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Chagos News

The Periodical Newsletter of the
Chagos Conservation Trust

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EDITORIAL

Evolving Science in Chagos

I am delighted to report that Dr Charles Sheppard, our chief scientific adviser and the current BIOT Conservation Consultant has been appointed Professor in Biological Sciences at the University of Warwick.

This issue of Chagos News is dedicated to an article by Charles Sheppard on the 2006 Expedition and how it fits in with the overall picture of the Chagos Archipelago.

Rats in Eagle Island

Sadly we have to report that the rats in Eagle Island were not fully eradicated despite all the hard work put in by the Magnificent Eleven (see Chagos News 28). A three person team visited in March and spent 4 days setting 250 snap-traps and 22 bait stations. They also each covered 15 km a day looking for signs of rats. Rats persist in most parts of the island and 72 rats were caught. The most likely reason is that some rats survived by not taking the poison bait and remaining in the canopy of the palm trees. However over 99% were killed and there has been a sharp reduction in the density of mosquitoes. We are making plans for the future.

Meetings

Please note the following two meetings and put the dates in your diary. You are all invited to attend.

AGM

Our Annual General Meeting will be held at 1815 on Tuesday 20 November 2007 at the Pizza Express, 46 Moreton Street SW1V 3PB. We have held our AGM here before and are returning because the venue gives us more opportunity to circulate and talk among ourselves better than a sit down dinner.

Future Conservation of Chagos

The Trust will be holding a conference entitled **'The Future Conservation of the Chagos'** on Thursday 25 October at The Zoological Society of London, Regents Park, London, from 12 noon.

Chagossian Resettlement

This important topic is not discussed in this issue, since the British Government has now petitioned the House of Lords to reconsider the Appeal Court's judgment in the Chagossians' favour. The CCT has however issued two press statements (available from the Secretary), explaining its longstanding position.

John Topp

The evolving science in Chagos

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Background and themes

A few short years ago, the Chagos Conservation Management Plan was prepared and accepted by the BIOT Government. Amongst several issues, one key point was the need to regularly update ecological information on the condition of this enormous system of reefs and islands, for purposes of management. The need for this is all the greater since monitoring and scientific assessment must now also be set against a picture of climate change which has seen at least one very severe mortality event across the whole archipelago. The last large study was undertaken in 1996. Then, in 1998, massive mortality occurred all across the tropical world, following which brief visits were made to Chagos to observe, map and quantify the effects of that event in this archipelago. The Management Plan was then developed, and a large expedition was planned for 2006 to follow up key aspects as best we could.

An important theme of the research expedition was to observe recovery from the substantial shallow water wipe-out that had taken place 8 years earlier. One point about Chagos is that for 35 years most of these islands and reefs have had very little or no human influence of a direct kind. Thus, although reef mortality can be studied in other more accessible places, often the direct human pressures that exist there mean that recovery process either don't happen at all or are greatly skewed by severe impacts from other causes, such as pollution and over-extraction of resources. For example, the elimination by fishermen of carnivores, which would have eaten the herbivores, which eat the seaweed, which complete with corals for space… and so on, mean that the resulting scenario is very confounded by multiple variables which can be difficult to interpret. In other words, natural recovery can only be observed in very few places around the world, and Chagos, as we know, is the best example of this. Furthermore, those who wish to help restore damaged systems around the world need to know what to aim for and, again, Chagos is one of very few places that can show what this is.

There is no shortage of scientists who wish to visit Chagos for one or more of the above purposes. I saw my task mainly as one of selecting excellent people whose skills fit the overall objective of developing a strong scientific base for conservation of the archipelago. Within that goal, some new themes were developed, and some older ones continued. This included revisiting many of the same sites that have been observed sporadically since the 1970s because, while a snapshot picture is valuable, a trend can be even more useful.

Climate

First, the climate background. Almost no ecological work now can be placed outside the context of warming. Figure 1 shows the striking trend of rising sea temperature over the past 140 years. Whereas the occasional warm year may be expected any time, the bias of red and orange in recent time is clear. The bars are annual averages, not just brief warm spikes, and are shown as excursions from a 'baseline', the latter being the average temperature between 1960-1990.

Coral monitoring

In 1998, there was severe mortality of corals in shallow water, which extended to 15 m depth in northern atolls and to over 30 m depth in the southern atolls of Egmont and Diego Garcia. This has been reported before. One aim in 2006 was to monitor recovery. Al Harris, Charles Sheppard and Anne Sheppard measured numbers of corals along transects and in nearly 2,000 quadrats around all atolls and at all depths to 25 m. Counts included the difficult to see and identify juveniles – those that had just settled out from the plankton. Several patterns were found. Numbers of new coral recruits varied from 6 to 28 per m^2, even the lowest densities being an order of magnitude higher than the numbers now being documented in reefs in South Asia, central Indian Ocean, and East African Coast where 'substantial'

rates of coral recruitment are less than 1 or even 0.5 per m^2. The extraordinary ability of Chagos' reefs to 'bounce back' to thriving reef communities has not been recorded in other reef environments in the Indian Ocean.

Patterns of recovery varied, as did patterns of present coral density. Shallow waters were still relatively depauperate, and this may be because there is still a shortage of potential parents in the case of shallow dwelling species, since these were the most depleted before. It may also be because 2002 and 2003 saw further warm years and more heavy bleaching. The two southern atolls in particular are still relatively depleted throughout their depth range.

Clearly recovery is far from complete, yet some areas, especially in the north, had recovered to such an extent that they were almost indistinguishable from decades earlier. Figure 2 shows western Salomon's seaward slope, on which the table coral *Acropora cytherea* has made a spectacular recovery. These tables and their branching relatives were the most severely affected group previously, and their absence after the warming resulted in massive ecological changes, partly because the reef simply lost a lot of its 3-dimensional structure.

