recommended that reef shark numbers continue to be monitored at least every 5 years.
- It is recommended that monitoring of reef sharks be extended to deeper reefs as these areas support a range of shark species targeted by illegal fishing activity.

e. Sea cucumbers

Illegal exploitation has been a major factor that has severely depleted these important 'cleaners of the sand' and nutrient recyclers (earlier footnote reference). New evidence suggests that natural recovery times may be very long (up to centuries).

- It is recommended that monitoring of species and numbers take place at intervals of five years at least, and that samples be taken for analysis to determine potential for recovery.
- It is recommended that the islands be regularly inspected for illegal fishing camps or signs of human activity.

f. Marine mammals

At present there is no monitoring of marine mammals – earlier attempts for funding have failed due to the high costs of the ship-borne work needed. The dugong, once recorded in Chagos, has long been extinct there. There are large schools of many hundreds of spinner and bottlenose dolphins around the reefs.

- It is recommended that a survey programme be initiated for marine mammals.

B.3. Island science and management

a. Seabird Research and Monitoring

Eighteen species of seabird breed on the islands, five in internationally important numbers[11]. Basic monitoring of these colonies commenced in 1996, though much has still to be understood about breeding cycles and strategies. Important questions for the management of the area for seabirds remain, e.g. when does peak breeding occur, what triggers breeding, are the same islands used for breeding or do colonies shift locations, what attracts a species to breed on an island?

- It is recommended that research of the internationally important breeding seabird populations is incorporated into a regular monitoring regime, twice per year.

b. Turtle Research and Monitoring

Nesting turtles. Turtles were heavily depleted during plantation days. Hawksbills (Critically Endangered) and green turtles (Endangered) breed throughout the islands. Monitoring and research work has been undertaken since 1996, particularly on Diego Garcia. Data are needed to identify the location of the adult foraging habitat utilized by both species of nesting turtles. Although genetic data have demonstrated phylogenetic relationships between hawksbills of Chagos and those elsewhere in the Indian Ocean, additional genetic sampling of nesting green turtles is still needed.

- It is recommended that further research of their nesting populations is funded and incorporated in to a much more frequent monitoring regime. The focus should be Diego Garcia which is accessible year-round. Work should include flipper tagging, genetic sampling (thus continuing work already underway) and satellite telemetry.

Foraging turtles. Diego Garcia hosts an unusual aggregation of foraging hawksbills in the shallow waters of a tidal channel (Turtle Cove). Although such aggregations may have once been abundant elsewhere in the ocean, human exploitation has eliminated most of them, making the Turtle Cove aggregation unique. Previous mark-recapture studies indicate the number of turtles is increasing, and their feeding ecology contrasts with turtles feeding on the outer reef of Diego Garcia.

- It is recommended that a long term study should be conducted over a period of one month every two or three years to assess trends in numbers, and of growth rates.

c. Coconut Crab Survey and Monitoring

Coconut crabs were also heavily depleted for consumption during the settlement era. Throughout the world this species is vulnerable to extinction, primarily due to over exploitation, and the species has never been bred in captivity. Given 40 years of recovery, research has demonstrated that today the density per hectare of coconut crabs on the protected eastern arm of Diego Garcia is the highest found anywhere in the world, an average of nearly 300 per hectare. Preliminary studies have indicated that many other islands throughout the Chagos also hold healthy populations of this species and, possibly, the archipelago is a world stronghold for coconut crabs and a globally important source for replenishment of depleted stocks elsewhere. High genetic connectivity for coconut crabs has underlined this importance.

[11] Carr P. 2011. *A guide to birds of the British Indian Ocean Territory*. Pisces publications for RSPB. 110 pp.

- It is recommended that a survey of all islands is undertaken to assess the populations of coconut crabs, and that populations are monitored at least every 5 years.

d. Island erosion

While erosion of shores on coral islands is commonplace and natural (along with accretion), net erosion is increasing in several locations. This has at present only been measured very crudely by repeated photographs in the same places over some years, including sites with stakes. This has large economic consequences in Diego Garcia, but in conservation terms this is equally important in the northern atolls.

