

## CHAGO ISLANDS RESETTLEMENT

A review  
by Jonathan Jenness, MA (Harvard)  
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of the

Feasibility Study for the Resettlement of the Chagos Archipelago, Phase 2B,  
Royal Haskoning for the British Indian Ocean Territory. June, 2002.

Peter Banks  
JJ Comment - ?  
on JJJ's  
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## 1. Preface

The Chagos Archipelago, or British Indian Ocean Territory (BIOT), is unique among present-day nations or territories. Its population, to the last soul, was expelled by their Sovereign, the UK, and remains to this day in exile.

The removal was meant to secure a USA military base on Diego Garcia, southernmost and largest of the Archipelago's six constituent atolls. (1)

In justifying expulsion, the Sovereign created a fiction, declaring the citizens, known as Ilois or Chagossians, to be merely contract workers and their families, repatriating to their countries of origin- Mauritius and the Seychelles. In fact, the Sovereign knew a population of Ilois had lived in the Chagos continuously since the 1700s, arriving initially as slaves, and becoming liberated estate workers in the mid-19<sup>th</sup> Century.

In November 2000, the UK High Court declared that the Ilois had been wrongfully removed thereby implying a right to return to the Chagos. This has now been limited by BIOT Order to exclude Diego Garcia, which is the largest atoll of the Archipelago.

The Ilois now number around 4,500. Many of them wish to return to live in the Archipelago. They point out that: (i) their main home was Diego Garcia, which is larger than the land mass of the "Outer Islands", and (ii) less than one half of Diego Garcia is occupied by a military base, the remainder being officially designated as "nature conservancy".

The UK Foreign and Commonwealth Office, BIOT Administration, is undertaking feasibility study of the potential for Ilois to reoccupy two outer atolls of the archipelago, named Peros Banhos and the Salomons.

The first feasibility study was Resettlement of the Salomons and Peros Banos Atoll: A Preliminary Feasibility Study, June 2000. The second is titled as above. Additional studies have been recommended by the studies' consultants and are expected.

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1) UK Admiralty Charts and Publications. Indian Ocean, British Indian Ocean Territory, Chagos Archipelago (scale 1:360,000), No. 3.

## **2. General Observations on this Review**

The Phase 2B study, either alone or in conjunction with the Phase I study, is inadequate as a feasibility study for resettlement of the Chagos.

Both studies have been done without participation of the Ilois; yet, resettlement planning must be demand driven to be meaningful and beneficial.

Resettlement has costs. The Phase 1 study included preliminary work on costs. The present (Phase 2) study includes no work on costs.

Feasibility study should follow a logical and scheduled framework of stages and tasks. The framework for the Phase 1 and Phase 2 studies is disjointed and no schedule is evident in the process.

Both studies address primarily the natural resources of the outer atolls, presumably because these are viewed by the client as the principal constraints on resettlement. The natural resources are not the principal constraints. The unbalanced emphasis on natural resources is therefore inappropriate.

To a limited extent, the present and previous studies have examined means for the Ilois to make a living. In the absence of consultation with the Ilois and potential private sector investors, the studies are unnecessarily weak.

Livelihood studies in Phase 2 are unbalanced by comparison with the studies in Phase 1, which included consideration of tourism. Phase 2 does not expand on the tourism potential identified in the preliminary study.

Both studies consider the environmental implications of resettlement. The observations are overly generic because the specifics have not been identified. Both studies underplay the fact that good planning and managing can limit and mitigate negative consequences of resettlement to the environment, and can actually be a means to improve it.

The Phase 2 study dwells on the potential of natural disaster to preclude repatriation of the Ilois. It uses one line of argument for cyclones, earthquakes, and tsunami: (i) identify a potential risk, (ii) find one example of that risk actually occurring in the Chagos (in the case of cyclone, earthquake and tsunami only one notable example of each exists in the historical record referred to in these studies); (iii) declare one example in the past implies more can be expected; (iv) use evidence from other parts of the world to demonstrate that such a category of risk can be destructive; (v) declare the Ilois will be subject to unacceptable hazard if resettled. This approach is responsible for a conclusion which lacks balance and objectivity.