But this group of corals also provided clues that further warming events continued. On Egmont's northwestern seaward slope, these vast acres of new tables had been recently killed again (Figure 3). The tables grow their radii about 10 cm per year, which is fast for corals, so these are about 3-5 years old. But, their grey 'dusty' colour gives away the fact that they are mainly dead (the contrast with the living green-brown patches are clear). Clearly a recent repeat warming had occurred here. Egmont atoll has a large and very shallow lagoon, which becomes 'super-heated' in periods when flushing is poor, presumably when currents are weak. It is possible that this basin of warmed water slopped over the rim a few months previously, and killed the corals. The damage goes deeper: when the decaying tables topple down the steeper slope to seaward, they abrade corals that were perhaps too deep to have been directly killed from the hot water. This was evidence that 1998 was not just a one-off episode. A sample of a dead table was collected for dating purposes.

At the same time, David Obura from Kenya studied the diversity of the Chagos corals with the view of placing Chagos in a better biogeographic context. With extensive knowledge of East Africa and other island systems, he is concluding that several other sites in the Indian Ocean have a greater number of species than Chagos does, caused partly by factors connected with both the relative isolation of Chagos and the much greater connectivity and dispersal amongst East African sites. This work is key to the development of better ideas about the role of Chagos in the Indian Ocean, and its importance as a reservoir of corals.

Soft corals

Soft corals remain more enigmatic. These also largely disappeared in the late 90s, but are returning to many reefs (Figure 4). When they died they left no limestone trace of their former existence, unlike the stony corals. This led to the peculiar sight of vast expanses of bare and unoccupied limestone in areas where previously they had dominated. Some sites were still like that, but in others, recovery was rapid. This depends both on the proximity of surviving adults which reproduce, and partly on serendipitous flows of local currents which can transport larvae to exposed patches on which to settle. It is likely that the passage of time simply has not yet been sufficient for soft corals to have recolonised all those places where they used to thrive. Professor Mike Schleyer from Durban assessed these and is nearing completion of his assessment of the total diversity, to place Chagos in the greater Indian Ocean context.

Reef diseases

Rachel Jones from the Zoological Society of London had two very different roles. One of the main influences affecting coral health is disease. Further, some coral diseases are triggered by warmth – it seems that here too the effects of warming are significant, this time indirectly. Her work consisted mainly of an assessment of

the presence and extent of coral diseases on the reefs which the expedition visited. The data collected was in the form of video footage of 43 transects, each 30m x 0.5m, giving a total of 645m^2 of reef filmed (Figure 5) . These transects are then split into still images, and a representative sample of these images analysed to reveal patterns of disease either by geographical site or by coral species. To complement this, numerous tissue samples and swabs were taken from corals that were showing signs of disease, so that the bacterial communities on these samples can be identified, particularly the pathogenic organisms.

To put this into context, it is now known that suppression of some of the key reef building corals of the Caribbean is being caused by pathogens associated with human sewage. At present, nobody is clear about the exact picture. But in the Caribbean it remains the case that even isolated bays contain this coral disease and, while currents may be responsible, it is also the case that yachts anchor in most of those bays and discharge sewage overboard. This is enough to raise alarm bells for me in Chagos, where yachts anchor in both northern atolls. There is as yet no suggestion of this effect in Chagos, but it could be catastrophic and irreversible were it to happen. Therefore moves have been taken to constrain the permitted anchoring zones of yachts. It is not the nutrient enrichment from sewage that is the concern here (though that too has led to reported algal blooms), but more the possibility of such pathogens which could, if released, trigger deleterious changes which would run against the ethos of conserving Chagos.

The ZSL Aquarium

The other element of Rachel Jones' work was to identify a site to act as a reference for a large reef exhibit in a new aquarium being planned by the Zoological Society of London called *Biota!*, due to open in 2011. This 140,000 litre tank with a huge window looking into a reef wall will be a signature exhibit for this development. It will offer a view of a Chagos reef, accurately reflecting the species and structure of a real reef, chosen to be both spectacular and typical. A steep reef on the seaward side of Ile Diamant in Peros Banhos atoll was identified as a most suitable site. Extensive video footage and pictures were taken to aid the exhibit designers and interpretive staff to develop this project, which is expected to attract millions of visitors.

Reef fishes

Reef fish surveys were an important element. These were conducted by Nicholas Graham of Newcastle University (Figure 6). One focus was to re-assess the reef fish assemblages at 10 sites spanning the Great Chagos Bank, Peros Banhos and Salomon atolls that had been surveyed by Mark Spalding 10 years previously. But the fish research also formed part of a larger western Indian Ocean study to assess long-term impacts on reef fish assemblages of the mass 1998 coral bleaching event. The results will form a distinct analysis of patterns in Chagos reefs and its associated fish assemblages, but it will also be incorporated into the wider western Indian Ocean regional analysis. Results suggest that fish assemblages in Chagos have remained remarkably stable compared to many other locations, largely due to the rapid and effective recovery of coral cover on these reefs, which has likely benefited through protection from fishing pressure. Also assessed were the feeding preferences and specialisation of coral feeding fish, which has been used to assess which species in the Indian Ocean are more vulnerable to declines following coral mortality.

Poaching

Nick Graham also re-surveyed the reef sharks using the same technique used during the 1975, 1979, and 1996 visits. The results highlight a continued decline in reef shark populations which indicate that poaching for shark, especially fins, is still a problem in this archipelago (Figure 7).

Poaching for other species is also a problem; sea cucumbers (Figure 8) are also targeted. Data from approximately 80 transects, each 100 m x 2 m2 were obtained by Dr Andrew Price, and on one day a large transect ~11 nautical miles long x 4 m wide was made around inside of Salomon atoll, using an inflatable. The

sea was so calm, and the water so clear, that sea cucumber counts could be made from the boat, moving at 2-3 knots. Transect data was supplemented by questioning scuba divers about sea cucumber numbers observed during every dive. No poaching occurs in Diego Garcia and the different densities between the latter and atolls where poaching does occur are remarkable. Differences in ecology may be partly responsible, but the main factor responsible is almost certainly sea cucumber collection. Within this pattern, it was observed that the presence of yachts also apparently discourages poaching from parts of Salomon too. Work is continuing on estimating the quantity of illegal catch every year.

New techniques

Some new techniques were introduced as part of the program, developed to measure aspects that could not be determined by existing means, by previous technology and at different spatial scales.