- It is recommended that a programme of work be initiated immediately to measure and forecast shoreline erosion at key sites in northern atolls.

e. Continued botanical monitoring for invasive species

Regular botanical monitoring is already funded by a new legacy to Chagos Conservation Trust. Monitoring of invasive species and potential invasives is a part of this. At present, several potential invasive species have been recorded. Only the coconut palm is ecologically important at present, though this could of course change over time. This is recognised in Diego Garcia where steps are continuously in hand to search for and where necessary eradicate invasives as need arises.

- It is recommended that this regular botanical monitoring survey focus on invasive and potentially invasive species, especially in the northern atolls.

f. Restoration of small islands

Restoration of natural vegetation in place of the introduced coconut is being undertaken in three large experimental plots in Diego Garcia. Preliminary results are good. Alongside this, rat eradication needs to be undertaken. This has been attempted before, where it failed, and it is at present unrealistic in Diego Garcia. The focus should now be on using the successful botanical methods alongside rat eradication on selected small islands. Three potential target islands have been identified in Peros Banhos atoll in conjunction with bird and botanical experts. (See section B4.e for additional and related work).

- It is recommended that a suitable small island in Peros Banhos is targeted for a coconut thinning/removal programme alongside a rat eradication programme.

B.4 Management activities

This section details several activities (many currently ongoing) which are required for environmental management.

a. Illegal fishing detection

One threat to Chagos is from illegal fishing which will continue whatever the law, or until detection rates or fine levels make it economically too costly for vessel owners to risk. For all poaching, the primary, direct means available to BIOT is its Patrol Vessel. Observations by others have been passed on to BIOT in the past both formally and informally, and such procedures with the Diego Garcia facility and its ships should be regularised. There are several different methods of remote detection, as technology rapidly develops.

- It is recommended that BIOT should increase its engagement with the Big Ocean Network in order to benefit from collaboration with other very large MPAs. Given the complexities of managing very large MPAs, particularly relating to surveillance, this is very likely to bring considerable benefits to management of the Chagos marine reserve. Membership of and interaction with this alliance should be a key item, budgeted from management funds, rather than relying on NGO and private donations for attending the meetings.
- It is recommended that detection of vessels within BIOT waters by all possible means be encouraged, and that links be developed and regularised between the military and BIOT Administration.

b. Improved facilities in BIOT

Efficiency for almost all work will be greatly increased if there is a modest facility available on the Patrol Vessel and in Diego Garcia which can facilitate work done on field visits.

- It is recommended that facilities be developed on the BIOT Patrol Vessel and on shore in Diego Garcia to provide some basic infrastructure to support scientific research. This includes simple portable wet and dry labs on the BIOT Patrol Vessel and an environmentally controlled storage facility in Diego Garcia. As funding has been secured for these facilities, this can be implemented immediately.

c. Co-ordination of independently funded and government funded research projects

Over the years, a number of scientists have joined expeditions in Chagos or have received sample collections from expeditions. This research is funded independently, and its continuation only depends on continued support from BIOT regarding permits for collection and export. At present, the amount of science work is relatively small, considering the huge area. However, it is likely that this will be increased, given that for the first time no less than four further expeditions have been approved and funded.

- It is recommended that a central database is developed of all resulting reports and associated outputs (including a specimen and DNA database).
- It is recommended that a policy is developed on scientific research in BIOT that covers specimen collection and a general ethical framework of operation. Research projects should be encouraged, prioritising those that help inform management about the protected area.
- It is recommended that a set of guidelines be written for visiting scientists, especially concerning possible future work in areas being used by others.

d. Central GIS database and ecological mapping

The foundation of successful conservation and management is knowledge of what you have got and where it is. Gradually a comprehensive, high resolution GIS for the entire Territory should be constructed, integrated into a web-based resource that can be updated with data from each successive scientific visit. This would not only include maps, but also bathymetry, currents and temperature monitoring data from *in situ* loggers, videos and photographs. This would also provide a good opportunity to communicate the science to the public.