The Phase 2 study concludes that the consequences of global warming (especially flooding) make resettlement of the Chagos a short-term and risky enterprise. The historical record and internal observations of this study do not support this exaggerated conclusion. Although appropriate levels of concern, assessment and planning are now a sensible part of life in many low-lying places, comparable atolls are not being abandoned for such cause. For example, in the Maldives, development driven by tourism is continuing.

The present study concludes that seismic events and consequent tsunami are a significant risk to resettlement. The Chagos historical record and worldwide experience on comparable atoll systems do not support this conclusion. The historical record for the Chagos reveals one single local earthquake and tsunami that did minor damage. Of the tens, if not hundreds of earthquakes and tsunami, which have affected the Indian Ocean since Chagos occupation, none appear to have impacted strongly enough to remain in the historical record, written or oral, as causing damage.

The Phase 2 study is silent on numerous issues of fundamental importance to beneficial resettlement, specifically: (i) Ilois numbers requesting repatriation and their demography; (ii) Ilois social and political organization, their capacity, interests and training needs; (iii) appropriate forms for local government and land tenure; (iv) a robust communications system; (v) an appropriate mix of energy sources; (vi) a realistic transport system that includes air transport; (vii) Diego Garcia as a market for produce and labour, and as a transport and communications hub; (viii) the development potential of the lesser islands of Peros Banhos and the Salomons, as well as other minor atolls; (ix) rainwater harvesting as opposed to exploitation of groundwater.

In general, the unbalanced approach of the Phase 1 and 2 studies means that the excellent prospects for repatriation of the Ilois are being underrated; Ilois rights and welfare are being side-stepped; and UK resources are being applied inefficiently.

### **3.1 General Recommendations of this Review**

The UK Government should consider transferring management of the remaining aspects of the feasibility study to the Ilois , and be advised internally on this issue by DFID, who have development and resettlement experience.

Further feasibility study should be transparent in its design and implementation. Oversight should include a reference group, under Ilois control, that includes participation by BIOT, DIFD, the Mauritius and Seychelles governments.

Further feasibility work should assume that repatriation and beneficial resettlement are sensible and desirable.

Further feasibility study should be comprehensive and to international standard, covering: (i) organization and training for Ilois, (ii) the resettlement itself, including economy and local government, and (iii) an environmental impact assessment. Costs and programme should be defined at appropriate scale.

The correct paradigm for dealing with Chagos vulnerability to climate change is objective hazard assessment, followed by appropriate planning and management involving the Ilois. Ilois need to be aware of the issues; and as well, participate in and determine the choices and responses.

The Phase 2B studies have generated data, information, and opinion that should be shared with the Ilois. The FCO/BIOT Administration should arrange for a one week seminar in Mauritius, where the consultants discuss their findings with the Ilois

Further feasibility should include more systematic effort to learn from relevant policy, practice and extension in the Indo-Pacific in general, and from the Maldives and Seychelles in particular.

Feasibility study should be accompanied and informed by a pioneer resettlement to commence on the ground, in the Chagos, by the end of 2003.

DFID and the Chagossians should (i) canvas and secure donor support for the resettlement, plus (ii) define the rules of play and actively seek private sector partners for enterprise, especially in fisheries and tourism.

Finally, and most important, the repatriation of the Ilois to the Chagos should transform from an adversarial to a developmental process, in which the relevant UK civil service and the Chagossians become partners.

### **3.2. Ilois Preparations for Repatriation**

Over a period of years, Ilois have consulted their community in Mauritius, Agalaga and Seychelles. During 2000/01 they undertook a census. The community numbers 4,466. About 1,000 are survivors born in the Chagos, many of whom are of advancing years. Most were born to a Chagos born parent in Mauritius or Seychelles. About 600 Chagossians live in Seychelles and Agalega; the majority live in Mauritius. An overwhelming proportion maintains a wish to escape the poverty and social inferiority in their host country and forge a new life in their homeland. In preparation for repatriation, the Ilois have taken a number of further preparatory steps:-