Firstly, studies at the centimetre scale, within 100 m^2 of reef. Detailed photographs of reef surfaces and their associated biota, are notoriously difficult to do. Although clear photos adorn many wildlife and diving magazines, most are of limited value in scientific terms. Planar (top down) mappings, showing the relative spatial distributions of species are especially difficult, even in the clear waters of Chagos. Robert Gibbs, whilst at Bangor University, developed a circular acquisition and digital mosaicing method, by which hundreds of video tiles are combined to form very high resolution image maps of 80m^2 areas together with stereo distance information, allowing the topography of the site to be reconstructed (Figure 9). The method was carried out at 5 sites within the Archipelago.

Secondly, studies at the biotope or habitat scale, of 1m within a few km^2. Dr Sam Purkis and Dr Bernhard Riegl from the USA's National Coral Reef Institute in Florida developed a method of detailed seabed mapping at a biologically useful scale. It uses acoustic measuring, linked with GPS position fixing, to take millions of depth soundings, to make a 'wire-frame' image of the seabed. Then, using very high resolution Ikonos satellite images which have a 1 metre resolution, the processed image is 'draped' over the wire frame to produce a 3-dimensional representation of the sea bed. The example in Figure 10 shows the islets in the mouth of Diego Garcia lagoon, the main shipping channel, and the highly complex topography of the far northern 'platform' of the lagoon where no bottom clearing for shipping has been conducted.

One purpose of this is clear from the next step, in which Sam Purkis, Bernhard Riegl and Nick Graham developed an extraordinary method to enable the prediction of reef fish diversity and abundance using satellite data. Around the world, data on reef fish distribution and diversity is badly needed due to man's over-exploitation, but the level of field effort required to evaluate aspects of the benthos that dictate fish abundance using traditional diving survey techniques is high, which prevents its use across entire reefscapes. It is known that the distribution of reef fish is strongly governed by the character of the seafloor so, with minimal ground control, both substrate type and seabed topography are amenable to monitoring using satellite data. Here, the remote sensing imagery was used to resolve the bathymetry and benthic character of this reef system in Diego Garcia, and it was then shown that richness and abundance of reef fish are in fact correlated with the satellite-derived seabed parameters. Significant relations are observed between fish communities partitioned on the basis of their size, functional groups and mobility, over areas of seafloor as large as 5030 m^2. Basically, the study proves that satellite remote sensing is capable of predicting habitat complexity at a scale relevant to fish.

Lagoons and sediments

Bernhard Riegl looked further at both coral reef regeneration and its relationship to sedimentation and geomorphology. On the Great Chagos Bank, in Peros Banhos and Salomon lagoons, he combined current profiles with sediment and regeneration patterns. He showed that the unusually dense coral growth which occurs at depth in open lagoonal settings in this

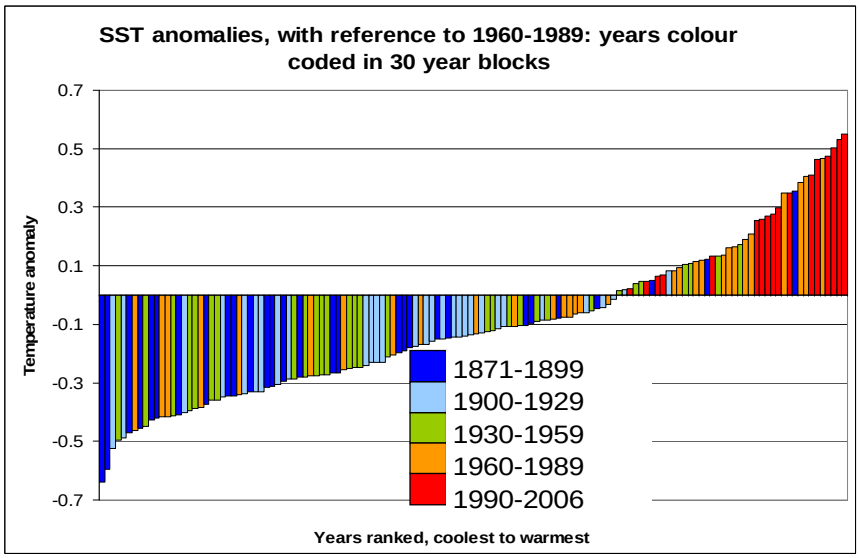


Figure 1. Chagos annual average sea temperature, shown as difference in ^{o}C from average 1960-1989 (a standard reference period). Years are ranked, coolest to warmest. Colours code for 30 year blocks, as shown in the key. Note the most recent block, 1990 onwards (red bars) has 17 bars, not 30. Data is HadISST1 monthly data, average of 9 cells covering Chagos.

Figure 2. View in 2006 of western seaward reefs. This one is Ile Anglais, west Salomon. The whorls of table coral are 'restructuring' the habitats. These tables are fast growing, expanding their diameters up to 20 cm per year (radii 10 cm per year) after an initial lag of a year of two.

Figure 3. A similar habitat at northwest Egmont, where the tables were recently killed. The patches of green-brown are living remnants. In the foreground is an upturned table. **Inset**: a dead table on the deck of the Marlin. It was later sawn up and used for taphonomy (study of decay rates).

