Chagos News

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Editorial

Two expeditions to Chagos in 2010, two in 2012 and again two in 2013. The research agenda for Chagos is really ramping up as the archipelago's importance as an unspoilt scientific reference site becomes more widely known. The data being gathered is used by scientists from many countries as they try to understand the impacts that mankind is having on the planet. But unless we reduce the global atmospheric CO_2 within a worryingly short time then research in Chagos and the few other well protected MPAs may become a case of recording the demise of the world's coral reefs which are so crucial to the preservation of biodiversity.

Last week Lord Stern announced from Davos that he had underestimated the risks of global warming in earlier IPCC reports and that he should have been much stronger about the risks to the world of global warming by 4 or 5 degrees centigrade. For those who would like to know more about how that might affect the planet, the book *Six Degrees* by Mark Lynas describes some very chilling likely scenarios.

So the research in Chagos becomes even more urgent and important and it is being disseminated through papers in research journals and by what is becoming an annual CCT conference.

The CCT website contains a lot of information about the research that has been carried out over the years, and future expeditions will post Information there. All back issues of *Chagos News* have now been placed on the website and reading through them from the beginning draws a very interesting picture of not only the development of CCT but also of the environmental research and conservation work that has been done in the Chagos over the years. As this year is the 20th anniversary of the founding of CCT as The Friends of Chagos, this is perhaps a good time to review our achievements.

We are also very much looking forward to an exhaustively researched history of the Chagos by Nigel Wenban Smith. Nigel was a past chairman of CCT and he has retained a keen interest in the archipelago. The book, which should be published this year, will be announced on the website when it is ready.

Anne Sheppard

The Chagos Marine Reserve: Building on Success

On 27th November 2012 there was a joint meeting of the Chagos Conservation Trust and the Zoological Society of London, with the support of the Pew Environment Group. Over one hundred people attended the conference day and the talks were enthusiastically received.

The friendly and informal drinks reception afterwards by the beautiful tanks in the Aquarium Building allowed people to mix and discuss many topical Issues.

The conference organiser, Prof Charles Sheppard, summarises the idea behind the conference in the article below and the talks themselves are presented.

Some of the conference delegates during a coffee break *Photo Anne Sheppard*

The BIOT marine reserve – Next Generation

Professor Charles Sheppard
University of Warwick.

We are in an unprecedented position regarding research on the reefs and islands of the Chagos Archipelago. From a long period of more or less sporadic research, never knowing when, or even if, the next grant might come, we now have several major expeditions planned. Work on these will expand our knowledge, continue time-series of information on several key aspects, and start some new projects which relate to issues identified in the draft contribution to a future conservation and management plan which was submitted to the BIOT administration. This set out the priorities for the future management of the Chagos marine reserve . On the islands, work now underway or planned includes: rehabilitation of large plots of derelict coconut plantations in Diego Garcia (which is proving to be remarkably successful), bird research on several key issues including the Important Bird Areas, and a new rat eradication programme in a northern island. These have applications in for funding, or already have funding, from numerous organizations, enthusiastic NGOs and researchers from the UK and overseas. We have never been in such a good scientific position – scores of scientists are involved in one way or another. The new outreach and training programme for those who have a Chagossian heritage is also underway – hopefully the first of several.

Coordination of all this is more complicated now, and is being done through several vehicles including the principal investigators of the expeditions, and we relate strongly also with the Big Oceans Network in a number of ways.

Later articles amplify these and more. Here I describe briefly some of my own results from the expedition of 2012, and summarize some of the results that are not going to be covered in later articles about the conference.

Activity	Impacting agent	Action	Effect on corals
Boating	Fuel	Hydrocarbon release	Tissue stress and reduced larval competence
Boating	Antifouling paint	Copper release	Reduced larval competence
Habitation	Sewage	Nutrification	Increased algal growth
Habitation	Sewage	Introduction of bacteria and viruses	New pathogens, more marine diseases
Habitation	Fishing	Reduction of herbivorous fish	Increased algal growth
Habitation	Coastal construction, increased dredging	Increased turbidity and/or sedimentation	Tissue stress in large corals, reduced settlement
Climate change	Increased SST	Bleaching events	Pulsed severe mortality
Climate change	Ocean acidification	Lowered aragonite production	Reduced larval competence
Habitation, climate and environmental change	Physical disturbance, fertilised water column, changed oceanic fronts	Increased predator outbursts	Increased frequency and severity of mortality

Figure 1. From Riegl et al. Some of the major causes of reef decline.

A new paper based largely on work done in Chagos (Riegl et al, 2012) is a good starting point for observing issues and effects which are likely to reduce or harm the reefs of Chagos in the future. It is complex, but the gist is clear enough and explains why the reefs are as good as they are: no surprise perhaps that it is attributed to the lack of so many of those common factors that damage reefs (Figure 1), and also show that not very much of the latter would be needed to materially affect them.

We have begun a series of measurements of juvenile corals, the next generation of corals to sustain and build the reefs of this archipelago and the results show (Figure 2) very high densities of juveniles. This must be one of the main reasons why the corals have recovered so well from the rise in water

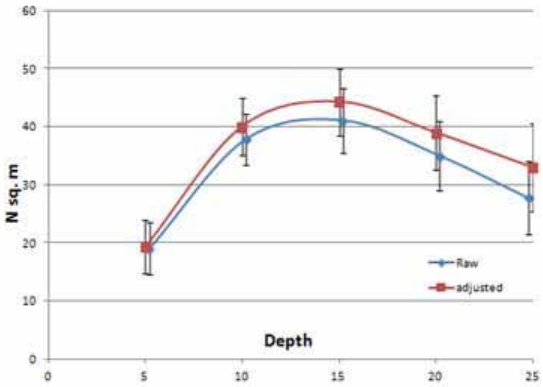


Figure 2. Numbers of juveniles per sq m at different depths in Diego Garcia's ocean facing reefs, in 2012

temperature in 1998 (Figure 3).

It took a decade for corals to recover to the states that they were in immediately before the wipeout of 1998, but they have recovered and this is in contrast to many other reef areas in the Indian Ocean which suffer severe human impacts such as dredging, industrial pollution and of course

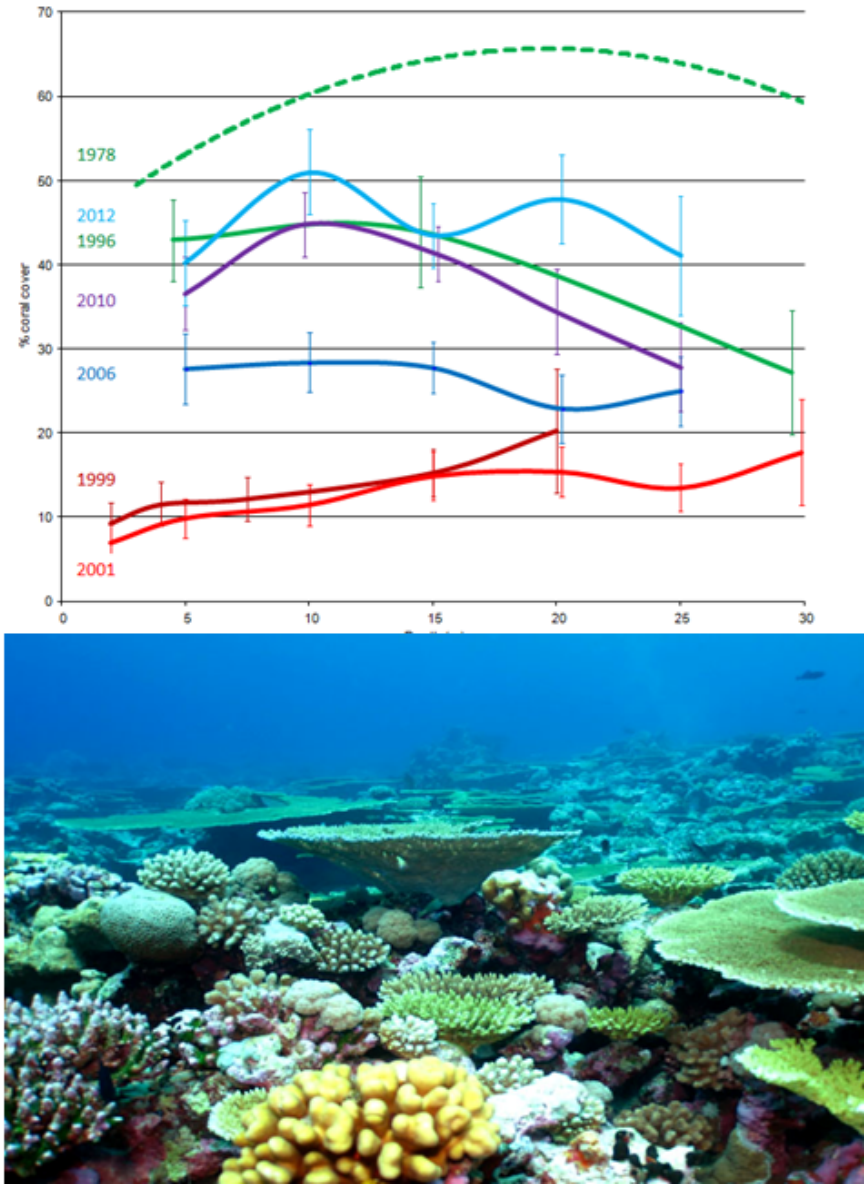
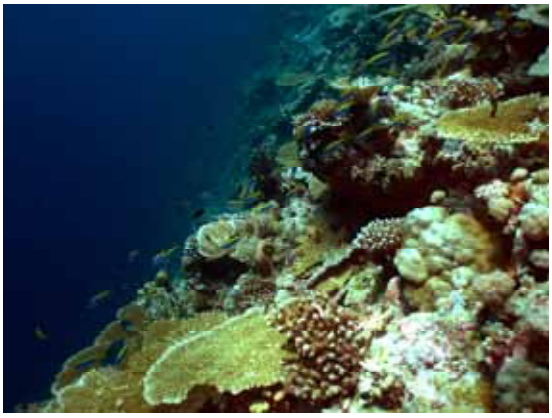


Figure 3. Graph showing recovery over about a decade of coral cover on ocean facing reefs in Chagos. (from Sheppard et al 2013). *Photo Anne Sheppard*

overfishing. But while for Chagos 1998 saw the biggest destruction of corals, temperature rise is inexorable and we cannot tell the future, other than to say that Chagos is best placed to delay the adverse effects of it. There have been in fact several more minor bleaching events which did not lead to coral death since then, and very recently the year 2010 was shown to be the warmest ever recorded in global terms, although in the central Indian Ocean things were not quite so bad as they were further east. So, monitoring the temperature of sea water continues and we have deployed 10 or more temperature recorders at various depths between 5 and 25 metres around these atolls, in the lagoons and on the ocean facing slopes. We have now built up a tremendous record of temperature readings every two hours in various places since 2006. Although we have lost one or two of these temperature loggers, our record at retrieving them, and indeed finding them again considering they get covered in coral growth, is pretty good. We have already published some unusual discoveries such as that of cold deep water upwelling during warm periods which doubtless has helped the Chagos corals, but now I am waiting to consolidate all this perhaps in a few years time, before

delving into this further.

Other publications recently have shown other possible reasons for why corals have recovered so well in Chagos. Yang et al. (2012) is a good starting point for this. It shows a possible change in the kinds, called clades, of the symbiotic algae held in many of the corals, algae which are more adapted to some of the new conditions. Again, like many of these programmes, this is in its infancy and is continuing.



Healthy seaward facing reef in Salomons Atoll

Photo Anne Sheppard

Two recent publications have shed a little more light on the 'position' of Chagos in the Indian Ocean. Briggs and Bowen (2011) look at this for reef fish, and Obura (2012) looks at it from a coral perspective. For fishes, Chagos is seen to straddle pretty well the East and West Indian Ocean, while for corals Chagos sits very firmly in the Western Indian Ocean group of sites. More work on this is continuing. Other papers, by Vogler et al. (2012) show that the crown of thorns starfish is from the Southwest Indian ocean group, and another paper, which we hope will be out soon, likewise shows that the very common species *Stylophora pistillata* is a southwestern Indian Ocean form of this coral, which we expect is a different species in fact. The coconut crab similarly is connected, as are turtles, with the Western Indian Ocean, in the former case Chagos being a recipient of larvae *from* the West about 10 times more frequently than it exports larvae *to* the West.

Some of these results are due to appear any week now in a new book in the series *Coral reefs of the World,* this one being … *of the UK Overseas Territories* (Sheppard (ed) 2013).