- [i] In October 1999, the Ilois' London solicitors presented a report to BIOT, following a request from BIOT to know how many Ilois wished to repatriate and what was their level of interest (a copy appears at Appendix A). The paper's conclusions were that a large proportion of Ilois wished to return, and several large commercial entities were very keen to invest in a restored Chagos economy. The principal requirement was the provision of international air access.
- ii) When the preliminary stage of the Feasibility Study was established, the Ilois nominated consultants for inclusion in the team. They were not approved by BIOT.
- iii) During 2000, a pilot study by an agronomist specialising in coconut production (Vinay Chand & Associates) was presented to BIOT and appears at Appendix B.
- iv) A training programme undertaken by the Ilois Support Trust (a UK registered charity no: 1087561 of Kings Hill, West Malling, Kent ME19 4TA) is presently providing advice and assistance for capacity-building of the Ilois community, with a view to the importance of training and education for the challenges which face this community. A brief summary appears at Appendix C.

#### **4. Detailed Comments on Feasibility Study Phase 2B**

##### **4.1. Volume 1: Executive Summary**

###### **4.1.1. Introduction**

The introduction speaks of the study having been done in response to a request from Ilois to return to live in the Chagos. Nothing is said to justify the unprofessional exclusion of Ilois from design, administration, and implementation of the study.

The third paragraph of the Introduction (page 2) submits a history of the Ilois which is erroneous in key respects.

“The Ilois inhabited the islands of the Archipelago from the early nineteenth century up until 1973, having been brought to the islands to provide labour for the copra plantations, which were the principal economy of the islands throughout this time. In the early 1970s, the economic foundation of the islands collapsed with the falling price of copra and the plantations no longer remained viable. At this time the British and US Governments entered into an agreement to reserve the use of the islands for defense purposes, which led to the subsequent establishment of a military base on Diego Garcia. This resulted in the depopulation of the territory and the relocation of the Ilois in Mauritius and Seychelles.”

It is clear from High Court documentation, that the British/American agreement to depopulate the Chagos for security reasons dates to the 1960s, when the military establishment on Diego was commenced and the Ilois removed from that atoll. It is a matter of record that Chagos was closed down after compulsory powers were taken by BIOT, and that Mouline &Co (Seychelles) Ltd. wished to continue exploiting the entire archipelago after 1973. The decline in copra price is historic fact but the report makes no reference to island economies such as Kiribati which have a viable coconut industry on a smallholding basis. Other economic opportunities might also have been exploited. The success of the Seychelles and Maldives in responding to tourism demand is relevant.

It is worth noting that no other military establishment of either UK or US involves the depopulation of such a large area. A comparable case is Bikini Atoll in the Marshall Island, once used for atom bomb testing. The continuation of the exclusion policy in the Chagos Archipelago results in continuous, gratuitous hurt to the Ilois.

The sixth paragraph of the Introduction speaks of the first phase of the feasibility study as recommending further studies “... to investigate these resources more fully and to engage the Ilois in this process.”

The report is silent as to why the Ilois were not engaged in the process as recommended by the consultants.

After the Phase 1 study the BIOT administration under took Phase 2A of the feasibility, which was installing equipment to monitor climate, tides and groundwater on Peros and Salomon atolls.

Phase 1 of the feasibility involved a four day visit to the outer atoll groups of Peros Banos and Salomon. Phase 2B involved a four or five week visit focused on the largest single island in each atoll, namely Ile du Coin and Ile Boddam and "... assessed the future vulnerability of a resettled population to possible climate change, and ... outlined infrastructure needs and the environmental implications that would accompany resettlement."

The penultimate paragraph of the Introduction states:

"This report has not been tasked (my underline for emphasis) with investigating the financial costs and benefits of resettlement, nor has it engaged the Ilois in discussion on their ambitions and proposed livelihood strategies. It remains, therefore, a somewhat theoretical study. These are essential elements of the resettlement debate, and should become a priority for any further stages of the study."

Neither Client nor Consultant should be allowed to hide behind 'further stages' as an excuse for not doing what should have been done to meet international standards in a feasibility study of resettlement. The Ilois should challenge such poorly planned work.