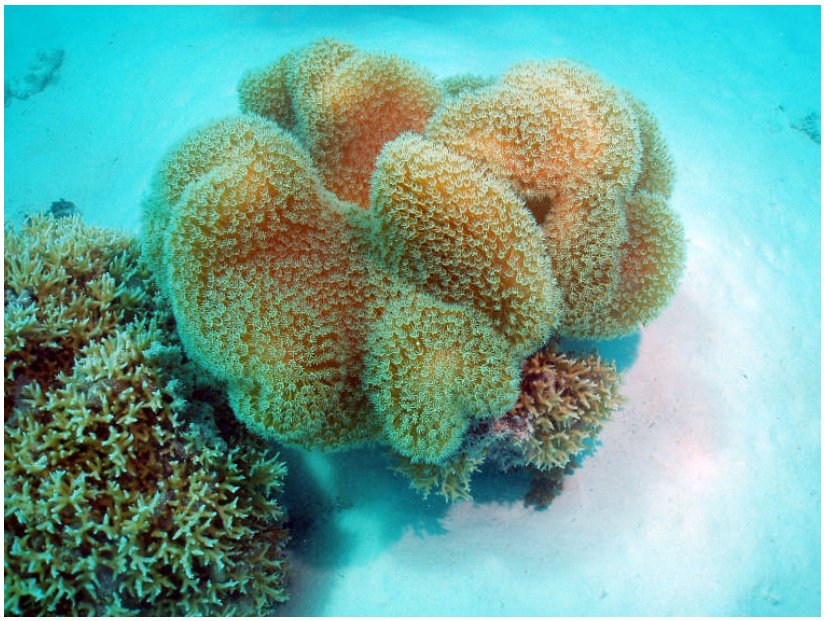


Figure 4. Soft corals are recovering nearly as well as the stony corals. They are recruiting with a relatively high diversity into lagoons and seawards reefs. This group of colonial animals are related to the stony, reef-building corals and are important space-occupiers on these coral reefs.

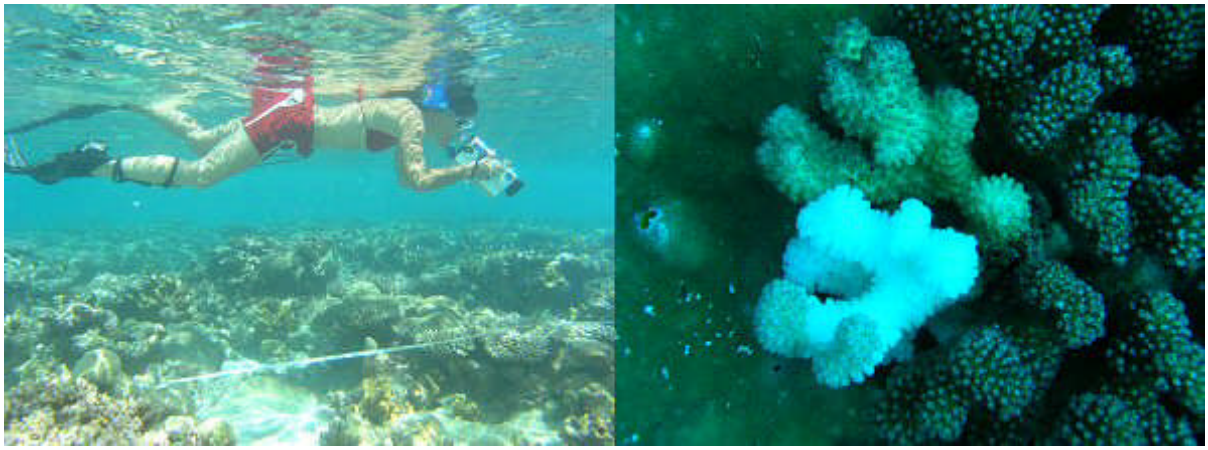


Figure 5. The disease monitoring project. **Left**: recording along a shallow transect, **Right**: section of a branching coral colony with three states, healthy tissue (dark, on the right) very recently dead (white in front), and dead for some weeks (centre and mid colour, formed by later settlement and growth of fine algae on the white skeleton).

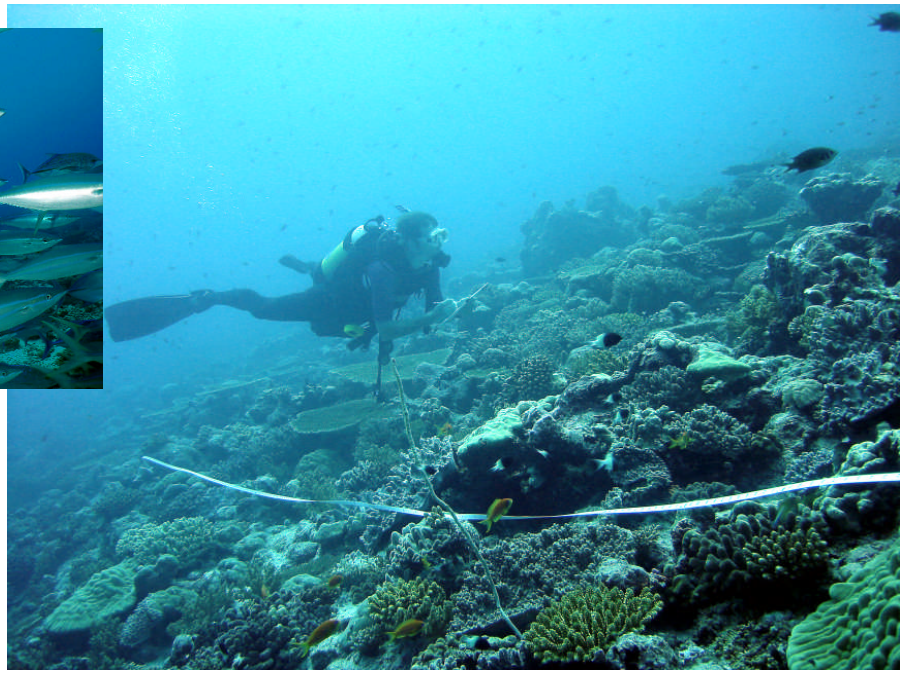
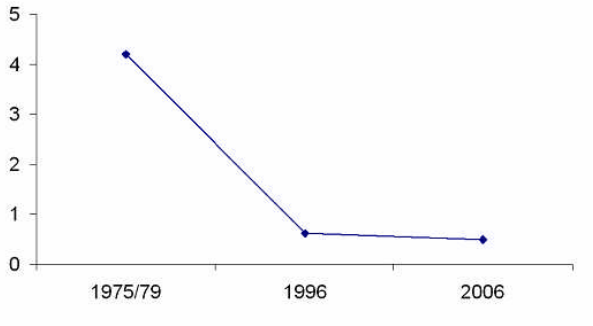


Figure 6. The reef fish project continued measurements started in 1996, and focussed on specialised groups. Nearly 1,000 species of reef fish have been recorded in Chagos waters to date. **Inset**: Rainbow runners.