- It is recommended that a central database be developed immediately and a plan for funding be developed for a comprehensive GIS-based system.
- It is recommended that the habitat and vegetation of all islands is mapped and monitored at ten year intervals, using high-resolution satellite imagery accompanied by ground-truth survey work.

e. Island Restoration and Rehabilitation

Over 90% of the land area has been environmentally degraded by habitat destruction and the introduction of invasive alien species, chief amongst these being the black rat (*Rattus rattus*), thought to be on approximately 45 of the 55 islands. Island ecological restoration has been successfully conducted around the world including in other UK Overseas Territories, and is seen as the only method available to increase biomass and biodiversity of native, original species including seabirds. Following abandonment of the plantations, coconut trees pose a major constraint on the recovery of native vegetation. Studies in 2010 identified and prioritised islands for restoration. There are two mangrove swamps in the Chagos, one on Moresby Island and the other on Eagle Island, both of which will be permanently lost as habitat within ten years if not rehabilitated by controlling the encroaching unmanaged former coconut plantations.

- It is recommended that the mangroves habitats on Moresby and Eagle islands are rehabilitated immediately and that a programme of island ecological rehabilitation and restoration is implemented that rehabilitates key islands within the archipelago.

f. Removal of debris, especially plastics, on island beaches

Beaches in Chagos receive large amounts of floating debris[12], and identification of the types shows that most comes from Asia, with much from lost and discarded fishing gear. This quantity possibly has the effect of interfering with turtle nesting.

- It is recommended that a programme of beach clearing (as currently happens in Diego Garcia at regular intervals, and which has also taken place episodically on other islands in the north as opportunities have permitted) be conducted periodically on as many islands as possible.

g. Move the Strictly Protected Area boundary in Peros Banhos

The western boundary of the Peros Banhos Strict Conservation Area at present excludes the pair of islands Moresby and Ile de la Passe from protection, and these are located near one of

[12] Price ARG, Harris A. 2009. Decadal changes (1996–2006) in coastal ecosystems of the Chagos archipelago determined from rapid assessment. *Aquatic Conservation: marine and Freshwater Ecosystems*. 19:637-644.

the permitted yacht anchorages. Nesting birds are now extending into this area and the newly discovered mangrove swamp.

- It is recommended that these two islands be included in the Peros Banhos Strict Nature Reserve by moving the northern point of the western boundary further westwards to encompass these two islands.

h. Impact from visiting yachts

Visiting yachts have periodically caused some damage both on islands by taking wildlife and by anchoring. The former is illegal, and has resulted in arrests and expulsions. Anchoring was greatly constrained a few years ago. Moorings have been considered and so far have been excluded as a possibility for practical reasons.

- It is recommended that careful watch on activities of visiting yachts be continued, to the best practical and possible degree.

B.5 Additional and ongoing activities

Many research projects are carried out in BIOT, all of which provide information useful to monitoring and management of the area. A research priority list was updated in 2010 (**Annex 3**). The following projects are noted here as they are already underway, some for several years. Together they will provide both BIOT and the scientific world with better information needed for continued assessment, which will lead to more effective management. Combined, the work in Chagos will be of benefit also to many of the MPAs around the world that lack proper baseline information. It is anticipated that these projects will continue to be supported by external independent funding (see later), but should be coordinated as part of the scientific research programme of BIOT. All results and outputs should be submitted to the central database.

Flexibility and opportunistic aspects should also be researched as appropriate. For example, in 2012 a heavy but localized outbreak of the coral eating Crown-of-Thorns starfish was discovered at Eagle Island, and work was diverted for a day to map the extent of this, for reference to mapping in 2013 to determine its progress.

a. Film archive of reefs

This was comprehensively undertaken in 2006 and the film is archived at Bangor University, providing a time-specific reference point. Repetition of filming whenever possible is desirable.

b. Genetic adaptation to warming

Evidence exists that corals can acclimatise to a small degree to warming waters, and that this happens by a change of the 'species' of symbiotic algae in their tissues. Recent work has shown that some acclimatisation is taking place in corals from Chagos[13]. This work will help in the prognosis of Chagos' reefs. In early 2012, numerous samples for this purpose were despatched to laboratories to extend this work. This work should also be extended to genetics of the animal host as well. BIOT should continue to support the collection of samples for genetic analysis and in exchange require copies of final results and publications so the data can be used to help management.