#### 4.1.2. Groundwater Resource Assessment

Both Phase 1 and 2 studies involved a high proportion of overall study effort in technically sound and increasingly detail study of groundwater resources on Boddam and Coin, including estimates of quantity, recharge, sustainable yield; assays of quality; and recommendations for management and land use to maintain quantity and quality of groundwater. While welcome and useful, the study is unbalanced from a resource use viewpoint. Worldwide, on comparable atolls, it's probable that the greater proportion, and certain that a large proportion, of freshwater comes from captured rainfall rather than from stored groundwater. Given ample rainfall, on the order of 3,000 mm/yr, with fair distribution, and the fact that the Ilois did in past use captured rainwater, it is extraordinary that means for direct capture of rainwater are not described and direct capture was not factored into the calculations of freshwater availability for the people and their enterprises.

Using conservative assumptions, the 2B study concludes that sustainable, uninterrupted, good quality groundwater is available on Ile du Coin and Ile Boddam for 3,000 and 1,500 persons respectively at 100litres/person/day. The exclusion of (i) groundwater potential of other islands in the Peros Banhos and Salomon atolls, and (ii) rainfall harvesting minimizes the notional figures for a sustainable population.

#### 4.1.3. Soil and Land Resources

A semi-detailed soil survey during Phase 2B revealed surprisingly fertile soils attributed to organic matter accumulation during a generation (~30 years) of fallow. The study emphasizes the importance of husbanding this windfall of organic matter for sustainable agriculture. It speaks of the fertility as ‘ephemeral’, which has been taken by some to mean fleeting, which is certainly not the case under good management.

The study notes the wealth of knowledge about ‘atoll agriculture’ and the value of its extension to the Ilois; and foresees the coconut as an important component of the future agriculture, but not as the basis of a viable export enterprise. The study does not identify any alternative export crops and doesn’t examine Diego Garcia as a potential market.

“There appear to be few agronomic obstacles in Peros Banos and Salomon to food crop production for local consumption using traditional atoll-adapted crops and technologies; however the islands and their remoteness are unlikely to support the development of commercial export crops.” (Vol. I page 11).

The absence of reference to economic small holding based exploitation of the existing coconut forest is a disappointing omission.

#### 4.1.4. Fisheries Resources Assessment

The fishery studies in Phase 2B, as was the case in Phase 1, are outstandingly excellent, and the observations promising.

“...it is suggested that exploitation of the finfish fisheries resource could be at least doubled yet remain within safe biological limits. Based upon experience in other parts of the Indian Ocean region, a fisheries development strategy for adoption by a resettled population has been suggested, which provides a realistic yet conservative scenario for providing both subsistence and income.” (Vol. I page 12)

The Phase 2B study examines subsistence fishing, outer reef and banks commercial fin-fish fishing, inshore invertebrate harvesting (sea cucumbers and giant clam harvesting are promising, albeit giant clam harvesting only if an airlink is available), and mariculture of seaweed and pearl oyster (both worthy of follow-up).

The study identifies need for outside management, capital and training for Ilois to benefit from the wide range of fishery opportunities.

The Phase 2 study acknowledges limitations:

“..., the two main elements missing from both this phase and Phase 1 are (i) an economic justification of the proposed activities and (ii) consultation with the Ilois.”

The fisheries study includes a sensible set of follow-ups.

#### 4.1.5. Natural Environment

Despite ~200 years of occupation and ~100 years of copra estate exploitation, but enjoying a break of ~30 years of strict controls on entry for fishing or island visits, and without a resident human population, excepting on Diego Garcia, the Chagos is an Eden with (i) a diverse and productive marine environment, (ii) an improving terrestrial environment, and (iii) a substantial significance for conservation of the World's biologic resources.

Chagos is also the Ilois' home. Enabling them to be keepers of the land is a laudable goal and should have had prominence in the feasibility studies. However, the studies to date suggest a commonality of interest between those who would deny the Ilois repatriation for military/security reasons, and those who would prefer to see the archipelago as a bio-reserve and research area. This commonality of interest is apparent in the study's evaluation of natural hazards- cyclones, flooding, and tsunami in particular.

In the 2B studies, the natural environment is covered from various angles, with foci on marine habitats and processes, coral reefs, and the expected consequences of global warming. Some of the sub-studies have more relevance to science, or to bio-preservation, than to settlement. However, in totality, the studies serve to remind readers that integrated environmental planning and management are economically prudent as well as biologically sensible.

The key natural environment section in Vol. 1 is 1.6- Coastal and Oceanic Processes.