Figure 7. Shark counts by divers have been recorded on several occasions. These use fairly large data sets and have shown a substantial decline, which remains relatively low compared to numbers in the 1970s despite arrests made by officials on the BIOT Patrol Vessel. (Photo BIOT Party on Diego Garcia). **Below**: counts of shark sightings per dive, 1975-2006.



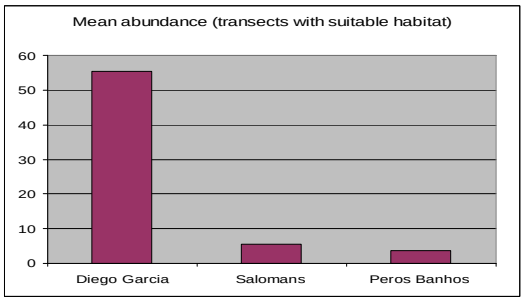


Figure 8. Sea cucumber poaching continues to be significant. The chart shows densities in Diego Garcia (left bar) and in Salomons and Peros Banhos (middle and right bars). No poaching occurs in Diego Garcia.

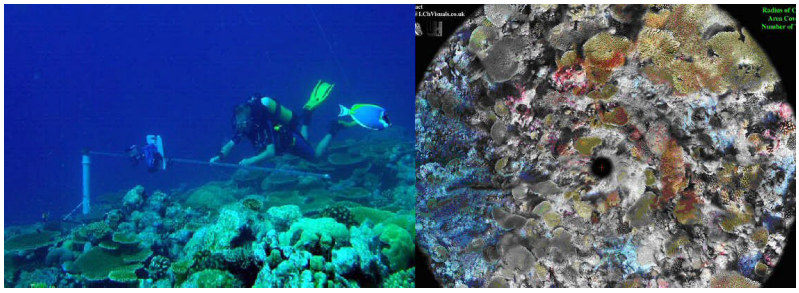


Figure 9. Very high resolution image of sea bed, using mounted video camera is shifted sequentially along horizontal arm. Stitching together hundreds of images produces circular fields of view with high detail. (Image Rob Gibbs)

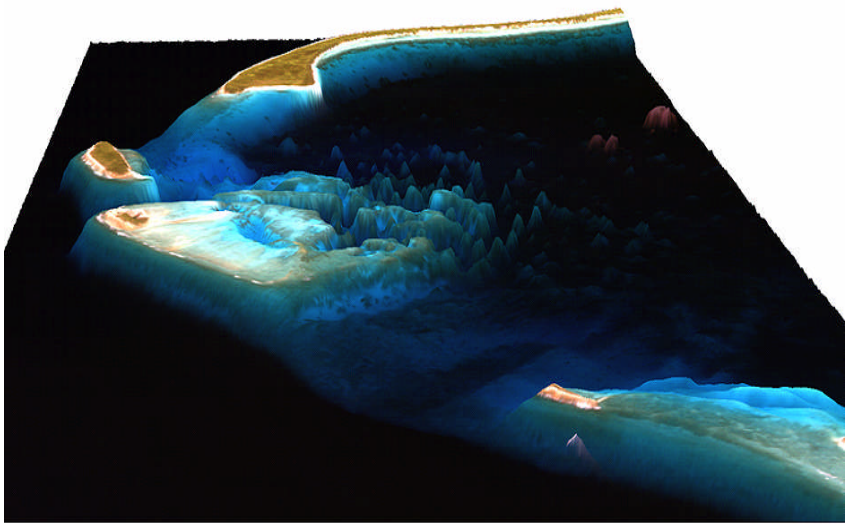


Figure 10. View of Diego Garcia entrance, made by combining a 3-D model derived from acoustics with a processed satellite image. The three islets are depicted, as is the channel, and the large platform with its complex reef structure supporting Middle island. (Image Sam Purkis)

Figure 11. The project on invasive marine species took large numbers of samples from artificial structures, focussing in the most likely locations where new introductions might appear, such as harbour pilings, walls and chains. (Photos Jerker Tamelander)