c. Connectivity of Chagos with other areas of Indian Ocean and within Chagos

Work to date has shown the connectedness of Chagos marine life with other areas, mainly as a recipient of species from heavily used areas to the west but also a supplier of larvae. This work mainly involves DNA analysis, but ecological methods and biophysical modeling have also been used and are being developed. This work will help assess the role of Chagos reefs as a stepping stone, a convergence point or as a reservoir in the Indian Ocean. Connectivity within Chagos is likewise an important aspect in terms of local impacts recovery.

[13] Yang SY + 5 others. 2012. Diversity and distribution of *Symbiodinium* associated with seven common coral species in the Chagos Archipelago, central Indian Ocean. *PLoS ONE* May 2012 | Volume 7 | Issue 5 | e35836, pp9.

d. Coral cores

Coral cores for palaeo-climatology work have been obtained on several occasions. Results have been valuable both for Chagos and for the international community engaged in climate change. The latest cores were obtained next to temperature loggers in early 2012.

e. Terrestrial invertebrate research

Invertebrates, particularly arthropods, are a critical component of an island environment and their contribution to ecosystem function is important. To date, no research has been undertaken to assess the ecological importance of the species and families present, or to assess the potential impact to the environment if they are lost.

f. Survey unvisited shallow areas

Approximately 98% of the shallow Chagos area is entirely unvisited, if only because most surveys done so far need to return to the same sites for reasons of continuity and extending the now valuable time-series of data. Chance observations, however, have shown many hectares of seagrasses, not observed at all in the general transect areas. However, improved surveillance of the vast expanses of shallow banks remote from the islands would help inform the management of Chagos.

g. 'Mesophotic reefs'

The illuminated regions in the clear waters of Chagos extend to at least 100 m depth and cover over 60,000 sq. km. SCUBA diving based visual surveys are limited to ~ 25 m depth in a remote location such as this. Surveying the substantial deeper reef areas requires specialist equipment such as deployable deep water video equipment or even small remotely operated vehicles (ROVs). In many areas of the world, diving methods with mixed gasses are used to survey these areas. The work should include archival video and stills photography.

h. Deeper regions

The deeper regions, by far the largest of the wider EEZ, remain completely unexplored. This deep zone includes about 300 seamounts of various sizes. World-wide these are being stripped on benthic life by fishing activities, but those in BIOT have likely never been exploited. Such deep water seamounts are known to be extremely diverse. Such work requires specialist equipment which mostly cannot be done from the BIOT Patrol Vessel. Initiatives are underway to develop a consortium to fund this work through the Natural Environment Research Council.

i. Atmospheric gases

Presently, the Indian Ocean is a large gap in the global monitoring network for atmospheric sciences. Projects have been proposed (but not funded) on basic measurements, such as carbon dioxide levels. Chagos could form an extremely valuable outlier station in atmospheric science and contribute to global monitoring of the effects of climate change. This would dovetail with southern African/multinational initiatives. If funded, the projects would provide a key linkage in the global understanding of atmospheric changes.

j. Cryptic Invertebrates

These small, often hidden ground-dwelling animals are the basis of many food webs and yet are hugely understudied. They represent a disproportionately high amount of the reefs' biodiversity, which is inter-linked with the health of the reefs. Studies of this benthic fauna in Chagos commenced in 2012. This will very likely result in discovery of new species and form a baseline for comparison with other coral reefs globally.

k. Alkalinity

Globally, sea water is becoming less alkaline, with probable consequences to many limestone secreting organisms, including corals, that are as great as those caused by temperature rise (though probably less immediate). The Indian Ocean is another enormous gap in the global monitoring of this. While not directly affecting management of Chagos itself, filling this gap with repeated measurements in Chagos will help to fill an important global need.