In Diego Garcia some experimental plots on restoration of native hardwood seedlings where there used to be coconut plantation, have shown some remarkably successful but sometimes complicated results. Freed of the competition and shading from palm trees, sometimes unwanted – weedy - species suddenly thrive, but where this does not happen, or where they are removed, native hardwoods are doing extremely well (Figure 4).

Figure 4. Part of an experimental plot where hardwoods were planted after removal of coconut. The fences are to prevent the wild donkeys from browsing on the young trees. *Photo Pete Carr*

In 2012 we visited again a remarkable but small and threatened mangrove stand in the North of Peros Banhos (Figure 5). It is threatened because coconuts are encroaching in the area. Without active management soon these will disappear.

Figure 5. part of the mangrove stand in Peros Banhos. Red-foot boobies are nesting in the trees. *Photo Pete Carr*

With others, I am increasingly concerned about erosion of many parts of many of these islands. In the south of Diego Garcia broaching of the raised land rim that surrounds almost all of these islands now takes place episodically at the highest spring tides. Tens of millions of US dollars are being spent by the US government to harden some shorelines in front of important infrastructure but the uninhabited parts of Diego Garcia, and of course all the northern atolls, are very unlikely to receive any attention at all in this respect. Many islands throughout the archipelago are showing some encroachment. We all know that palm trees topple into the sea everywhere, now and again, and this adds to the attractiveness of a tropical beach. But the attrition is sometimes considerable: noticeably enlarging chunks are being taken out of islands in Northwest Peros Banhos and

Figure 6. Top: lemon shark foraging over grass, after flooding at high tide. Bottom: The car park at 'Turtle Cove' a day or two later.
Photo Charles Sheppard

In southern Diego Garcia I photographed a group of four or five small lemon sharks foraging for food over the roadside grass (Figure 6), but in several large areas much of the land was inundated with saltwater during these high tides too, such as the car park in the far south (Figure 6 bottom). It was not particularly stormy either, and both these sites were in a sheltered lagoon. The highest tides are certainly increasing in net effect, and it is not consoling to know that the next IPCC report looks like it is going to increase the predicted global mean sea level rise by about four fold. We know that Chagos experiences average sea level rises of less than the global average, but it is still likely to be four times greater than we thought previously.

Earthquakes are important in Chagos too it seems and these may cause small vertical changes in elevation at localized sites. Henstock and Minshull (2004) state that the present rate of seismicity is higher than the long-term average; indeed it is 3 to 10 times more. I have long wondered about the little island Resurgent in the Three Brothers group which has appeared since Moresby's survey of 150 years ago, and about old reports that Blenheim atoll, which is now completely awash, used to have three vegetated islands on it. There has been a considerable cluster of small earthquakes in the southern part of the Great Chagos Bank, attributed to stretching of the crust.

We are engaging strongly now with the "Big Ocean Network", the grouping of the largest marine protected areas in the world. We expect to increasingly exchange views and information about both the science of such large areas and its management in future.

Our contribution to a future conservation and science management plan was placed on the CCT website in 2012. All feedback received has been incorporated appropriately. It is hoped that the BIOT website will be up and running shortly, which might show the final version of this.

Future research progresses well, but it is all expeditionary in nature, based from the *Pacific Marlin* (except for when Diego Garcia work only is done). The great advantage of this ship-based approach is that we can cover this huge area very effectively. A long time ago several of us investigated potential possibilities of having a research station based perhaps on Diego Garcia or

Figure 7. Vache Marine, in southern Peros Banhos, where it is hoped to carry out a vegetation restoration and rat eradication project soon.

perhaps on a northern atoll. In present economic conditions, and indeed even before the monetary crisis, it was concluded that such a facility would be very underused and therefore most likely would not be viable, nor even the optimum base from which to carry out the research over this very large area. We have concluded that, for the present, continued and expanded use of the *Pacific Marlin* is the way to go.

In February 2013 we will start some filming in the northern islands and reefs as part of the outreach programme. On each expedition now we take at least one assistant who has Chagossian heritage assisting one or other of the teams in their projects and we hope to continue with this, sometimes for terrestrial work and sometimes, as in 2012, with underwater work. More on this in a later article.

Finally I would comment that proposals are in for another rat eradication project, focusing this time on the small island of Vache Marine in Peros Banhos (Figure 7). This is being done in conjunction with the Royal Botanic Gardens Kew and the RSPB, organized by Peter Carr in Diego Garcia.
We have entered a new, structured, and exciting time for conservation research in this remarkable archipelago. We hope to build on both the number of scientists around the world who have participated, to involve more Chagossians in the work, and continue to help to conserve what appears to be the world's largest network of reefs which is in very good condition.

Quis custodiet ipsos custodes?

The fish do!

Briggs and Bowen (2011) A realignment of marine biogeographic provinces with particular reference to fish distributions. *Journal of Biogeography*

Henstock TJ and Minshall TA. (2004). Localized rifting at Chagos Bank in the India-Capricorn plate boundary zone *Geology* **32**:237–240.

Obura D (2012) The Diversity and Biogeography of Western Indian Ocean Reef-Building Corals. *PLoS ONE* **7**(9): 14 pp.

Riegl BM, Sheppard CRC, Purkis SJ (2012) Human Impact on Atolls Leads to Coral Loss and Community Homogenisation: A Modeling Study. *PLoS ONE* **7**(6) 11 pp

Sheppard CRC et al. 2013. Coral reefs of the Chagos Archipelago, Indian Ocean. In Sheppard CRC (ed) *Coral Reefs of the UK Overseas Territories*. Springer, Germany

Sheppard CRC (editor) 2013. *Coral Reefs of the United Kingdom Overseas Territories***.** Springer book series Coral Reefs of the World, Volume 4..

Sheppard CRC 2012. Sharks on the lawn: the reality of rising sea-level on Indian Ocean Islands. *Ocean Challenge*,**19**, p 17.

Vogler C, Benzie J, Barber PH, Erdmann MV, Ambariyanto, Ambariyanto, Sheppard C,Tenggardjaja K, Gerard K, Worheid G. (2012) Phylogeography of the Crown-of-Thorns Starfish in the Indian Ocean. *PLoS ONE* **7**(8) 10pp

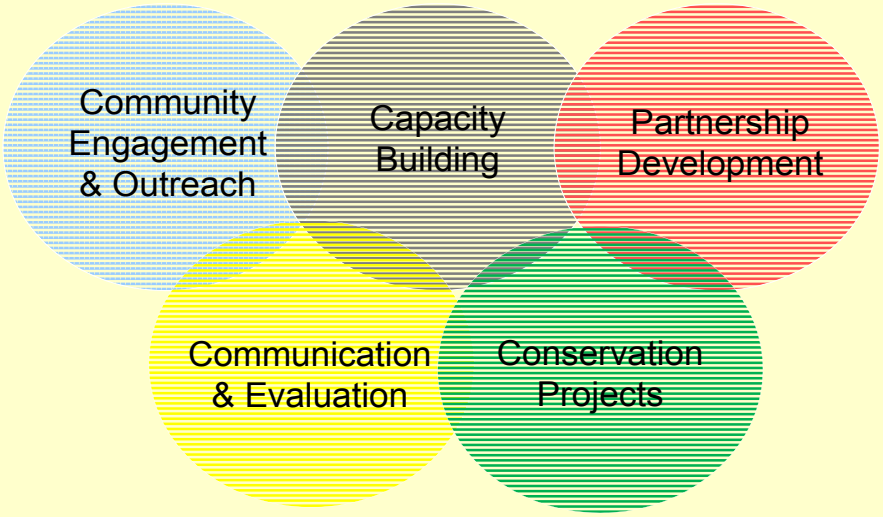
Yang S-Y, Keshavmurthy S, Obura D, Sheppard CRC, Visram S, et al. (2012) Diversity and Distribution of Symbiodinium Associated with Seven Common Coral Species in the Chagos Archipelago, Central Indian Ocean**.** *PLoS ONE* **7**(5) 9 pp

A grapsid crab- one of the most common inhabitants of the reef flat.
Photo Anne Sheppard

A crab of the genus *Ocypoda* which along with the hermit crabs are common inhabitants of the sandy beaches
Photos Anne Sheppard

Chagossian Community Environment Project

Xavier Hamon
Rebecca Short
Rudy Pothin
Zoological Society of London



Regular readers of Chagos News will remember being introduced to the joint CCT/ZSL Chagos Community Environment Project early in 2012, aimed at raising awareness and building capacity within the Chagossian communities of the UK. A presentation at the CCT 2012 conference by Outreach Officer Xavier Hamon of the progress made 8 months into this project was met with deserved applause and proclamations of optimism for the future.

The multi-faceted project involved a number of streams of activity designed to engage the community at large with the project and the archipelago's environment, build capacity for Chagossian involvement in future conservation in Chagos, develop new partnerships and transform these into on-the-ground projects with Chagossians at their heart.

The trainees demonstrated their enthusiasm throughout coral identification, bird monitoring, sustainable fisheries theory and practice, island restoration techniques and numerous other disciplines. The final session gave the trainees a chance to experience SCUBA with a try dive held at the London School of Diving

All of the trainees have shown amazing fervour throughout the course, engaging fully with classroom and practical sessions alike, always seeking to learn more.

To mark the end of the course an award ceremony was held where trainees received an emphatic well done (as well as certificates and medals). Generously hosted by the Ramada Plaza Hotel in Crawley, the red carpet décor served to create an appropriately premiere-esque feel to the first showing of a film made throughout the project, with input from the trainees and showcasing the project as a whole.

This film can be viewed at: www.zsl.org/chagosfilm

Their increased awareness of how fragile the Chagos environment is and methods of protection has inspired their tagline - **'Join us in preserving our Chagossian heritage, from the land to the sea and the sea to the land'**.
All those involved with the project now hope that they can take this tagline and begin to inspire others within and beyond the Chagossian communities.

One in particular will be doing so in February as he becomes the sixth Chagossian to join research teams out in the archipelago itself.

Working with Pete Carr, Yannick Mandarin from Crawley will be assisting in bird surveys and monitoring of parasites in Sooty Tern populations, with a view to discovering more about their mobility and island use.

For the rest of the graduates, a number of bursaries and opportunities have been created to further their skills and maintain momentum in communicating their message. It is hoped that these trainees will now not only be directly involved in conservation projects on the ground in Chagos, but also become stewards of their own outreach objectives, and maybe even begin a career in conservation.

To keep up to date with how the project progresses, for more information or if you feel you could contribute please visit our webpage www.zsl.org/chagoscommunity or email rebecca.short@zsl.org or rudy.pothin@zsl.org

Turtle Research in Chagos – January 2013 Update

Dr Graeme Hays[1]

Dr Jeanne Mortimer[2], Dr Nicole Esteban[1]

[1]Swansea University, [2]University of Florida

With support from a small "Darwin" grant award from the UK Department of the Environment, Food and Rural Affairs (DEFRA) and FCO, and the Chagos Scientific Advisory Group (SAG), a small team visited Chagos for three weeks in October 2012 to continue sea turtle conservation and research work. The main objective for this visit was to initiate research to assess the movements of juvenile and adult turtles and continue the monitoring of juvenile turtles in the lagoon and nesting activity on the beaches. Research focussed on Diego Garcia due to the short duration of the visit.

On the nesting beaches, activities included attachment of satellite tags to eight nesting green turtles (carapace lengths ranging from 101.5 – 111.5cm) to assess the extent of post-nesting movements, and the burial of 30 temperature loggers at a range of nest depths in various nesting habitats to measure sand temperature for one year to enable informed predictions of hatchling sex ratio in the Chagos Archipelago. At Turtle Cove, a sheltered creek in the southern part of the lagoon in Diego Garcia, monitoring of the population status of green and hawksbill turtles continued from previous visits in 1996, 1999 and 2006 and more than 60 immature hawksbill turtles and a couple of green turtles were caught, tagged, measured and weighed, and dozens more untagged turtles were encountered. Electronic tags were attached to 10 of the juvenile hawksbill turtles (carapace lengths ranging from 36.2 to 70cm) to allow their diving and horizontal movements in the lagoon to be assessed. Prior to this visit, Antenor Nestor Guzman, Environment Department, USN NAVFAC had been conducting regular nesting beach surveys at Diego Garcia in collaboration with Jeanne, and these will continue. Nestor was also involved with the deployment of the temperature loggers, and will be monitoring their position in the coming months to ensure that they don't wash away.