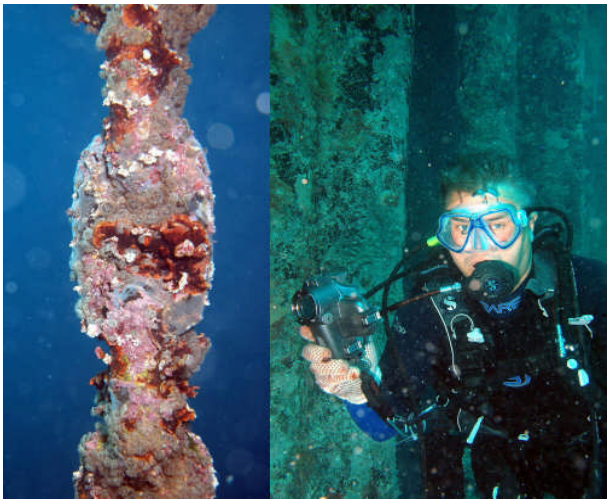


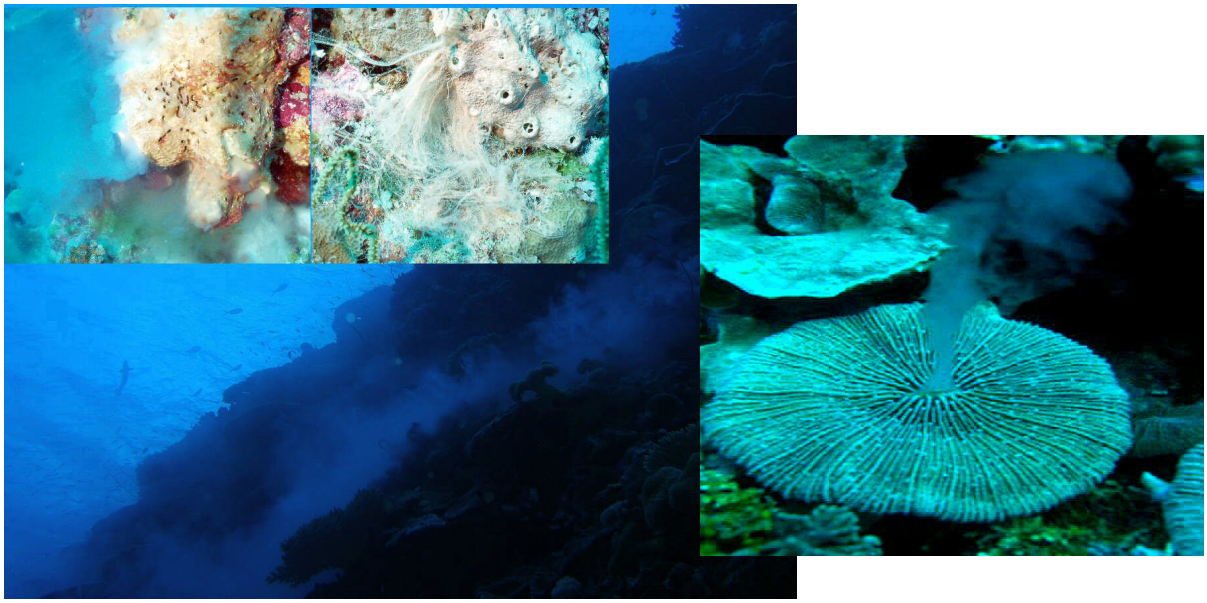
Figure 12. Aggressive interactions between corals as they become crowded on a reef indicates recovery and a return to normal condition. **Centre**: The aggressive *Fungia* (mushroom coral) aggressively interacts with a subordinate *Montastraea*, defending its territory. **Right**: two colonies of the same species of *Acropora* (but not identical clones) meet along a band of more densely calcified limestone with excretion of a great deal of mucus. The interaction here is probably histochemical. (Photos John Turner)

Figure 13. A nesting green turtle on Eagle Island, Great Chagos Bank. (Photo: Jeanne Mortimer)

Figure 14. Birds of Chagos. **Left**, a Noddy tern off Sea Cow (photo Andrew Sheppard), **Right**, Masked Boobies on Resurgent - the least common boobies in Chagos, found only on two rocky islets.

Figure 15. The BIOT Protection Vessel Pacific Marlin, on which the expedition lived, loading the last of four inflatables.

Figure 16. Accessing Resurgent Island is possible only by swimming in on the swell, judging the swash and, hopefully, landing on its smooth algal covered rock gently and without damaging the contents of the waterproof case. In the background is South Brother.



F**igure 17.** New life. **Left**: Spawning sponges. The 'smoke' on the reef face is a cloud of gametes ejected by adult sponges in a synchronised spawning event. The insets are close-up photos of (left) clouds of male sperm and (right) strings of eggs. Salomon seaward slope. **Right**: A mushroom coral caught in the act of ejecting puffs of gametes in Salomon lagoon.

Figure 18. Several members of Chagos 2006. From left: **Prof Mike Schleyer**, Durban, soft corals; **Dr Sam Purkis**, National Coral Reef Institute, Florida; **Nick Graham** (in red hat), Newcastle University; **Prof Charles Sheppard** (more distinguished hat), Warwick University; **Rachel Jones**, Zoological Society, London, **Dr Andrew Price**, Warwick University; **Dr Bernhard Riegl**, National Coral Reef Institute; **Dr Bob Crawford**, medic; **Dr Jeanne Mortimer**, Florida University, **Anne Sheppard**, Warwick University; **Rob Gibbs**, Bangor University; **John Turner**, Bangor University; **Dr Andy McGowan**, Exeter University. Missing for various reasons, **Al Harris**, Warwick University; **Dr Carl Lundin** and **Dr Jerker Tamelander**, IUCN; **Dr David Obura**, Cordio, Kenya.

archipelago is essential for reef regeneration, and may have a strong bearing on the rate at which these atoll lagoons are regenerating. This has considerable importance for estimates of coral reef resilience in today's rapidly changing and (in reef terms) degenerating world. Oddly too, sediment grain size distribution on Peros Banhos patch reefs is inverted from the usual: smaller grain sizes occur in the shallows, with bigger grain sizes in the deep. This is due to dense *Halimeda* growth that creates large grain-size sediment. This is the reverse of many, perhaps most, atolls. In an assessment of areas of coral regrowth in lagoons, Peros Banhos and Diego Garcia lagoons were found to have different patterns of regeneration. In Diego Garcia, dense coral areas for reseeding were distant from the regeneration areas, while regeneration patterns in the shallows had no apparent pattern, instead being random, conforming to a 'lottery hypothesis'. In Peros Banhos in contrast, regeneration patterns were more predictable, likely due to the closer proximity of dense "reseeding areas". This work on recovery within lagoons, closely matches and complements the whole-archipelago reseeding model described at the start of this article.

Invasive species

Introduced species occur all over the world, and sometimes become triggered to become invasive, meaning that they multiply rapidly, can become ecologically disastrous and economically damaging. Marine examples cost billions annually, world-wide. In Chagos, the terrestrial story of rats on islands has been described in Chagos News in the past, and some invasive plant species such as Dodder are beginning to cause a problem on land also. Dr Carl Lundin and Dr Jerker Tamelander from IUCN carried out a study of possible invasive marine species, given that Chagos sees appreciable, trans-oceanic, maritime traffic. Most of their effort was placed on sampling at primary inoculation points, in particular the port and lagoon area of Diego Garcia and areas frequented by yachts in Salomon and Peros Banhos (Figure 11). Methods used included scraping biota off hard substrates and collection of specimens or assemblages containing taxonomic groups with species previously known to translocate, sediment cores for identification of dinoflagellate cysts and infauna, and extensive photography for documentation. Fortunately, no signs of invasions or major shifts in reef species assemblages were observed, and no immediately recognizable non-native marine species were encountered during the surveys. Samples are still being analyzed, and final results are likely to be published together with the final results from a wider Indian Ocean survey on invasive species being conducted by IUCN.