"Investigations of these coastal processes, particularly around the Ile du Coin and Ile Boddam, were undertaken to inform an appraisal of the current and future vulnerability of a resettled population and its infrastructure to climatic conditions. The investigations will also serve to guide the most suitable and reduced-risk siting of any infrastructure on the islands, and determine the need for coastal defense. The investigations were divided into four main topics: 1) meteorological and oceanic information from the Indian Ocean region; 2) the physical development of the coastline; 3) overtopping events; and 4) current patterns within the atolls."

"1.6.1 Meteorological and oceanic information

"A search of the literature and meteorological records was undertaken to assess the risks of cyclones, earthquakes and associated tsunamis, and other events that pose a severe threat to the coastlines and islands as a whole."

The above sentence deserves careful thought because it implies that the severe threat exists, when the overwhelming evidence is that no such severe threat exists. I will return to this analysis below.

The study text continues (Vol. 1 page 16):

“The investigations revealed that a number of events, such as cyclones, earthquakes, and tsunami, have occurred within the region, and future events would have the potential to cause severe flooding on the islands with the possible loss of life. The Chagos is on the northern edge of the cyclone belt and hence is not subject to frequent cyclones. However, there is the potential for cyclones to reach the islands even though (and partly because of their infrequency) there is little historical evidence.”

I will now deal with the facts as provided in the Phase 2B report for cyclones, earthquakes, and tsunami.

#### Cyclones.

During the 30 year record of wind speeds at Diego Garcia, the maximum recorded wind was only ~ 40 miles/hr (35 knots). (Vol. 2 page 222). There is NO record of a cyclone in this 30 year record.

“On the basis of the wind speed data it is therefore concluded that it is unlikely that a cyclone has passed directly over Chagos during the last 30 years.” (Vol 2 page 228)

The barometric pressure records from Diego Garcia reinforce this conclusion- Vol 2 first paragraph of page 230; as do the limited tidal records (~12 years) from Diego Garcia which show no significant difference from tidal change as a result of storm induced surges. (Vol. 2 page 230).

“One piece of information that does demonstrate that cyclones have indeed occurred in Chagos in the past is the Admiralty Pilot which states “A cyclone occurred in 1891, when great damage was caused.”

Given the above, a reasonable conclusion is that at least one cyclone has occurred in the Chagos in the last 100 years and that cyclones are not a prominent problem. Nevertheless it would be prudent to keep cyclones in mind in land use planning.

The Maldives are known to have been hit by long period swell waves which caused ‘severe flooding in 1987 and again in 1988. (Vol. 2 page 232). The Phase 2B study concludes:

“It is very likely that Chagos experienced the same events, and it is likely that such events are not infrequent.”

On the contrary, what is clear is: if the ‘events’ were experienced in the Chagos, they were certainly not of the magnitude experienced in the Maldives, or they would have been recorded, and be noted as a class of phenomena which occurs ‘not infrequently’. But, such notation of severe flooding as a ‘not infrequent event’ does not exist in Chagos written or oral history. The consultants do not report any case of severe flooding in the Chagos, from the Chagos historical record.

## Earthquakes

"Chagos is not in one of the main areas of seismic activity but the Admiralty Pilot reports that earthquakes are sometimes felt on Diego Garcia. The very large earthquake (7.6 on the Richter scale) that occurred on 30<sup>th</sup> November dramatically illustrated this. The earthquake caused significant damage to a number of buildings on the island." (Vol. 2 page 234)

On the same page appears:

"There is no doubt that Chagos does experience earthquakes, some of which are severe ... However, the risk and potential magnitude of similar events recurring in the future cannot be predicted with any certainty, given the current baseline information."

Given the above, many atoll dwellers, in parts of the Indo-Pacific region with fuller and more dramatic baseline information, would be happy to swap seismic conditions with the Ilois. The direct historical evidence of one, and apparently only one notable earthquake in the Chagos, is certainly not of such significance as to preclude or limit settlement of foreseeable types. However, it would be prudent to keep earthquakes in mind in planning vulnerable infrastructure.