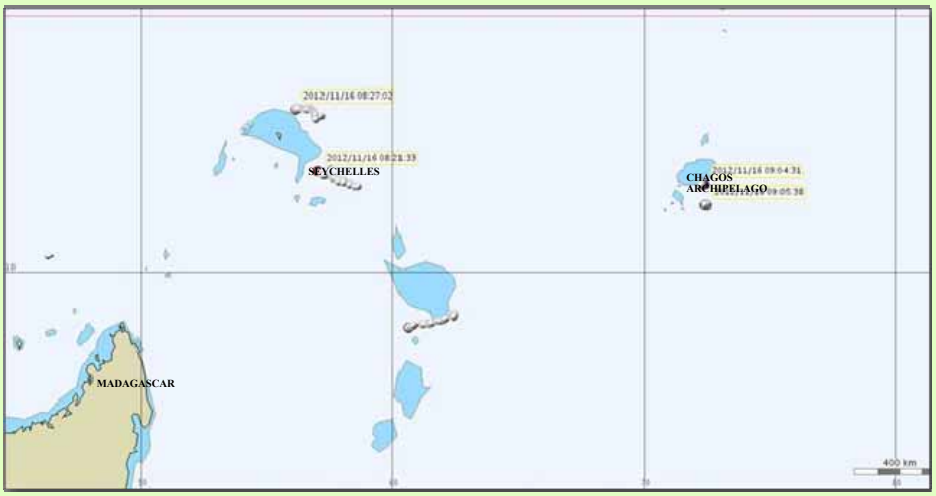
The start of the visit coincided with a typhoon, providing ample time for meetings and a well-attended evening presentation to members of the military and civilian community on Diego Garcia. These events resulted in well over 100 people (from the US and UK military as well as civilian contractors) joining the research team with great enthusiasm to assist on day and night work in the lagoon and on nesting beaches. The achievements and overall success of the visit was greatly enhanced due to the support received from these volunteers.

A green turtle equipped with a satellite tag, returning to the water at dawn

Jeanne Mortimer with a hawksbill turtle at Turtle Cove, returning to shore to flipper tag and measure the turtle.

The turtle research team with volunteer Clayton Halpain

The team departed from Diego Garcia with the hope that the satellite tags would continue to transmit, revealing foraging grounds for the green turtles. As we approach February 2013, all eight tags continue to send a huge amount of information. While some turtles are still at Diego Garcia, others have travelled more than 3000 km to mainland Africa, while others have travelled to the Seychelles. We are in the process of working up these data and expect the first scientific publications, including detailed maps of the routes followed, to appear later this year. The success of the satellite tags has massively exceeded our expectations. As we pay for the data received (akin to receiving a monthly phone bill from the space agency), we have now exhausted the funds in our small Darwin grant. So we are now trying to quickly source some funds to cover the costs of the ongoing satellite tracking data collection.



Locations of eight green turtles on 16 November 2012, showing tracks for previous three days; at that date four turtles were still close to the nesting beach.

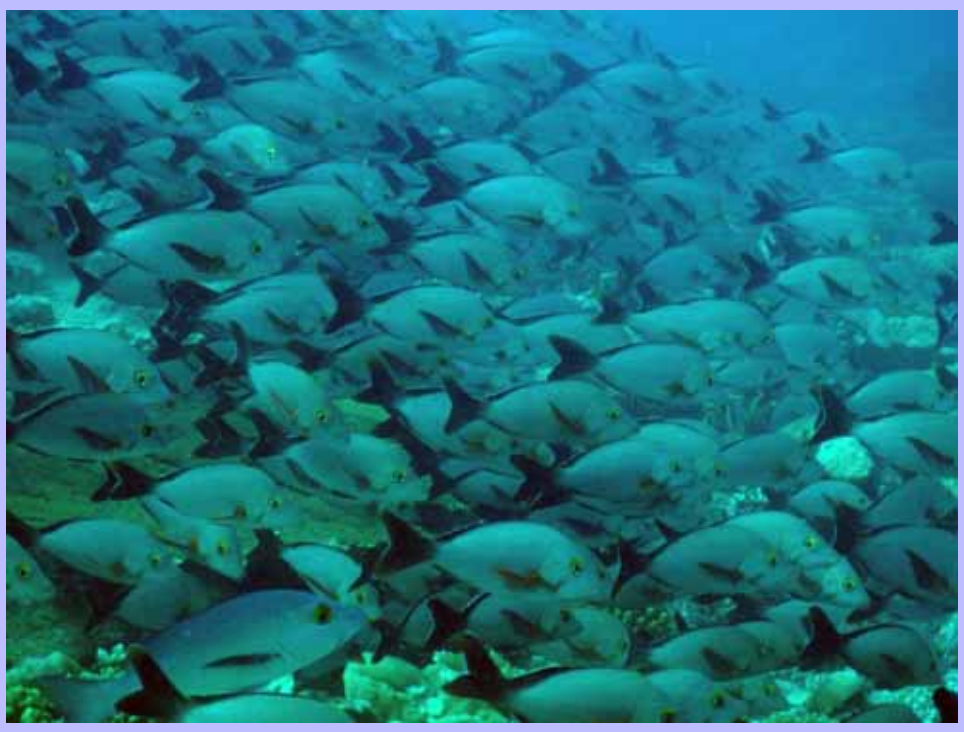
Locations of two green turtles in Chagos in mid-January: one has travelled to the Great Chagos Bank, one was still close to the nesting beach. By this date the other six tagged turtles had departed to distant foraging grounds.

At Turtle Cove, eight of the captured turtles had already been marked with tags first attached during earlier visits. Data analysis has shown that during the intervening years the turtles have grown an average of about 1cm per year. This shows how slowly the turtles grow and how long lived they are. They probably only mature when they are several decades old which emphasises the importance of long-term conservation. Relatively fewer previously tagged turtles have been found in Turtle Cove than during earlier visits in 1999 and 2006. In those years, a much higher proportion of the turtles encountered had already been tagged. The relatively lower rate of recaptured turtles this year might be an artefact of increased numbers of turtles now living in Turtle Cove. In 2006, Jeanne noticed that there were more turtles in Turtle Cove than in either 1996 or 1999. There appear to be even higher numbers of turtles in 2012. This increase in turtle numbers at Turtle Cove can be attributed to the long-term protection that the US military base and BIOT legislation have afforded the turtles of the Chagos archipelago. Initial analysis of the data-sets coming back from the range of data-loggers attached to juvenile hawksbill turtles are revealing patterns of behaviour of these small turtles. They feed during the day, but at night sleep on the seabed, doing dives of up to 45 minutes between breaths.

Following the success of this visit, the team hopes to acquire funding to return to Diego Garcia in late 2013 to continue with research and, in particular, to excavate the temperature loggers buried on the nesting beach, download data and re-bury them for long term monitoring of nest incubation temperature. At the same time, it is hoped that discussions will continue in preparation of a project application to fund a much longer-term project running over several years and funding further visits as well as funding the provision of resources on Diego Garcia to continue and expand the turtle conservation and research work.

The condition and stability of reef fish assemblages in the Chagos Archipelago

Dr Nicholas Graham
James Cook University
Australia



A large school of paddletail snapper in the Chagos Archipelago.
Photo: Anne Sheppard

Through various work across coral reefs of the western Indian Ocean, colleagues and I have shown that fish biomass on these coral reefs tends to peak at around 1,200 kg/ha. One of the best examples of this is from long-term time series of reef fish biomass build-up in Kenya's marine national park network. After 20-25 years, the biomass within these parks stopped increasing and levelled off at 1,200 kg/ha. This value was therefore assumed to be the maximum that these reefs could support. However, it was noted that most marine parks in the region are quite small and are found along populated coastlines and are therefore embedded within large areas of heavy fishing pressure. My presentation at the Zoological Society of London (ZSL) put these findings in the western Indian Ocean into context, by comparing these other nation's fish biomass values to fish biomass values I recorded in Chagos. The fish biomass at Chagos was up to 6 times greater than that in the rest of the Indian Ocean, and included much more biomass from fish that were high up the food chain and of larger body size. These data form the basis of a forthcoming paper in the journal BioScience (Graham & McClanahan in press).

I went on to compare reef fish biomass among atolls within Chagos, showing that the biomass of reef fish around Diego Garcia was generally lower than the biomass at the northern atolls. There is a recreational fishery around Diego Garcia, and even light fishing such as this has been shown to be detrimental to fish biomass in other locations. Although it is very hard to pinpoint that the recreational fishing is driving these differences, the fact that higher trophic level and larger fish are more scarce in Diego Garcia than the northern atolls is suggestive of fishing impacts. More details on these data can be found in a forthcoming book chapter (Graham et al. in press). The chapter also updates a time series on the relative abundance of reef sharks in Chagos. These data, collected during scientific dives in the archipelago, extend from 1975 to 2012. Shark abundances had dropped by ~90% after the 1970s, most likely due to increased fishing for shark fin. The numbers have not recovered, but there are weak signs that a little recovery may be occurring. Importantly, this will be dependent on how well the Chagos marine protected area is enforced and complied with.

The final part of my talk assessed the impact of the 1998 coral mortality event on the reef fish communities in Chagos. This large disturbance event caused substantial reductions in the abundance and diversity of reef fish communities in some other parts of the Indian Ocean, such as the Seychelles. However, in Chagos the impacts were much smaller. Only obligate coral feeding fishes showed some reductions in abundance by 2006. The rapid recovery of corals in Chagos, combined with the lack of other human impacts (e.g. fishing), are the most likely reasons for the lack of impact.

Interestingly, by 2012 the fish communities, including the obligate coral feeding fishes, were abundant. A study of specialisation

of these coral feeding fishes has shown that the more specialised a species is the more abundant they are, suggesting some sort of competitive advantage of this specialisation (Pratchett et al. in press). This is the first time this has been shown, again highlighting the novel scientific insights a largely untouched location such as Chagos can offer.

More details on these findings can be found in the following publications, all of which should be published in the first half of 2013:

A grey reef shark at Diego Garcia. *Photo: Nick Graham*

Graham NAJ, McClanahan TR (in press) The last call for marine wilderness? *BioScience*

Graham NAJ, Pratchett MS, McClanahan TR, Wilson SK (in press) The status of coral reef fish assemblages in the Chagos Archipelago, with implications for protected area management and climate change. In: Sheppard CRC (ed) Coral reefs of the United Kingdom Overseas Territories. *Springer*

Pratchett MS, Graham NAJ, Cole AJ (in press) Specialist corallivores dominate butterflyfish assemblages in the Chagos Archipelago, central Indian Ocean. *Journal of Fish Biology*

Obligate coral feeding butterflyfishes in the Chagos Archipelago. *Photo: Morgan Pratchett.*

Pervasive Plastics

As can be seen from the data presented in Prof Jim Readman's article in this issue of *Chagos News,* plastic is very pervasive in our oceans.

The diagram opposite shows just how long some common materials persist in the environment.

Hopefully, in the not too distant future, instead of having to recycle large amounts of plastic from your weekly shop, there will either be much less or none at all.

Island Restoration in Chagos

Colin Clubbe
Royal Botanic Gardens, Kew
Peter Carr
University of Warwick

Argusia argentea (L.f.) Heine (beach heliotrope). *Photo Anne Sheppard*

Introduction

The five coral atolls that form the Chagos Archipelago comprise some 55 islands set within the 640,000 km^2 Chagos Marine Reserve. The islands vary enormously in land area with many <1 ha, some 10-100 ha, a few >100 ha and Diego Garcia at 2,720 ha accounting for over half the archipelago's total land mass.

As currently circumscribed we recognise 45 species of vascular plants, comprising 41 seed plants and 4 ferns, as native to Chagos. There are no known endemic plant species in the Chagos and all these native species are relatively widely distributed across the Indian Ocean Islands and neighbouring continental land masses. This is probably a consequence of the relatively little time for colonisation and speciation on islands that have been above water for probably less than a few thousand years. The current vegetation cover of the islands reflects past exploitation, no activity with greater impact than the conversion of much of the native vegetation to coconut (*Cocus nucifera* L.) during the plantation era together with the widespread introduction of rats.

Developing a Restoration Strategy for Chagos

We are developing a restoration strategy for Chagos which involves both looking back to try and establish what the natural vegetation of the Chagos would have been like before Man's settlement and looking forward to determine what our restoration goals are.

We can recognise six broad categories of native vegetation:

Beach Pioneers: a handful of small, creeping, herbaceous species on the shore line, highly salt tolerant, which trap and stabilise the sand starting the process of island building. Typical beach pioneers are *Boerhavia repens* L. and *Sida pusilla* Cav. which are important components of the beach flora of most islands within the archipelago.

Boerhavia repens L. *Photo Colin Clubbe*

Littoral Hedge: as the sand stabilises seedlings and saplings of small shrubs become established forming the characteristic littoral hedge of the beach crest of many islands. Two of the most widespread species are *Scaevola taccada* (Gaertn.) Roxb. (scavvy) and *Argusia argentea* (L.f.) Heine (beach heliotrope). The littoral hedge provides nesting sites for many birds including the Red-footed Booby (*Sula sula* L.)