Archiving and community ecology

Dr John Turner from Bangor University collaborated on the reef monitoring, and especially important was his extensive, archival documentation by video of all sites. This used wide angle video (45 degrees, distance 0.5 m from substrate) along transects running from 25 m depth into shallow water. Random point count analysis on screened video images allow estimates of recovery to be made, supplementing methods used by others described earlier. Also, in shallower water on the reef terrace, the structural complexity of the canopy is being assessed using fractal analysis of appropriate selected images. Importantly, the transects were located at the same sites as were examined with complementary methods by other members, and the video data will be archived for future comparisons.

Biological competition between coral species is one determinant of reef composition. Corals are aggressive against each other, using special tentacles and chemicals to secure space on crowded reefs, and today coral cover is high enough for this once again to become important. This ecological control was extensively photographed and counted, as it can be used as a measure of the 'health' of a thriving coral community.

Rapid assessments of coastal condition

A 'rapid assessment' of coastal ecosystems of Chagos was made by Andrew Price. Its purpose was to assess the relative abundance of coral reef, sand patches, and any terrestrial ecosystems and species groups

within a standardized 'quadrat', 500 m x 500 m, using a simple log scale (0-6) of abundance. Within each quadrat, the magnitude of oil, construction and other human uses/activities are also scored using the same 0-6 scale. Abundance of human litter (plastic, metal, wood etc.) is more severe in Chagos than in many other regions of the world, probably because it lies down current of SE Asia, and there is no human population to remove or salvage it. Its consequences may be minor, if unsightly, although too much can interfere with turtle nesting.

Water pollutant chemistry

Continuing a project started a decade earlier, pollutant levels in Chagos waters were analysed, focussing this time on Diego Garcia and on specific groups of organic chemicals, particularly 'booster biocides' - chemicals from antifouling paints which are highly toxic to marine life - and on terrestrial herbicides. Both groups inhibit the photosynthesis of plants, and are very damaging to corals. Anne Sheppard collected water samples in a grid across Diego Garcia lagoon, and throughout a tidal cycle, and later processed the samples in Diego Garcia. Analytical sensitivity was such that during sampling of seawater no sunscreen, perfume or deodorants could be worn in case this caused contamination, and sampling was done from the bow of a slow moving boat, into wind. Again, concentrations found were at mostly below detection limits of 1 part per trillion, using the most sensitive instrumentation available. It was confirmed again that Chagos water could be considered appropriate as a global reference baseline. This is remarkable from a populated atoll.

Turtles

Dr Jeanne Mortimer from University of Florida once again surveyed beaches throughout the Chagos Archipelago to assess levels of turtle nesting activity and physical status of the nesting habitat. Whenever possible, she collected DNA samples from nesting females and egg clutches (Figure 13). For the outer islands, the survey data is being compared to that collected during the 1996 survey to determine trends in health of the nesting population. For Diego Garcia, data collected during 2006 are being compared to 1996, and to data collected during a month-long survey conducted in 1999. During the 2006 expedition, Jeanne identified two stretches of nesting beach on Diego Garcia to be used as index sites (one near the GEODDS and one near Cannon Point); and trained Mr. Nestor Guzman of the NSF Environmental to carry out semi-monthly beach surveys at those sites. These will document seasonal changes over a full year of both turtle nesting activity and sand movement.

Jeanne also worked with immature foraging turtles in Turtle Cove. This is an on-going study initiated in 1996 and continued in 1999. This long-term study is providing interesting data on growth rates, sex ratios, migrations, genetic structure, and population structure of the aggregation of foraging turtles of a most unusual and dense collection of Hawksbills. Most of the turtles originally tagged in 1996 were recaptured in 1999 and 2006, showing a high degree of residency.

DNA tissue collections

DNA samples from a wide range of other organisms was collected by several people, all connected with the aim of seeing how interlinked Chagos is with the rest of the Indian Ocean. Minute samples of tissues are all that are necessary for such studies provided they are properly preserved, and this is the desired method for many species, especially for rare or endangered species. Tissues of several have been passed on for molecular studies in Stockholm and Turin Universities, and to a UN, ocean wide survey on the distribution of key species. Various fish species have been sampled for similar reasons, and staff of the University of Hawaii will be visiting shortly to further this work, in what we hope will be a trend of increasing participation from leading institutions around the world, to develop the knowledge of interconnections of this unusual site. Scrapings of the shallow reef building corals and of the fast growing table corals which are now visually so striking on many Chagos reefs were collected to see how many different 'parents' are responsible for each site's next generation.

Diversity of species may be the best understood level of measuring diversity, but genetic diversity is, if anything, even more important, though harder to describe. In several cases, the molecular techniques needed are not yet available, but the samples are stored for when they are. After all, it is never certain when these reefs may be revisited, and the information is vital to far more than Chagos itself.

Birds

On the islands, Dr Andy McGowan of Exeter University did a rapid assessment of seabirds (Figure 14). Indian Ocean seabirds are subject to numerous threats, and population levels are thought to be at a fraction of historical levels. Despite being a well-known taxonomic group there is still a paucity of data for most seabird species on many remote Indian Ocean islands. He surveyed 26 different islands covering all four main island groups of the Archipelago. A total of 17 species of breeding seabird were recorded. Since the last similar survey in 1996, nine species showed reductions in the number of breeding pairs, with brown noddy *Anous stolidus* and lesser noddy *Anous tenuirostris* showing reductions of ~22,000 and ~27,000 pairs respectively. These reductions in breeding pairs, coupled with sooty tern *Sterna fuscata* colony relocations, are central to suggestions of a review of the current Important Bird Areas (IBAs) in the Archipelago and the proposal of two new sites for IBA status. Again, he is setting his findings within a regional conservation context to provide recommendations for an annual monitoring scheme of Chagos seabird populations to allow appropriate management. Given the global and regional importance of the Chagos seabird populations, the UK government would be remiss not to implement an annual monitoring survey. The archipelago is fortunate to have the increasing attentions of scientists worldwide, one of whom, Pete Carr of the RN Birdwatching Club, has linked with the overall Chagos scientific programme to its great benefit, and who will be leading further ornithological studies in the archipelago. This is one field of study especially, among many, where results of an integrated series of measurements are much greater than the sum of a number of isolated snap-shots.