C. Diego Garcia

Diego Garcia is not included within the Chagos marine protected area, but is briefly commented on here in view of its important role in the archipelago and large land area. In Diego Garcia, the network of Nature Reserves and Strict Nature Reserves is comprehensive. Access to these areas differs and in all cases is subject to permission granted by BIOT or the British Representative in BIOT.

An important potential impact to Diego Garcia which would have consequences to the rest of BIOT includes the introduction of species from ballast water or from hull fouling (both of species and of toxins). An IUCN survey in 2006 showed no introduced marine species, which is now a very unusual condition for ports. Management of this potential problem for ships using Diego Garcia is good, but must remain so. Likewise oil spill preparedness, also regularly practiced, must remain well managed.

The atoll has its own *Natural Resources Management Plan.* **Annex 8** gives the 2005 version, and this is being updated for 2012. The environmental *Final Governing Standards* (**Annex 9**) also undergo periodic updating; **Annex 9** is the latest version dated December 2011. This contains a very detailed scheme for pollution monitoring, undertaken both internally and by accredited laboratories in the USA and UK, with regular audits. Details of pollution monitoring and analyses are contained in the *Final Governing Standards*, with further environmental details in the *Natural Resources Management Plan* for the island. The latter document encompasses the eastern uninhabited arm of the atoll as well as the military base on the western arm. The environmental unit in Diego Garcia is responsible for numerous and regular measurements of air and water pollutants.

There is a Ramsar site covering the eastern side which includes a large body of water including most of the lagoon. **Annex 10** shows the map of its extent**,** while **Annex 11** provides the IUCN Secretariat technical description of the site prepared by JNCC.

C.1 Diego Garcia recreational fisheries

Although outside the marine reserve, Diego Garcia is biologically part of the Chagos archipelago. Therefore it is important that the recreational fishery in Diego Garcia complements the reserve by being well managed and sustainable. To achieve this, good records of species, numbers and sizes, and fishing effort and location, are required, including those that are caught and released, noting that significant proportions of fish may die post release.

- It is recommended that the Diego Garcia fisheries management plan is reviewed and updated biannually. It is also recommended that a monitoring system for all aspects of the recreational fishery is introduced, with resources for compilation and analysis of the data.

D. Requirements and recommendations for funding

D.1 Funding for science activities

Previous funding for research has come from a wide range of sources. The BIOT Administration provides the BIOT Patrol Vessel, which has been used extensively and successfully in almost all research projects to date. This will continue at least until 2016. Previous expeditions using this ship have received some core funding by the UK Government, notably via the Overseas Territories Environment Fund (OTEP).

However, most funding has come from the visiting scientists using these facilities and by scientists who receive and work on materials sent to them by the organisers of the expeditions. The principle has been to invite participation from senior scientists and their research students from many countries, who have covered costs such as salaries, equipment and laboratory needs from their own resources and grants. Typically (and on at least three past occasions), an expedition of twelve scientists might be supported by a grant from the OTEP fund of £50,000 which approximately covers air fares and accommodation; the BIOT Administration allocates the ship at no cost to the project (but costing approximately £100,000 pro rata ship cost) while all salaries and materials costs are borne by the participants. Given that (depending on discipline) this may require two scientists for a year, and given that laboratory costs almost universally must be budgeted for by the participants, this amounts to about a ten-fold leverage, so that a typical expedition collectively costs about £300,000 to 500,000, for a UK outlay of the £50,00 OTEP grant plus use of the ship.

A £300,000 Darwin award won in 2012 will underwrite three more such expeditions to 2014, funding half the available space (six berths each trip), and it is envisaged that the model described above will be used to fill the remaining six berths each trip. In addition, one grant from University of Western Australia and DEFRA will fund a pelagic, fisheries monitoring expedition in late 2012.

US scientists under the auspices of the Navy and working towards fulfilling the Natural Resources Management Plan continue to work at intervals on Diego Garcia, on invertebrates as well as vertebrates and plants.

The Science Advisory Group is currently developing a grant application for the much more expensive deep water work that to date remains completely unresearched, and which will need a vessel other than the BIOT Patrol Vessel. Also, various donors have expressed an interest in supplying vessels, people and expertise as well as funds for particular elements of the work recommended in the following pages. Such interest appears to be increasing, and needs to be explored further. One recent bequest has been received for periodic botanical work, which is being linked to rehabilitation for some of the islands.