Sublittoral Thicket: behind the beaches in well drained areas a community of small trees may develop, the Sublittoral Thicket, comprising species such as *Ochrosia oppositifolia* (Lam.) K.Schum. and *Cordia subcordata* Lam., rarely more than 5m tall which also provide important roosting sites for many birds including the Red-footed Booby.

Cordia subcordata Lam. *Photo Anne Sheppard*

Climax Forest: where more moist undisturbed conditions pertain, climax forest may be established which represents the most luxuriant and complex vegetation found on the islands. These forests comprise mature trees which can reach over 20m tall and support a range of different species including *Pisonia grandis* R. Br. The soft humus which builds up in mature forests provides the only nesting sites for the Audubon Shearwater (*Puffinus lherminieri* Lesson) which burrows in the soft humus to lay their eggs. Other important forest trees include *Barringtonia asiatica* (L.) Kurz (fish poison tree) which also provide important roosts for the Red-footed Booby; *Calophyllum inophyllum* L. (takamaka) widely exploited for boat building in the past; and *Intsia bijuga* (Colebr.) Kuntze. The climax forest provides the greatest diversity of niches for roosting and breeding birds including Common White Tern (*Gygis alba* Sparman), Lesser Noddy (*Anous tenuirostris* Temminck) and Brown Noddy (*Anous stolidus* L.). The mature forests also support a relatively wide range of shade-tolerant ferns and fern allies – both epiphytic and ground dwelling, especially *Asplenium nidus* L. and *Psilotum nudum* (L.) P. Beauv.

Savanna: where the hydrology prevents tree establishment savanna-like open areas are established, dominated by grasses, sedges and small herbs. These communities are very important for ground-nesting birds including Brown Booby (*Sula leucogaster* Boddaert) and Sooty Tern (*Sterna fuscata* L.).

Birds nest fern Asplenium nidus L.
Photo Anne Sheppard

Mangrove Woodlands: where saline conditions persist mangrove woodlands may establish, but this is a very rare vegetation community in the Chagos context – discovering the one on Moresby Island was the botanical highlight of the 2010 scientific expedition, as the only documented case of mangrove prior to this is a small area on Eagle Island which is drying out and desperately in need of restoration.

Healthy mangrove forest on Moresby Island *Photo Anne Sheppard*

Non-native Vegetation

The native vegetation has been supplemented by the introduction of non-native species ever since the islands were first discovered by the Portuguese. Useful plants were introduced during the plantation era, but many other species arrived by accident, along with early arrival of rats which have had a disastrous impact, especially on nesting sea-birds. Ornamental introductions to beautify downtown Diego Garcia and other casual introductions increased during the 1970s. Currently there are about 232 non-natives, of which 128 have only been recorded on Diego Garcia.

Mayflower *Tabebuia pallida* (Lindl.) Miers
Photo Anne Sheppard

Around the Settlements you can see the evidence of these early introductions of useful plants that were grown for food including taro (*Colocasia esculenta* (L.) Schott),

the starchy root vegetable native to SE Asia; pawpaw (*Carica papaya* L.), the tropical fruit native to the tropical Americas and first cultivated in Mexico; cucumber tree (*Averrhoa bilimbi* L.) used in cooking especially to flavour fish, thought to be native to Indonesia. These species don't really pose any threats to the native flora and fauna and are not really spreading to any great degree.

Taro *Colocasia esculenta* (L.)
Photo Anne Sheppard

The biggest negative impact on the native flora was the gradual conversion of most of the terrestrial land on the accessible islands to coconut plantations for the extraction of copra oil. Since the collapse of the coconut oil industry and the abandonment of the coconut plantations and with the consequent lack of any management these areas have become impenetrable coconut forests which prevent virtually any other species getting established, except more coconuts. An adult coconut can produce 80-100 nuts per year. The nuts drop from the mature trees and germinate *in situ* to form a 2-3m impenetrable mass. Perhaps the only organism to benefit is the coconut crab (*Birgus latro* L.) the world's largest terrestrial arthropod, reaching over one metre in leg span and 3.5-4 kilos in weight. The coconut crabs, threatened over much of their range, on Chagos comprise one of the most undisturbed populations in the world.

There are no records of the origins of other non-native plant introductions but many are becoming a problem as they spread and negatively impact native communities. For example, the fast growing tree, *Tabebuia pallida* (Lindl.) Miers (white cedar or mayflower), native to the Caribbean, is spreading invasively at East Point on Diego Garcia, and *Casuarina equisetifolia* L. whose main native distribution is SE Asia, Australasia and the Pacific is widespread on many of the islands in Peros Banhos.

Coconut crab (*Birgus latro* L.)
Photo Anne Sheppard

Restoration Activities

Our restoration goals are to move from the invasive dominated Chagos present to a more species-diverse native-dominated future by:

1. Rescuing threatened habitats with mangroves being our key habitat priority and
2. Restoring native habitats with a priority for rat eradication and coconut removal to re-establish climax forest to replace coconut plantations.

We are currently fund-raising to start a programme of mangrove restoration. The newly discovered mangrove woodland on Moresby Island looks to be comprised of old trees with no current regeneration which may be the result of years of accumulated coconut debris which may have affected the tidal flow of the water. The habitat needs rehabilitating by first removing years of accumulated coconut debris. In addition, propagation material needs to be collected to establish a nursery to enable material to be produced for experimental re-introduction of young mangroves.

On Eagle Island the mangrove looks in a really poor state. It is being strangled by surrounding coconuts and by many over-topping vines. In addition the hydrology has been seriously undermined, possibly by the formation of a sand barrier which has prevented any tidal movement of water which mangroves need for healthy growth. Some areas are drying out whilst others areas are becoming flooded with fresh water as evidenced by the establishment of colonies of the fresh-water sedge, *Eleocharis geniculata* (L.) Roem. & Schult. So here we are looking at serious habitat restoration which is likely to require engineering work to re-establish tidal water flow, removal of coconuts and climbers, at the same time collecting propagation material, establishing a nursery so that we can trial some experimental re-introduction of young mangroves. If this programme doesn't start soon we are very likely to completely lose the Eagle Island mangrove ecosystem within the next decade.

Collecting coconuts from the ground before clearing the area for restoration work.
Photo Anne Sheppard

The second major restoration challenge is the conversion of coconut plantation back to species-rich forest. On Diego Garcia work has already started with the very successful Barton Point Restoration project in the Nature Reserve on the Eastern arm of Diego Garcia. Here coconut trees are being removed and native species planted and the results monitored to assess success. The techniques developed at Barton Point have proved really successful – clearing coconuts, corralling them and covering them in dead fronds to prevent regeneration, and planting out seedlings/saplings of native species grown specifically for the purpose or relocated seedlings from neighbouring natural seedling beds. Any indigenous plants present under the coconut canopy are retained. Initial results look really encouraging and a management plan for the area is being developed. The work on Diego Garcia is being scaled-up by using large diggers to enable clearance of larger areas and fencing them off to keep feral donkeys out. It will be fascinating to see how this develops.

On the outer islands in addition to coconuts we have the extra challenge of rat eradication. Rats are a major problem on many islands and have a huge impact on the resident bird populations, eating both eggs and young chicks. They also eat seeds and reduce plant establishment. Eradication plans are being formulated with advice from RSPB and NZ rat eradication experts. The February 2013 expedition includes a feasibility study for rat eradication from Ile Vache Marine in Peros Banhos. In the longer term a programme of rat eradications and island rehabilitations is being planned and fund-raised for.

So what does the future hold for the Chagos Islands? We have techniques available to swing the pendulum back from the current invasive-dominated state to more native-species rich communities. Our involvement with the Chagossian Community Environment Project (see this Issue) has provided participants with an introduction to botany and the plants and habitats of the Chagos Archipelago. These conservation trainees have proved that we have future conservation practitioners amongst them and we've incorporated their participation into our restoration funding proposals. Collectively our aim is to establish more species-rich forests supporting a wide range of native wildlife and a better future for the thousands of birds that nest in Chagos.

Pollution, Microplastics, Litter and Human Induced Impacts in Chagos

Professor Jim Readman
Plymouth Marine Laboratory

The geographical and ecological isolation of the Chagos Archipelago render it of special interest with respect to 'baseline' measurements and the threat of any potential effects of pollutants. Prior to a 1996 scientific expedition, however, there were negligible data in the open literature concerning the extent of contamination of the archipelago. Sediment samples during the 1996 event were analysed for hydrocarbons, steroids, organochlorines and toxic metals. Subsequent expeditions have further investigated the possible existence of persistent organic pollutants (POPs) and contaminants potentially linked to the military base on Diego Garcia. Indeed, associated with this base is regular sampling with many analyses in accredited US laboratories for over one hundred contaminants including metals and organic substances. In addition to the chemical contaminants, results from beach litter and tar ball surveys together with preliminary microplastic assessments were described.

Concentrations of potential Pollutants

Oil and combustion products

Oils contain a complex mixture of hydrocarbons and combustion processes result in the formation of toxic hydrocarbons. Analyses of the hydrocarbons in the sediment samples collected in 1996 revealed a dominance of hydrocarbons with odd carbon numbers and branched compounds of natural/biogenic origin mainly from planktonic plants. There was negligible evidence of contamination from petroleum with hydrocarbon levels similar to those reported for Antarctic sediments. An unresolved complex mixture of material in the analyses is often taken as a measure of chronic oil contamination: this was only measurable in one sample that came from the inhabited Diego Garcia and that was ten times less than concentrations reported for unpolluted UK estuaries.

Although oil slicks have not been reported in the Chagos region, tar balls were observed at eight beaches/islands throughout the archipelago in 1996, at three in 2006 and were not evident in 2010. This decrease may reflect improved international ship ballast cleaning measures over that time period throughout the Indian Ocean. No tar balls have been reported in Diego Garcia.

Sewage

The sediments collected in 1996 in Diego Garcia were also analysed for steroids. No evidence of sewage contamination, as would have been demonstrated by the presence of the faecal steroid coprostanol, was observed. Indeed, coprostanol was below the limit of detection at all stations, including Diego Garcia. Natural sterols dominated all sediments examined and compositional ratios were consistent with the input of organic matter derived primarily from planktonic or benthic algal sources, with a small terrestrial component.

Organochlorines - Persistant Organic Pollutants (POPs)

These compounds gained notoriety through Rachel Carson's book "Silent Spring", published in 1962. This exposed the hazards associated with the pesticide DDT which can biomagnify and contaminate food chains, harming animals, particularly at the higher trophic levels, including humankind. POPs are organic compounds or mixtures that share four characteristics; high toxicity; persistence; potential for bioaccumulation; and ability for long-range transport. Examples include the pesticides lindane and dieldrin and industrial polychlorinated biphenyls (PCBs) used in transformers and electrical components. In response to concerns relating to the protection of human health and that of the environment, the United Nations Stockholm Convention on POPs was adopted in 2001 and, following appropriate notification, became binding international law for those participating governments in 2004.

Sedimentary PCBs and organochlorine pesticides in Chagos were investigated in the 1996 expedition. Only some PCB congeners were above the detection limits of the analytical technique. Total PCB concentrations were much lower than those reported for deep and remote sediments, such as the Sargasso Sea and the Mediterranean basin. The predominance of the lower chlorinated PCB congeners and lindane suggest atmospheric deposition as the main route of introduction for organochlorine compounds into the sediments.

Flame retardants and polyfluorinated compounds

Whilst organochlorine POPs are of particular concern, other persistent compounds are emerging that also exhibit global ubiquity. Of these, flame retardants and polyfluorinated compounds (PFCs) [e.g. perfluorooctanesulfonate (PFOS), a synthetic fluorosurfactant used in abundance for many years as a fabric protector/stain repellent (Scotchgard®)] are important and have warranted inclusion in the Stockholm Convention. In addition, some can be linked closely with aviation, and hence potentially to Diego Garcia. To investigate this issue, in 2010 coastal sediment samples were collected for analyses from Diego Garcia, (the inhabited atoll) and from selected uninhabited atolls and islands.

Of the brominated, chlorinated and organo-phosphorus flame retardants analysed, only Dechlorane Plus® (a polychlorinated flame retardant) was recorded above the limits of quantification. This compound occurred in eight of the 20 sediment samples analysed, albeit at low concentrations (≤ 38.4 pg.g-1 dry sediment). Seven of the eight samples were from Diego Garcia with its associated military base, so elevated concentrations may not be surprising. The eighth sample was from Salomon Atoll, Ile Boddam, adjacent to a jetty/yacht anchorage. For comparison, concentrations of the compound recorded in the Great Lakes (USA and Canada) range from 14 to 4,390 pg.g-1 dry sediment.