Diving, medical and ship support

Dr Bob Crawford was the final member of this expedition. As a surgeon, his surgical skills were not needed, but his dive buddying, photographic, collecting and boat repair skills were. His contrivances with compressed air cylinders and hypodermic needles for treating minute tissue specimens were as creative as they were alarming. As before in Chagos, with diving and dampness, his main battles were with sweat rashes in embarrassing places, and with divers' ear canals where infections can cause problems. He discovered that using the antibiotic Ciprofloxacin eye drops in the ears (he said he can tell the difference quite easily) was by far the best solution for this. He organised a set of lectures for residents on Diego Garcia, where his skill in seamlessly blending the subjects of orthopaedic surgery with coral biology was still being remarked upon a year later. The US military medics were most helpful in supplying controlled drugs (morphine) and oxygen, the former in case of e.g. stonefish stings, and the latter in case of decompression sickness, neither being needed.

The BIOT vessel *Pacific Marlin* and its crew were always helpful, loading and unloading our four inflatables daily (Figure 15). Mostly work was hot, thoroughly enjoyable and always spectacular. Some islands could only be reached by judging the surf and landing sea-lion fashion, while gripping waterproof boxes of equipment (Figure 16).

In conclusion

It is not widely recognised that one set of dives or island fieldwork usually requires weeks or months of further work, in analytical laboratories, with computers, or in writing software to do jobs which nobody else has yet developed. The results of 2006 will take a long time to complete. However, further progress does not wait until all that is finished and published. Further projects are planned: bird surveys, and collections of fishes and birds for DNA analyses, for

example. Indeed, one mapping and GIS project to define zones of all kinds (yacht anchoring, protected areas, Ramsar areas, user zones and excluded zones of all kinds in the atolls, for example) was proposed, funded, carried out and completed all after the expedition had ended and before much of the expedition results were finished. That project used data from many of the expedition participants.

The single main impression gained by most of us was one of tremendous recovery on the reefs of the archipelago, sometimes seen most graphically during spawning events, always a rare sighting (Figure 17). Most of us regularly visit reefs around the world which are in terrible states, dead or dying, and unable to function ecologically due to resources extraction, many not really being reefs any longer. In total, the expedition members have spanned all the world's reef areas, many times, and most of the scientists remarked that the Chagos reefs were, 8 years after their massive assault from warm water, the best they had seen for many years.

This unusually undamaged condition brings with it a tremendous responsibility on the part of its environmental governance. It is one of very few places where natural ecosystems can be studied without the confounding impacts of man. At the same time, finally and after many years, an increasing urgency is being discovered by the media and by politicians for action to turn the tide of tropical marine and island despoliation from both exploitation and climate change. This could mean that there is possibly hope for the hundreds of millions of people who depend on healthy reefs in one way or another. BIOT has a significant role to play in this, and several parts of the UK Government are becoming increasingly interested in this Territory. It is, after all, the most biodiverse part of Britain and its Territories, by a huge margin.

What of the future?

To return to sea temperatures, we installed about 20 underwater temperature recorders in 2006. These are located at depths of 5, 15 and 25 metres on several seaward slopes of atolls, and in three lagoons also, including Egmont. They will record at about 15 minute intervals for about 3 years, and will enable us to 'calibrate' the temperature values we already have, and understand better the profiles of temperatures with depths. Of course, we have to find them again!

For any kind of management, data is essential, and environmental management needs environmental data, which comes from monitoring. With a solid core of scientists who understand the value of Chagos' natural systems, there is today an increasing list of scientists who wish to visit for research purposes. The present mechanism of expedition-type research visits has served well enough in the past, but now there is a need for a modest but longer term facility in the islands. Much new science needs equipment which simply cannot be flown out on a temporary basis but needs a non-humid, fixed location. Some can be moved (the Warwick University diving equipment and boats now seem to fly back and forth regularly) but this is unnecessarily costly and less desirable than storage in Chagos between uses. Several projects are planned following the expedition briefly described here, some of which are already funded and underway. Avenues for funding the needed facility are being explored. I hope that, next time the science of Chagos is written about in Chagos News, such a facility will have come into being to the benefit of all.

Acknowledgements

Funding of the expedition came from several sources. The essential core come from the OTEP fund (joint FCO and DfID) which, with the provision by BIOT Administration of the BIOT Protection Vessel ensured success. Further sums were provided by Chagos Conservation Trust and Cable & Wireless. Most funding came from a range of sources to individual scientists for direct costs of field work and for the far greater post-expedition work, which involved many more people than are mentioned here. All participants are grateful to such sources for the success of this ongoing project. We are also very grateful to the Britrep at the time, Chris Davies, and his staff on Diego Garcia for help in numerous ways, to Tony Humphries, BIOT Administrator during this period, and to the Marlin skippers Bob and Neil, and their crews, for their continuous help in a busy but enjoyable 8 weeks.

AGM

Our Annual General Meeting will be held at 1815 on Tuesday 20 November 2007 at the Pizza Express, 46 Moreton Street SW1V 3PB.

In accordance with the Constitution those present will elect a Chairman, a Treasurer a Secretary and Members of the Executive Committee.

One third of the members of the Executive Committee stand down each year, and this year the following five are standing down in accordance with the Constitution:

Richard Martin
Paul Pearce-Kelly
Mark Spalding
John Topp
Nigel Wenban-Smith

Geneviève Edis resigned earlier in the year.

Nominations for office must be received by the Secretary at *Ground Floor Flat, 29 Champion Hill, London SE5 8AL* at least seven days before the meeting.

Special Conference

The Trust will be holding a conference entitled **'The Future Conservation of the Chagos'** on Thursday 25 October at The Zoological Society of London, Regents Park, London, from 12 noon. Full details will be promulgated in September by email.

This working conference will consider future challenges and possible solutions for the conservation of The Chagos.

Following an inauguration with distinguished guest speakers, there will be a sandwich lunch and plenty of opportunity for informal contacts and discussion, and then working sessions whose provisional themes are:

BIOT's natural environment, BIOT and Climate Change, Frameworks for internationally-supported Conservation of Chagos, BIOT's Coral and Fisheries Conservation and Management, Priority Projects for BIOT, and Funding.

The conference will close, with wine, at 5pm.

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