This funding model has worked well for all island and shallow water work to date, and is assured until end 2014 at least. With use of the BIOT Patrol Vessel on two occasions each year, much of the work described above should be achievable for the immediate future at least, and some additional visits to Diego Garcia without need of any ship have also become possible, with one concerning turtles already funded by BIOT Administration and Defra.

D.2 Funding for core management and coordination

The current staffing by contract from BIOT Administration is the legacy of the fisheries management programme that has existed since the mid 1990s. Since becoming a no-take protected area, this role needs to change. It is recognised that funding is extremely limited, and that staffing for core management will probably, for the immediate future, be of the order that previously existed during fisheries management, with less need for UK overheads and staffing. A minimum would be one person on the BIOT Patrol Vessel and one person in the UK, the two persons rotating, with the support of a UK office. This is the bare minimum. The staff on the BIOT Patrol Vessel will likely have a Masters degree in marine environmental sciences and at least 5 years field experience.

a. UK office

Management of the programme will be carried out from an office in the UK and will likely be occupied by one of the two employees rotating off the BIOT Patrol Vessel. The role of the office will include:

- Liaison as necessary with the BIOT Commissioner or Administrator or their advisors on all matters concerning the effective implementation of the contract and the protection of BIOT's biodiversity.
- Attendance at regional and international scientific meetings as agreed with the BIOT Administration.
- The central co-ordination and administration of the programme.

b. Surveillance and compliance control

- Tracking and where necessary interception of ships in BIOT's waters, with a view to detecting fishing activity. Use of satellites and transponders is required.
- Preparation and execution of an effective patrolling plan designed to deter and detect illegal activity and make the most effective use of the enforcement capacity available.
- Inspection of islands, especially looking for signs of poaching and poachers' camps, and for fishing gear on reefs and in lagoons (e.g. set nets, baskets, Fish Aggregation Devices etc).
- Where appropriate, arrest of vessels / persons contravening BIOT law in the manner currently done by Fisheries Officers.

c. Science

- Assist in implementation of the on-going monitoring programme, as developed and decided by the BIOT Commissioner on the advice of scientific and conservation advisory bodies (e.g. SAG, CEN, Conservation Advisor, various expedition leaders etc). This will mostly be collection of materials (sediments, seawater etc) as is needed by research programmes underway in the UK and elsewhere, but will include some basic snorkelling and land-based surveys as directed by the Commissioner on the advice of the scientific and conservation advisory bodies noted above.
- Exercise overall vigilance over the reserve and record and report periodically any observed changes or impacts to the natural environment, with possible causes if known or suspected.

d. Conservation and Outreach

- Provide input to the ongoing updating of a conservation management plan in collaboration with the members of CEN engaged in this and with the BIOT scientific advisory group.
- As required and agreed, attend regional and international scientific meetings on Indian Ocean tuna stock assessment and management and Regional Fisheries Management Organisations.
- Liaise with the currently funded programme (by BIOT Administration) concerned with outreach and education.

e. Information Management and Reporting

- Coordinate the database of all evidence of illegal activity in the BIOT marine reserve, including where possible details of species affected, date, location, number taken, and individual weight/length.
- Securely warehouse all data collected and make full duplicate data sets available to the BIOT Administration.
- Prepare reports at regular intervals summarising work done. Each report to be provided with a version suitable for public dissemination. To this end a web site should be created (or pages on the FCO website) to bring together all information about the reserve. Further, an annual scientific seminar should be encouraged and an annual summary of action produced. Given the interest in this reserve from members of the Chagos Environment Network, it is likely that these could be actioned at no cost to the Government by collaboration between FCO and CEN members.

The creation of the Chagos Marine Reserve has already significantly increased scientific and public interest in this area and it is expected that this will further increase in the coming years.

This reserve is probably the most significant contribution made by the UK to a number of international treaties and targets (for example the Convention on Biological Diversity and the global target on marine protection), and the UK should be proud of this achievement.