The polyfluorinated compounds are used for a variety of purposes. Ionic polyfluorinated compounds were only detected in one of the twenty sediment samples. PFOS, PFHxS and PFOA, at low concentrations (2.4, 0.028 & 0.105 ng.g-1 dry weight, respectively), were recorded in a sample from Diego Garcia adjacent to a landfill and burn pit site. For comparison, ∑PFC concentrations of < LOQ to 85 ng.g-1 dry weight have been reported for Arctic Lakes in Canada.

Figure 1. Great Chagos Bank, eastern side of Eagle Island. Collecting sediment samples at low tide for subsequent analyses of PFOS and related compounds. *Photo Charles Sheppard*

Herbicides and antifouling agents

Antifouling biocides on boats and ships provide a threat at very low concentrations, especially to the algal symbionts of corals. In 2006, replicate water samples were taken from fourteen coastal locations focussed around the Diego Garcia lagoon but also including oceanic reference sites. Samples were analysed for the popular antifouling booster biocides Irgarol®1051, chlorothalonil, dichlorofluanid and Sea Nine 211®, together with triazine herbicides (atrazine, simazine and ametryn). Results revealed negligible contamination, with levels generally below the limit of detection. Only in two harbour samples was an antifoulant (Irgarol®1051) detected, at very low concentrations. With respect to the antifouling agents and herbicides analysed, it was considered that they pose no chemical threat to the coral communities. Further investigations were, however, suggested into which antifouling products/ herbicides are used in the region.

Toxic metals

Metals were analysed in surface sediments and biota collected during the 1996 expedition. Concentrations of copper, zinc, cadmium, lead, chromium and nickel were exceptionally low. Analyses of the biota revealed that lead and chromium (non-essential elements) levels were also very low. Concentrations of cadmium in invertebrates were similar to those found in open ocean areas.

Copper and zinc concentrations were, however, elevated in hermit crabs and clams. The elevated copper concentrations probably originate from the historical fungicide treatments previously used in coconut agriculture.

Contamination by solid waste

Shoreline debris

Despite their near pristine status in terms of chemical contaminants, Chagos beaches accumulate surprisingly high densities of solid debris. Observations were made in 1996, 2006, and 2010 at 20 sites in the outer atolls, and one in Diego Garcia as part of rapid environmental assessments. Median levels of the number of litter pieces were high (score 4) in all years; this corresponds to 1,000 to 9,999 items (geometric mean 3,162) per terrestrial portion of a site inspection quadrat, i.e. 500m (along the beach) to 250 m 'inland' from the shore. Items were mainly macro- plastics, polystyrene (Styrofoam) and rope, much being lost fishing gear or debris discarded from ships, most commonly of south-east Asian origin. Levels in Diego Garcia in all years were two orders of magnitude less than in other atolls, reflecting periodic clean-up events in that inhabited atoll. The method did not determine size categories or weight; most items were a few cm in size or less, but several northern islands, which are uninhabited, appear to collect substantial volumes of larger flotsam. Similar numbers are found in remote Pacific atolls where ocean current gyres are the main transport vector. Driftwood and lost timber from ships was low on beaches in all years, but decreased over time from 1996 to 2006, attributed to use for fuel by illegal fishing camps on the islands during this period of increasing fishing pressure. While these are unsightly, they have the potential also to impede nesting turtles in some areas.

Microplastics

Plastic debris now contaminates marine habitats from the poles to the equator. Whilst most attention has addressed debris items that are visible to the naked eye, attention is increasingly being focussed towards smaller particles termed microplastics. Small fragments such as these have the potential to be ingested by a wide range of organisms. They can also accumulate and transport pollutants. Widespread contamination of shorelines and the water column with microscopic plastics including brightly coloured granular and fibrous fragments has been reported.

Quantitative sampling for microplastics was undertaken using sediment collected from the low water mark at 20 sites in Chagos during 2010. Six samples were from remote, uninhabited atolls (Salomon, Peros Banhos, Great Chagos Bank and Egmont Atoll) while fourteen were from Diego Garcia. Synthetic polymers were found at all 20 sites (Table 4) including nylon, polyethylene, polyester, polypropylene and rayon, with an average size of 1.5mm ± 1.6mm (mean ± 1SD; range 30µm – 4mm). There was no significant difference in particle size between Diego Garcia and the northern atolls. The abundance of synthetic pieces was 4.55 ± 2.74 (mean ± 1SD) fragments per 50ml of sediment and was toward the upper end of the range reported from other locations worldwide. Hence it is apparent that microplastic contamination in the Chagos Archipelago is both widespread and relatively high compared to other locations.

Table 1 Number of synthetic fragments of microplastics at each site. (uninhabited sites are indicated by shading)

Sample Location	Number of synthetic fragments (per 50ml sediment)
Salomon Atoll	4
Peyos Banhos Atoll	6
Great Chagos Bank Middle Brother	6
Great Chagos Bank Eagle Island	13
Great Chagos Bank Danger Island	3
Egmont Atoll	5
Diego Garcia	2
Diego Garcia (seaward east of atoll)	3
Diego Garcia (back of Barachois)	2
Diego Garcia (beach rock at edge of lagoon)	3
Diego Garcia (atoll seaward)	5
Diego Garcia (turtle cove)	2
Diego Garcia (turtle cove Barachois)	6
Diego Garcia (southern tip of atoll)	5
Diego Garcia (off landfill site)	1
Diego Garcia (end of runway)	3
Diego Garcia (entrance to small boat harbour)	9
Diego Garcia (lagoon beside accommodation blocks)	5
Diego Garcia (nearby pipe running into sea)	5
Diego Garcia (yacht club)	3

There were some differences in relative abundance among sites with significantly more pieces at uninhabited sites compared to the inhabited military facility at Diego Garcia and the greatest number of synthetic pieces at the uninhabited Great Chagos Bank Eagle Island site. The reason for this spatial pattern is not clear but the results clearly indicate the potential for microplastics to accumulate in remote locations.

Figure 3. Sampling sites in northern atolls. Top: Great Chagos Bank - Middle Brother beach. A sample was collected nearby. Bottom: Peros Banhos - Ile du Coin beach. The line of the old jetty can be seen in the distance, a sample was taken on the shore there.
Photo Anne Sheppard

<u>Holothurian (sea cucumber) poaching</u>

Besides loss of an important natural resource in Chagos, concern arises over potential harmful ecological effects of poaching holothurians. Being largely detritus feeders, holothurians play an important role in the recycling system of sedimentary habitats, including sandy banks and lagoons of coral reefs; they 'condition' the substratum. Also, commercially fished holothurians have important functions in nutrient recycling, which increases the benthic productivity of coral reef ecosystems. Thus, removal of these animals through fishing may reduce the overall productivity of affected coral reefs.

Holothurians likely play a pivotal role in maintaining ecosystem integrity and resilience of coral reef systems.

Holothurians are particularly susceptible to overfishing. The evidence for heavy poaching in Chagos is substantial. Photographs of part of a haul comprising an estimated 5,000-7,000 holothurians on Eagle Island, a Strict Nature Reserve is one example. Significantly higher populations were observed (in 2006 though not in 2010) on the populated atoll of Diego Garcia, with poaching reducing numbers on the uninhabited outer atolls. Reduction in total holothurian abundance (all species) has also been observed in Salomon atoll between 2006 (2142 individuals) and 2010 (1661 individuals) from a complete census of a large transect 18.8 km x 4 m encircling Salomon atoll.

Figure 4. Sampling sites in Diego Garcia for antifouling analyses.

Summary

From a chemical contaminant perspective, the marine environment surrounding the Chagos Archipelago can be considered as pristine. It is certainly as uncontaminated, or less contaminated, than all other sites measured in e.g. the Antarctic or Sargasso Sea. In this respect too, therefore, it provides a useful global reference site. There is evidence, unsurprisingly, of poaching which could have ecological consequences (e.g. that of holothurians).

Holothurian on sand. Of the species commonly taken by the poachers
Photo Anne Sheppard

The Endemic Chagos Clownfish

Anne Sheppard
University of Warwick

You might think that the Chagos Archipelago, like the similarly isolated Galapagos Islands and the Hawai'ian Archipelago amongst others, would have an abundance of endemic species. However it is in fact quite the opposite case – Chagos appears to have very few endemic species. This is possibly due to Chagos' position, sitting between the South-East Asian Eastern Indian Ocean and the East African Western Indian Ocean and on a thoroughfare between the two. This position stops the isolation necessary for endemism to occur.

Of the very few Chagos endemics, the Chagos Clownfish *Amphiprion chagosensis* is uncommon in Chagos - especially when you have a camera with you! But Professor Charles Sheppard, while looking through some photographs he had taken a few years ago, wondered if these might be of the elusive fish.

The photographs were sent to fish biologists Dr Chas Anderson and Dr Nick Graham for identification, who confirmed that they were indeed *A. chagosensis.*

Photos Charles Sheppard

Small Life, Hidden Life: Reef Cryptofauna of the Chagos Archipelago

Catherine Head
University of Oxford

Coral reefs are thought to be the most species rich marine ecosystem, and the majority of this biodiversity lies within the so-called reef cryptofauna, the communities of animals that live hidden within the coral framework, e.g. crabs, brittle stars, and shrimp. The cryptofauna are a functionally important suite of animals but are understudied. This project assesses the diversity of select groups of the reef cryptofauna in the Indo-Pacific to better understand their role in coral reef ecosystem function and resilience. Chagos forms the scientific "baseline" for the project, representing one of the most undisturbed reef ecosystems globally, against which other reefs in the region will be compared.

On this year's Chagos scientific expedition we collected cryptofauna samples from dead coral heads across the Archipelago. These samples will not only allow us to assess species richness but will also allow the investigation of evolutionary patterns of reef cryptofauna, as well as identification of whether losses in species diversity on disturbed reefs disproportionately target specific functional groups or phylogenetic clades. Here we will present some preliminary results focusing on a subset of the cryptofauna, the Caridae (shrimp and snapping shrimp). We will also look to the future outlining what we are currently working on and plan to achieve from the project.

Pulling Back the Blue Curtain in the Chagos: Using Underwater Video Technology to Explore Communities Below 15m

Dr Heather Koldewey, Dr Matthew Gollock and Dr Kirsty Kemp, ZSL
Prof Jessica Meeuwig, Dr Tom Letessier, Phil Bouchet, Lloyd Groves, Gabe Vianna, University of Western Australia

Following the establishment of the Chagos Marine Reserve, legal commercial fishing ceased within the reserve's boundaries in October 2010. This provides a large 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 be effective. Fundamental to resolving this so far largely data-free debate is the collection of baseline information on the status of key open-ocean indicator species, such as yellowfin tuna and blue sharks, with respect to their distribution and movements, relative abundance, size structure, sex and maturity. Such pelagic species are difficult to monitor given their mobility and patchy distribution.

Open ocean habitats are, by their very nature, remote, and consequently difficult and expensive to access, monitor and manage. This similarly applies to the species that exist, be it permanently or transiently, in these regions. Understanding population structure has traditionally relied heavily on either commercial catch data or fisheries independent but destructive surveys, neither of which is appropriate for a no-take marine reserve such as Chagos.

In a collaborative project between the Zoological Society of London (ZSL) and the University of Western Australia (UWA), a monitoring programme in Chagos for open-ocean species is being developed, particularly for those formerly targeted by the fishery that are vulnerable in much of the Indian Ocean. This has required some innovative approaches, based on the use of underwater video technology and tagging fish. Baited remote underwater videos (BRUVs) are a well-established method to monitor species using equipment that sits on the sea floor. Through careful selection of sites and the number of BRUVs deployed, data can be gathered on diversity, the location and relative abundance of different species, and through repeated sampling, changes in abundance. During the February/March 2012 expedition, BRUVs were deployed on the seabed at over 150 locations around the archipelago to depths of 80m giving us an insight into parts of Chagos never previously explored. The most exciting of these deployments was during the discovery of a new seamount which was named Sandes Seamount after the Captain of the Pacific Marlin and recorded for the first time using a BRUV http://www.zsl.org/conservation/news/seamount,991,NS.html .

In order to be able to monitor species in the open ocean, our project has developed a pelagic version of the BRUVS, known as the SISSTA (Stereo Imaging System for Shark and Tuna Assessment) which was trialled off Dirk Hartog Island in Western Australia in April 2012. By testing different depths, attractants and the techniques to deploy and retrieve the camera units, the first surveys were run using this new technique in Chagos by November 2012. Data are now being analysed, but novel findings included the first sighting of a false killer whale in Chagos. Next steps will be to establish systems for longer term deployment and remote monitoring.

This first open-ocean expedition in November 2012 also included research on shark satellite tagging, oceanography, acoustics and open ocean bird surveys. A blog on the CCT website provided updates http://www.chagos-trust.org/news/ and more detailed articles will feature in the next Chagos News.

Our results to date offer encouraging results in scientifically validating the no-take status of the Chagos marine reserve, particularly with regards to shark and tuna conservation, and ensure it fulfils its role as a unique scientific reference site for marine biodiversity. Such research has broader implications in assessing how the growing number of large protected areas will affect ocean productivity and biodiversity.

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Big Ocean Network and the Future of Chagos:

Dr Randall Kosaki
Papahanaumokuakea Marine National Monument

In November I spoke of the forthcoming collaborative research agenda and on February 1, 2013, the members of the Big Ocean Network will release the Big Ocean Research Agenda. This research plan represents a framework for shared research that addresses the unique scientific needs and challenges of large-scale MPAs. As a member of Big Ocean, Chagos will continue to expand engagement in collaborative research with scientists from other large MPA sites who share scientific interests, challenges, and management needs.

Big Ocean, a network of the world's largest marine managed areas, was established in December 2010 with the goal of improving the management of very large MPAs through sharing information, expertise and resources. The Big Ocean Research Agenda is an outgrowth of a Big Ocean Think Tank meeting held at the International Congress for Conservation Biology (ICCB) held in New Zealand in December 2011 (see *Chagos News* no. 39 for details). The Think Tank highlighted various unique features of conducting research in large-scale MPAs.

The primary aims of this shared research agenda are to capitalize on collaborative and comparative research opportunities that are based on the scientific needs shared by large-scale MPAs, and to identify a set of research priorities to be jointly addressed by Big Ocean sites. The Research Agenda notes that large-scale MPAs contain entire, diverse and relatively pristine ecosystems, as well as larger scale natural processes which cannot be studied in their entirety in smaller regions.

Three main categories of research activities were identified as being most relevant and shared amongst large-scale MPAs:

- **biological and ecological characterization**, including studies on the abundance and distribution of organisms, habitats and ecosystems;
- **connectivity,** including biological, physical and anthropogenic connectivity; and
- **monitoring** of temporal trends, including patterns caused by both anthropogenic sources and natural variability.

In other words, these three research themes focus on characterizing what natural resources are present at the sites, how these natural resources are connected to each other as well as to external sources, and how these natural resources change over time

Like many of the remote, archipelagic-scale MPAs of the Big Ocean Network, Chagos is one of the greatest natural laboratories on earth, and represents an ideal control site to which local anthropogenic impacts at less pristine sites can be compared. Nowhere is this comparative power more valuable than in the study of climate change and its impacts to coral reef ecosystems.

Indeed, one of the first major collaborations resulting from the Big Ocean Research Agenda will be a study of coral disease, bleaching, and resilience on a broad geographic scale, and across a large gradient of human use and impact. In coordination with other Big Ocean sites (including the Papahanaumokuakea Marine National Monument, and the Phoenix Islands Protected area), Chagos scientists will be collecting baseline data on the prevalence of these coral afflictions for a comparison to other Indo-Pacific sites impacted by local anthropogenic stressors. Using these remote, pristine MPAs as control sites will enable scientists to differentiate between the impacts of specific local stressors and global-scale drivers of bleaching and disease. Ultimately, identification of these key stressors and risk factors will allow the managers of compromised reefs to improve reef health by reducing the impacts of local human activities.

The Big Ocean Research Agenda can be downloaded from the Big Ocean web site at bigoceanmanagers.org. Additional information about each of the member sites is also available at this web site.

Chagos News CCT AGM 2012

Courtesy of the Zoological Society of London the Trust held its 2012 AGM in their Huxley theatre on Tuesday 27th November directly after the conference ***Building on Success*** reported elsewhere in this issue.

The Chairman gave highlights of his annual report, Carol Garner presented an update on CCT-US and John McManus gave the view from BIOT administration. Full minutes etc will be posted on the website.

Executive Committee Officers and Members were elected and now are:

Alan Huckle, Chairman,
Richard Martin, Treasurer,
Hayley Tam, Membership Secretary,
Simon Hughes, Secretary,
Birgitta Bostrom,
Pete Carr,
Colin Clubbe,
Chris Davies,
Rachel Jones,
Heather Koldewey,
Sam Purkis,
Pete Raines,
Anne Sheppard,
Charles Sheppard,
John Turner,
Elisabeth Whitebread.

Alan Huckle, CCT Chairman addresses the AGM. *Photo Anne Sheppard*

CCT- US Report on CCT Annual Meeting November 27, 2012

Carol Garner,
Secretary CCT US

It was with great pleasure that I was invited to represent Chagos Conservation Trust US (CCT- US) by attending the Chagos Conservation Trust (CCT) Annual General Meeting in London on November 27, 2012. Prior to the Annual Meeting I attended the conference: **The Chagos Marine Reserve: Building on Success** hosted by CCT and the Zoological Society of London. I found the conference programs to be most informative on a variety of topics that reinforces our mission and goals to support the environmental preservation of the Chagos Archipelago.

During the AGM immediately following the conference, I was allotted time on the full agenda to present the CCT- US 5-Year Business Plan and new brochure.

As the Plan explains:

Short term goals *– In the near-term, CCT – US will build a membership base and begin fund-raising to instigate projects in the Archipelago.*

Long term goals *– Funds raised by the CCT – US will be put to good use to expand and support selected initiatives. CCT – US will continue to support any project that helps to preserve the natural biodiversity found within the archipelago and scientific and conservation efforts undertaken to tell us more about these islands, remove invasive plant and animal species, and restore native vegetation. These initiatives will be an important contri bution to the conservation of global biodiversity. Through academic, public and private sector partnerships, CCT-US will support conservation based research, education and outreach programs.*

Business Goals *- CCT – US business goals are derived from our conservation and preservation mission, and are consistent with both the flexibility and constraints imposed by our 501(c)(3) not for profit/charitable status. Business goals are the essence of the more global business plan. We have identified 5 business goals for our 5 -year plan. The fiscal year (FY) 2012 plan represents only the remaining 6 months of FY 2012 (July-December). Each business goal is described by a set of activities. As appropriate, revenues accruing from or attributable to these activities provide fiscal parameters and objectives.*

Goal #1:Build CCT – US Membership

We will expand our membership base to allow us to facilitate conservation, preservation and education activities in the Chagos Archipelago and the Chagos MPA.

Goal #2: Perform Fund-Raising for Environmental Projects in Chagos

CCT – US will expand our membership base to allow us to facilitate conservation, preservation and education activities in the Chagos Archipelago and the Chagos MPA.

Goal #3: Promote Education and Awareness of Chagos Environmental Issues

CCT – US will support education and awareness in the scientific and academic communities, perform community service in environmental conservation in schools and with conservation groups, and attend and present at conferences focusing on conservation and protection of the rich biodiversity of the Chagos Archipelago and its surrounding waters.

Goal #4: Sustain Presence and Outreach

CCT – US (in cooperation with CCT) will continue to promote marine conservation and expand relationships with influential organizations such as the Big Ocean network, The New England Aquarium, The Marine Conservation Society, The Nature Conservancy, The Living Oceans Foundation, The Pew Environment Group, The Zoological Society of London, and other appropriate marine conservation nongovernmental organizations (NGOs). These important relationships need to be maintained to facilitate broad understanding of the need to preserve the environment. We will use our web site as a tool to enhance all outreach projects and record and publish scientific research and information. There will be an increasing need to attend relevant conferences to address and promote Chagos conservation. Films and publications could be produced as finances and/or opportunities permit.

Goal #5: Support Scientific Contributions to Preservation of the Chagos Environment

CCT – US will promote and contribute to the organization of practical monitoring, conservation and scientific work in Chagos. The archipelago lies at the center of the Indian Ocean and is vulnerable to exactly the same physical pressures from global environmental change as other reefs in the same ocean. Chagos is, however, unique in that it boasts 25,000 km^2 of reefs with very low human impacts. This provides a unique opportunity to examine the effects of global warming without the additional (human) effects of pollution, over fishing and other extractive processes. To date, science in the archipelago has been funded through a combination of grants awarded to UK universities by the UK government.

Alistair Gammell, UK Director Global Ocean Legacy, Pew Environment Group and Carol Garner, Secretary and Co Founder CCT-US

These visits, though sparse until now, span three decades and deliver an excellent record of the wax and wane of the reef system's coral and fish. With more funding, monitoring could become regular, more extensive and thus more valuable in ensuring the effective management of the MPA. Specific opportunities for habitat restoration and conservation have been identified on Diego Garcia and in the outer islands. Larger island restoration projects may be developed and supported by tax-deductible contributions.

This Business Plan shall be reviewed at least annually, and shall be consistent with the CCT – US annual budget.

I want to thank CCT for their invitation and support making it possible for me to attend this meeting.

Climate Change – it isn't us is it?

Everyone will be aware that there are some 'climate change deniers', those who still argue that mankind is not responsible for the raised atmospheric CO_2 which is leading to global climate change and ocean acidification—two big and potentially fatal problems for coral reefs as well as many other, if not all, Earth's ecosystems.

You may be one of them or you may be one of those who are frustrated by the lack of action by governments to do anything about it. The logical argument below was written by Professor Dennis Hubbard and to me it represents a wise and sensible stance that everyone should be able to agree on – although it is probably not a logical stance that the deniers take.

With thanks to Prof Hubbard for permitting Chagos News to reprint it.

Let's start with what we know:

1) The sun has a HUGE effect; in fact, it's largely what has driven major climate cycles.

2) CO_2 and a host of other things are "greenhouse gases", etc. and they do cause temperature increases - how much we can argue about later.

3) CO_2 levels have risen by a measurable amount; there is a significant amount of "old" carbon in this; so it's related to burning fossil fuels.

4) The rate of sea level (SL) rise was largely slowing through much of the 19th century, save those pesky "little ice ages", and later the flat spot in the 1960s (largely due to reflectivity of particulates related to increased coal consumption)

5) SL rise has accelerated by *ca* 0.009 mm/yr since 1860 and has increased (conservatively) two-fold in that time.

6) During past SL rises, sometimes CO_2 goes up first and sometimes temperature leads the way; these are inter-related inasmuch as CO_2 drives up temperature but higher temps also increase CO_2; nature is fickle that way. [but see note below for more recent information]

I'm sure I've missed a few, but that's enough to start with.

So, for now, let's set aside the issue of whether solar forcing or CO_2 is the main driver or not. If we combine the points above that we can hopefully agree on, then we go to the following:

Projections have been shown to have errors, but most upgrades have produced worse projections and not better ones. Recent performance seems to be ahead of most models. A recent synthesis of all available Holocene core data demonstrates that over half of the world's coral reefs built at rates below the PRESENT rate of SL rise - so there is already a problem that was not there a century ago and is worsening. And... those reefs didn't have to deal with **Homo stupidus.* New York just went underwater. Perhaps this is within the statistical limits of error (I just don't know that yet); higher sea levels will exacerbate these two examples and countless more.

So..... if we can agree that these are bad things for humans, the economy and all the other stuff that usually gets a priority in the discussion,

then:

The accelerating SL rise is a problem regardless of the cause (the pattern tells me that the recent blip can't be explained only by solar forcing). Anthropogenic contributions are at least a measurable PART of this pattern. These are the only ones we can do anything about unless someone comes up with a way to control solar output or we want to tinker with geo-engineering. Therefore, lowering our CO_2 emissions is in our best interest both socially and economically.

To me, this is the proverbial gorilla in the room that gets lost in the quibbling about things that we are not going to convince one another about.

To me, the data show that the anthropogenic signal is a measurable and significant part of the pattern we are seeing today. Compared to the energetics of the 125,000-year cycle, this is a pimple, but on a human timescale (which we are talking about), CO_2 is playing a disproportionate role in the short run (centuries to millennia) and some pretty well informed folks argue that the CO_2 part of the signal has overwhelmed the solar component for the time being. I'm not going there for now, but IF they are right, we are really screwed. If they aren't, then we're still back to the realities that derive from my six points above and the reality that carbon emissions are the only part we can control.

I don't have time or the space here to convince you that anthropogenic CO_2 is the dominant signal at present, but hopefully we can agree that however important resolving this might be in the long run scientifically, we are experiencing events that we don't like – and anthropogenically created CO_2 plays SOME role in that pattern whether or not the sun is still the dominant player in all of this. If we agree on my underlying point, then we need to move forward to get folks focused on this. If not, then we'll just have to face the fact that one of us has to be wrong.

So, we're down to Pascal's wager - originally designed to address the existence of God, but equally applicable here. We have a binary question:

IS anthropogenic CO_2 playing a measurable and negative role in climate regulation?

Answers: Yes – No. The validity of our answers are likewise binary, we are either right or wrong.

If you argue no and are correct, then climate may self-regulate but all the crap we put into the air will significantly deteriorate the air and water and there will be disproportionate increases in suffering and economic costs regardless of any possible climate ties. If you are wrong, we will probably reach a tipping point where no amount of money will allow us to reverse whatever comes from our denials.

This is the equivalent or Pascal's "eternal damnation" option.

In contrast, if I argue yes and am right, then we can perhaps do something to reverse this trend. Arguing from an economic perspective, the discount rate would support the idea that it's cheaper to not break it using today's dollars than it is to fix it using tomorrow's. If I am wrong, I am perfectly happy to say, "gee, it wasn't us after all, but we have cleaner air, water and a better environment. Don't I feel stupid".

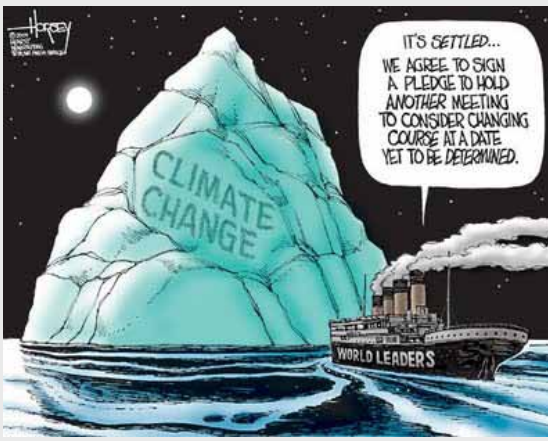
This was Pascal's "excess of morality".

So, whether I've convinced you of anything or not, I hope that you will at least agree that I am not blindly taking what the conspiracy is selling. I am a pragmatist. While I believe that we have a significant role in all of this, I am less worried about quantifying it or arguing over how it stacks up against everyone else's favorite climate driver. I feel that doing science is a privilege, so I will continue to take advantage of that luxury by looking at all the data and changing my perspectives as the data get better. However, that privilege comes with a responsibility to not "fiddle while the planet burns".

Dennis Hubbard
Dept of Geology-Oberlin College
Oberlin OH 44074

* so this is probably an optimistic characterization.

Note: Shakun JD et al. 2012. Global warming preceded by increasing carbon dioxide concentrations during the last deglaciation. *Nature* **484**: 49-55.



Shipwreck and Artwork

Howard L. Resnikoff Boston and Gloucester, USA
Nigel Wenban-Smith London and Gloucestershire, GB

Both editions of *Peak of Limuria* reproduce a painting of the East Point settlement on Diego Garcia in 1819. It shows survivors of the *Admiraal Evertsen*, a Dutch warship which sank off the atoll on 9 April 1819, strolling around the settlement as the plantation workers go about their daily tasks. In the background lies the American brig *Pickering*, which has rescued everyone aboard. Here it is:

Figure 1. Painting, by 'WLV', of the settlement at East Point showing the brig *Pickering* in the lagoon.
Who was WLV?

In *Peak of Limuria*, this painting is ascribed to Lieutenant Verhuell (*sic*). The two of us were intrigued by this picture for different reasons and only became known to each other through the intervention of Major Ted Morris, that wonderful spider at the centre of every Chagos student's web. One was investigating the *Pickering* and all who sailed in her; the other the history of the Chagos. The first knew all about Captain Ver Huell's voyage in command of the *Admiraal Evertsen* but was puzzled to find this painting on Morris's website, since it was neither in the collections of his art in Dutch museums nor known to the editors of Ver Huell's memoirs; the second was equally puzzled to find a different painting of the same scene, undoubtedly by Ver Huell, in the same edition of his memoirs. Let readers spot the difference!

Figure 2. Painting of the settlement at East Point by Q.M.R. Ver Huell. 39.6 cm × 56.5 cm. National Maritime Museum, Rotterdam.

The context of the *Evertsen*'s voyage was the end of the Napoleonic wars. An 80-gun ship of the line, she had been sent from Holland in 1815 as the head of a small squadron of men-of-war to restore Dutch sovereignty in the Dutch East Indies after the British, who had captured the Dutch colonies after the Netherlands was conquered by Napoleon, returned them. Now, in 1819, having succeeded in her mission, she was returning to Holland with a precious cargo: Commissioner-General Cornelis Elout and Rear-Admiral Arnold Buyskes, respectively the highest ranking civilian and military official in the colonies, and the civilian Hendrik Doeff, the former president of the Dutch East India Company concession in Japan, who had perforce remained in Japan for 17 years because of the raging world-wide war. Only now, with the war over, was Doeff able to return home with his pregnant wife, but he had made his enforced stay productive by writing the first dictionary between Japanese and a European language. These distinguished passengers and Captain Ver Huell had collected a treasure trove of anthropological artefacts from the Indies and Japan that would be lost.

Ver Huell was not the only member of the crew of the *Admiraal Evertsen* to write about his experiences. Doeff wrote a fascinating account of his time in Japan and the disastrous voyage. Also, at least two of the ship's Lieutenants – H. P. N. 't Hooft and W. L. Veerman – kept journals recording the ship's last voyage.

Finally, the ship's own log has survived, together with a series of official reports on the disaster. Here, we need concern ourselves only with the circumstances of the ship's sinking, her crew's rescue and the artistic records born of those events. Books in preparation, on the exploits of the *Pickering* and on the history of the Chagos Archipelago, will reveal much more about American merchant brig's activities in the Indian Ocean during the nineteenth century and about life on Diego Garcia, including observations made by the Dutch during their six-week sojourn.

Admiraal Evertsen had been in difficulties since passing through the Sunda Strait. She lost the top part of her mainmast and was leaking seriously. Continuous pumping had managed to get her into the most isolated part of the Indian Ocean where, finally, Admiral Buyskes made the decision to divert to the nearest land – the island of Diego Garcia. The dispirited and exhausted crew succeeded in bringing her to the atoll but the heavily laden ship, its hold filled with water, seemed unlikely to be able to make it across the coral reef at the lagoon's entrance. It was then that the *Evertsen* saw an American brig – the *Pickering* – in the lagoon and fired a gun to attract her intention. *Pickering* was on a three year sealing voyage from Boston under Captain Samuel B. Edes, an experienced China trader. She had dropped a sealing gang on Prince Edward Island in the Southern Ocean and was plying the transport trade while waiting for them to collect skins and oil. It was purely by chance that *Pickering* was in the lagoon to fill her water casks and load a cargo of coconuts.

Captain Edes boarded *Evertsen*, was appalled by her condition, and advised Rear Admiral Buyskes that she could not make it across the coral reef into the lagoon. She could not go but neither could she stay. While the implied irrevocable decision was debated, the *Evertsen* drifted farther away from the island. Over Captain Ver Huell's objections, Buyskes and the other officers concurred with Edes' counsel and the order to abandon ship was issued. *Pickering*'s cargo was dumped overboard and the more than 300 crew and passengers piled into *Pickering.* They were too many for *Pickering* to take to the nearest port – Mauritius; they would be brought to Diego Garcia where half would have to remain while the other half would be transported to Mauritius.

Obviously, no-one was making sketches of the last hours of the *Admiraal Evertsen,* most of them shrouded in darkness. However, both Captain Ver Huell and Lieutenant 't Hooft recreated the scene in imaginative paintings made later (fig.3 and fig.4 respectively). But we should remember that none of the great sea paintings ever was painted *en plein aire* – in the heat of the action.

Figure 3. Q.M.R. Ver Huell, *Leaving His Majesty's Ship Admiraal Evertsen off Diego Garcia.* 40.3 cm × 53.5 cm. National Maritime Museum, Rotterdam.

Ver Huell emphasized the orderly departure from the stricken ship, an aspect for which he could claim some credit. 't Hooft's picture, on the other hand, is less formulaic. It gives priority to sea and wind conditions and the drama of the whole situation. In particular, he shows the sails of the Dutch ship being blown in every direction and brings out the power of the rollers

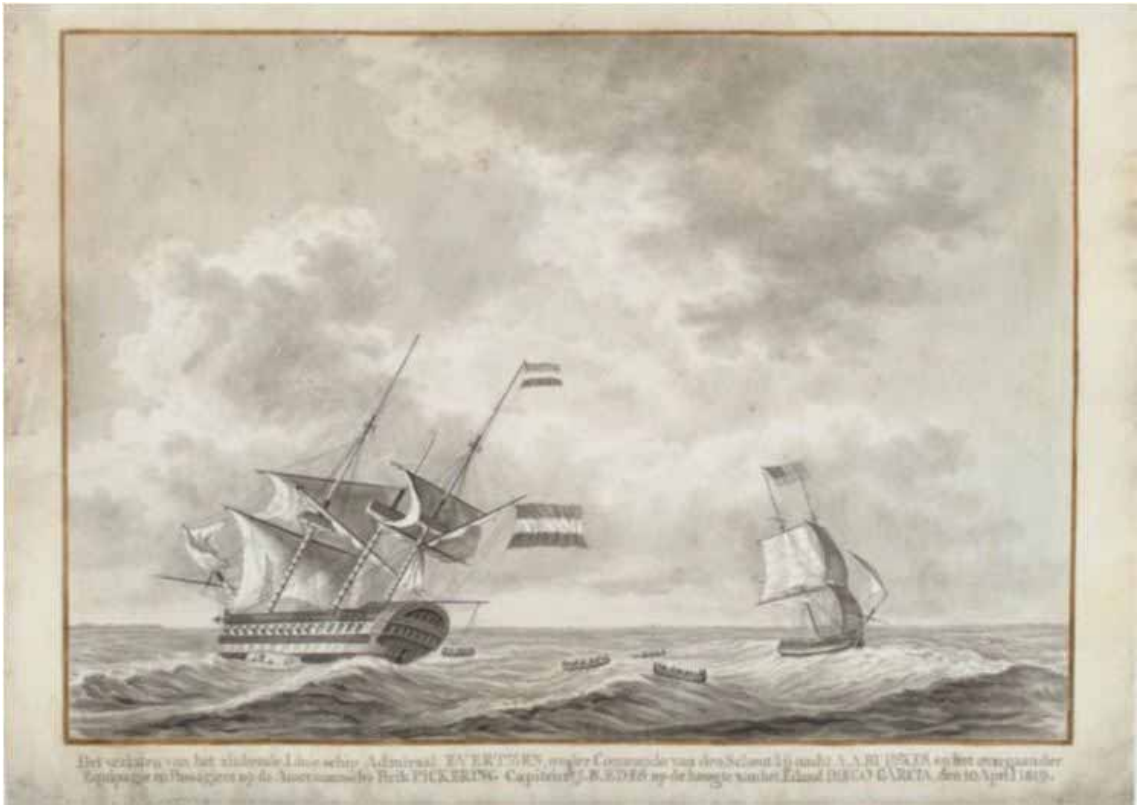


Figure 4. H.P.N. 't Hooft, *The Rescue of the Crew of the Ship of the Line Admiraal Evertsen*. 37.2 cm × 50.2 cm. National Maritime Museum, Rotterdam.

The styles of ‘t Hooft and Ver Huell were very different but both are very much more refined than what one sees in figure 1. The clumsy handling of the Dutch flag and the unsophisticated rendering of the clouds differentiates fig.1 from both marine paintings. The differences between figure 1 and Ver Huell’s painting of the scene from essentially the same vantage point are legion. It seems clear that neither Ver Huell nor ‘t Hooft painted figure 1.

Who, then, might have been responsible?

Figure 5. Extract from figure 1 showing initials ‘WLV’.

Some circumstantial evidence is provided by the log kept by one of the Dutch officers left on the island with Ver Huell, where an entry for 13 May 1819 reads “made sketch of the island”. More interestingly, close examination of the first painting shows that there are initials at the bottom right hand corner, which appear to be ‘WLV’; cp. fig.5. ‘W. L. Veerman’ was a second lieutenant on the *Evertsen*’s roster and had responsibility for the ship’s log. And Veerman had been left on the island with Ver Huell to be transported to Mauritius with the second group of survivors. Problem solved! This Veerman was surely Willem Leonardus Veerman, who was born in 1793 and died on 9 July 1824 while captain of the Dutch frigate *Algiers* at Smyrna (Izmir), Turkey after a 4 week illness. He was a recipient of the ‘Ridder der Militaire Willems Orde’, the highest Dutch military honor, for his bravery in helping put down a mutiny in the Moluccas in 1817 during his service on *Evertsen*.

Our evidence is all circumstantial but there are many elements and all the pieces dovetail. We have no doubt that a more detailed search of the roster of the *Admiraal Evertsen* will reveal only one officer with the initials ‘WLV’; only one 2nd Lieutenant W. L. Veerman; only one Willem Leonardus Veerman.

There remains the question of when and where figures 1 and 2 (and indeed, figures 3 and 4) were painted.

Based on the information available to us, it is impossible to say. Nevertheless, the log note “made sketch of the island” strongly suggests to us that the survivors had sketchbooks and drawing materials. Although Rear Admiral Buyskes had forbidden the crew to take more than the merest essentials when they abandoned *Evertsen* we know that Ver Huell arranged for a servant to save his ‘sketchbooks’. Sketchbooks can be small or large; intended for simple drawings or high quality watercolors. Ver Huell could well have saved his watercolors and brushes. And he might well have shared them with ‘t Hooft in the days before *Pickering* first went to Mauritius, and with his compatriot Veerman during the tiresome weeks while they awaited her return to Diego Garcia. Moreover, for naval officers in Age of Sail, the ‘merest essentials’ certainly included materials for keeping up the logbook, which was the legal record of the vessel and her voyage, and an essential element in providing information for future sailors. This was the responsibility of ‘t Hooft and of Veerman separately, so one might believe that both of them had made independent efforts to save drawing materials and paper.

Indeed, ‘t Hooft kept a journal on the voyage from Diego Garcia to Mauritius that incorporates a 3-page fold-out drawing with light green and brown watercolor washes of the approach to Mauritius. We suppose someone could argue that Captain Edes supplied the materials on *Pickering*; given the weight of evidence, we find that unlikely.

Figure 6. BIOT Postage stamp commemorating the rescue by the brig *Pickering*

In 1991 the British government issued a postage stamp commemorating *Pickering*’s rescue of the crew and passengers of the *Admiraal Evertsen* (fig.6). The designer of the stamp copied a portion of Veerman’s painting.

As with most attempts to uncover historical truth, each revelation leads to new questions. Why is the large Dutch flag displayed as the ensign – the position reserved for the national flag – on *Pickering*? Was this Veerman’s conceit? Or had some arrangement been made that temporarily transferred *Pickering*’s nationality to the Netherlands?

Finally, did Veerman paint other views of Diego Garcia that have been obscured by the mists of time?

National Geographic have produced a short film which explains the benefits of marine protected areas. It is simple and would be useful to explain the concept to young children (who often grasp the idea more quickly than adults).

The video can be viewed at

http://education.nationalgeographic.com/education/multimedia/what-marine-reserve/?ar_a=1&ar_r=999

Chagos Scientific Research Expedition to Northern Atolls
Outline

21th February – 12th March 2013

PRIFYSGOL BANGOR UNIVERSITY

ZSL LIVING CONSERVATION

THE UNIVERSITY OF WARWICK

DARWIN INITIATIVE

Overview

Between 21th February – 12th March 2013 a scientific research expedition will take place in the Chagos Archipelago (British Indian Ocean Territory). Most of the cash funding comes via DEFRA's Darwin Initiative, but the expedition is supported and facilitated also by the BIOT Administration and numerous other institutions including Chagos Conservation Trust and institutions of all participants. Fourteen scientists and supporting team members will participate. Our research plans prioritise the continuation of long-term monitoring programmes for the large BIOT marine reserve, and continue to establish the best and most resource-efficient methods to monitor and manage the area. The work includes both shallow reef and island work and is designed to assist the BIOT administration in understanding and managing the world's largest fully no-take MPA, maintaining this extraordinarily rich area of marine and terrestrial biodiversity.

Research Objectives

These are in no particular order, with access determined sometimes by weather conditions, slippage in programmes (or the reverse), and taking opportunities when something unexpected occurs (e.g. investigation of the unexpected outbreak of the coral predator 'Crown-of-Thorns' off Eagle Island in 2012). We have always previously succeeded in achieving most goals and more, thanks also to the enthusiastic support from the cfficers and Crew of the *Pacific Marlin*.

1. **Long-term monitoring of reef condition in the Indian Ocean (Charles Sheppard, John Turner, Anne Sheppard, Ronan Roche, Morgan Pratchett)**

There are two long-term reef monitoring programmes that involve measurement of reef changes over time. One has involved coral cover measurements since 1978, including coral recovery assessments following the climate change driven mortality of 15 years ago. The value of this routine, ongoing project has been to show that coral recovery patterns in Chagos are unmatched by most other places in the world, and that the value of this area is extremely important in the context of the ocean. Furthermore few places have coral cover data over such a long period and over such a significant time for coral reefs, which is scientifically of considerable importance.

We will conduct repeat measurements at the same locations across Chagos to contribute to the longest time series of reef condition data in the Indian Ocean – this being valuable because a 'trajectory' yields far more information than does a one-off set of measurements. Archival video will be recorded at permanent monitoring sites for future comparison, and for comparison with video records first made 7 years ago, at a time when the reefs were just beginning to recover from major bleaching events.

Now that recovery is complete - following the 1998 bleaching event, but perhaps only until another warming episode – we will expand monitoring to measure juvenile coral recruitment, which is the basis of the next generation of reef and island building corals.

In addition, growth and growth rates of selected and dominant forms of corals will be measured. This is an indication of coral 'health' in broadest terms, and good growth (which is apparent though unquantified) underpins the growth of reefs and islands as a whole.

2. **Technology development for monitoring fish and shark assemblages across the Chagos shelf (Gary Fletcher)**

Deployment of video systems during both pelagic and coastal expeditions in Chagos during 2012 in order to study the fish and shark assemblages of the coral reefs yielded extremely positive results. However, these deployments were limited only to 2-3 hours and as such only provided a snapshot of the species and associated habitats of interest. As such, solutions to allow longer term-monitoring will be developed as part of the present expeditions. This will improve the techniques, and the efficiency of their data collection, that are presently being utilised and also allow satellite up-link of these units to allow real-time analysis of data. Once these sentient units are complete, it will offer a low-cost monitoring system that, when deployed as a network, will greatly expand the area that can be observed. While the primary focus for these units is the monitoring of large, especially pelagic fish, which have previously remained a significant gap in our understanding of the BIOT region, they can easily be deployed to monitor shallower ecosystems.

3. **Coral reef biodiversity (Catherine Head, Morgan Pratchett, Michelle Gaither, Daniel Wagner)**

Our understanding of biodiversity of smaller species groups is extremely poor in comparison with that of some groups such as reef-forming corals, fish and some bottom-dwelling invertebrate mega-fauna, despite making up the largest component of coral reef diversity. This project develops the work which was started in 2012 and focuses on assessment of the diversity of select groups of reef crypto-fauna and examines the relationship between these and reef-forming corals, fish and conspicuous mega-fauna on the relatively pristine reefs. To assess the number of small bottom-dwelling invertebrate species and their abundance at sites within the Chagos Archipelago dead coral heads and coral rubble will be collected on exposed and sheltered sides of the reef slope. Samples will be analysed using a combination of morphological and molecular methods, including novel DNA barcoding methods. These will be compared with the diversity of corals, fish and conspicuous megafauna, established using conventional survey methods.

The broader scope of this project involves biodiversity assessments over varying scales of human impacted reefs at locations across the Indian and Pacific Oceans enabling a trans Indian–Pacific Ocean biodiversity and connectivity comparison to be made with the Chagos Archipelago.

In addition, standard blocks of settlement plates will be deployed for collection a year later, to help understand new recruitment of biota to the reefs.

4. **Long-term monitoring of bird populations (Pete Carr, Yannick Mandarin)**

We will continue the long-term monitoring and research of the important breeding seabird colonies on the ten designated and two proposed Important Bird Areas (IBAs). The focus of the monitoring and research is to unravel the breeding phenology of the seabirds of BIOT in order to determine whether the present specific island designation for IBAs (as opposed to island clusters) is the best long-term conservation management strategy for breeding seabirds in BIOT (collaborative project with RSPB), and, what triggers breeding of seabirds in BIOT?

5. **Monitoring physical parameters on Chagos reefs (Charles Sheppard, Anne Sheppard)**

We will continue the collection and replacement of currently deployed temperature loggers which have recorded a set of two-hourly sea temperature measurements taken at many depths and locations, some since early 2006. Analysis of these data is helping to determine what physical factors assist in maintaining the good condition of Chagos reefs.

6. **Video transects of reefs (John Turner, Ronan Roche)**

Many sites have been used for recording for many years. Several were filmed along transect lines in 2006. These form permanent records for later lines of work. These transects will be recorded again.

7. **Structural complexity of coral reef communities (John Turner and Ronan Roche)**

Recovered reefs have increased in their structural complexity, and this will be measured by assessing rugosity (the roughness) of the coral canopy, and identifying the types of coral that most contribute to creating that structure at habitat scale.

8. **Filming of BIOT marine reserve (Jon Schleyer)**

High definition video will be taken of the underwater, terrestrial and aerial wildlife and environment of the BIOT marine reserve, as well as the scientific efforts and research being undertaken by the expedition. The focus will be on natural history, to document for future use and reference, and for outreach as decided by the BIOT Government.

9. **Sample collection (Anne Sheppard)**

Important, value-for-money aspects of previous expeditions have been the collection of material for other research programmes in other parts of the world, including for laboratories and collaborating scientists in UK, USA, Germany and Taiwan. This will be continued.

10. **Sea cucumber recovery (Anne Sheppard)**

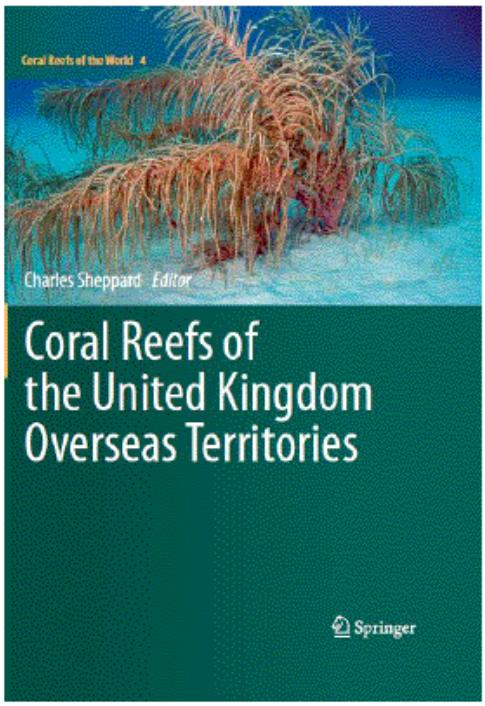
Heavy poaching in earlier years greatly reduced the population of these animals, one of whose functions on the reef is essentially to clean sand. In 2012 signs were evident of recovery with large numbers of juveniles spotted on a couple of locations. These will be measured systematically this time in order to determine the rate and extent of recovery of this key group of organisms.

11. Reef fish connectivity work (Michelle Gaither)

The position of the Chagos Archipelago in the geographic centre of the Indian Ocean indicates that its reefs may act as a stepping stone between the habitat-rich regions to the east and west: a role that would have important biodiversity consequences throughout the region. New collections during the proposed expedition, coupled with the samples previously collected from elsewhere in the Indian Ocean, can shed light on the level and direction of migration within the region and allow us to address several questions of evolutionary and conservation importance, including 1) Is there cryptic diversity in the Chagos archipelago? 2) How important is Chagos as a stepping stone between the western and eastern Indian Ocean? 3) Are populations of reef fish in the BIOT more affliated with locations to the west, as suspected from oceanographic current patterns, or to the north, as predicted from geographic proximity? This work began in 2009, will continue in 2013 and subsequently.

Participants

Dr John Turner, Bangor University, School of Ocean Sciences,
Principal grant holder of Darwin Award.
Professor Charles Sheppard, University of Warwick,
BIOT Commissioner's Environment Advisor and Expedition Leader.
Dr Jon Bailey, Expedition doctor, medical logistics.
Peter Carr, University of Warwick
Jason Davis, Maintenance and Supply Manager BOS contract
Gary Fletcher, Zoological Society of London
Dr Michelle Gaither, California Academy of Sciences
Catherine Head, University of Oxford
Yannick Mandarin, Assistant to Peter Carr
Professor Morgan Pratchett, James Cook University
Dr Ronan Roche, Bangor University, School of Ocean Sciences
Jon Schleyer, Filming, outreach, Expedition logistics
Anne Sheppard, University of Warwick
Dr Daniel Wagner, NOAA, Hawaii



Coral Reefs of the United Kingdom Overseas Territories

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Charles Sheppard - *Editor*
School of Life Sciences, University of Warwick, Coventry, United Kingdom

Key words:

- Coral reef ecology
- Marine Biodiversity
- Marine protected areas
- Reef conservation
- UK Overseas Territories

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