## Tsunami

The very large earthquake experienced in Diego Garcia on 30 November 1983, was accompanied by a tsunami that "... caused significant wave damage to the southwest tip of the island and a wooden pier was destroyed." (Vol. 2 page 234)

It would be useful to know more on the damage. It is also useful to note tsunami are so infrequent and so benign in the Chagos. Nevertheless, it is wise and common practice on low-lying atolls, for buildings to be placed on the lagoon-side, and in locations which folk knowledge and scientific observation suggests are comparatively immune to tsunami and storm induced flood damage.

Weighing the evidence in Vol. 2, against the statement in Vol. 1 (1.6.1. page 16), suggests the report exaggerates the hazards to life in the Chagos from storms, earthquakes and tsunami.

### Section 1.6.2 Physical development of the coastline

This section (Vol. 1 page 16) records that-

“... the oceanic sides of the islands are eroding, but the lagoon sides of the islands are generally stable.”

and concludes that -

“... it has not been possible to quantify the rates of erosion, but it will be important to establish these rates prior to advancing any plans for future development on the islands. Failure to do so could result in development in inappropriate areas, and the subsequent need for coastal defense which may prove costly and possibly impractical to sustain.”

The conclusion needs close examination.

One reason the rate and pattern of erosion were not estimated is because aerial photography was not provided to the consultants. The reason is not given.

It is not necessary to defer any plans before the rates of erosion are established. This proposal is obstructive. It would be poor land use, and simply daft, to build on the ocean as opposed to the lagoon sides. There is no need for this to happen, and no consequent need for ‘coastal defense’, which in any event would be too expensive and of uncertain overall effect on backshore erosion.

### Section 1.6.3 Overtopping events

The Chagos are low atolls in a deep ocean with winds of long fetch. Large waves are a reasonable cause for concern and indeed the report states (Vol.1 page 16):

“... the islands are likely to experience overtopping on a regular basis, e.g. annually.”

This statement raises grave concern. Overtopping? How extensive? Annually?

The same section answers some of these questions, e.g.-

“... the studies have been invaluable in identifying the dominant process responsible for potential flooding but do not facilitate any precise statement of the return period of flooding events. For the present study, therefore, we must also draw on visual evidence and the limited historic data.” (Vol. 1 page 16)

“The fact that the Ilois survived this environment for some eight generations, and that copra was cultivated on a commercial basis during this time,

suggests that the islands have not, historically, been subject to frequent inundation by seawater." (Vol. 1 page 16)

"In future we can expect flooding to be more frequent as sea level rises, thus lowering the threshold event that can result in over topping of the ocean coastal edge." (Vol. 1 page 17)

"Summing up, it is likely that overtopping caused by wave action on the ocean side occurs regularly (e.g. more frequently than annually) but this does not necessarily lead to inland flooding. From time to time, when the sea is elevated, principally through wave set-up, severe flooding over a significant proportion of the island can be expected to occur. The return period for such an event is not known, however, from available (very limited) evidence this might be in the order of tens of years."(Vol. 1 page 17)

"Overtopping is most likely to occur on the ocean side of the island because wave energy is much greater than that on the lagoon side. This is supported by the fact that beach material, including quite large boulders, was found on dry land up to 20m from the ocean shore, whereas no evidence of previous overtopping was found on the lagoon side." (NB the underline does not appear in the original text. I have added it as a highlight.) (Vol. 2 page 254).

The report helpfully notes (Vol. 2 page 265):

"A detailed topographic survey of the island is required to enable likely flood areas to be identified and indicate the main routes of the floodwater back to the sea."

The report further notes (Vol. 3 page 345):

"Rather than dealing with overtopping at the coastal edge, it may be better, and more economical, to manage the flooding using bunds. These would not have to resist significant wave action, and in their simplest form could be an earth bank. The bunds could be set back from the ocean side defense or located to defend specific areas of the island, such as the fresh water zone, particular infrastructure or residential areas."

The soils report in Vol. 2 also provides valuable observations relevant to overtopping, which seems to be a long-standing, normal and frequent phenomena, normally confined to localized, small-scale overtopping of backshore ramparts, with more widespread events extending to areas which can be identified by their soils (are saline) as well as topography. Such overspill areas are limited.

Summing up, the history of the islands is silent in so far as severe flooding is concerned, but overtopping does occur on and nearby the ocean side of Boddam and Coin, and presumably the other islands.

For planning and management, the siting of infrastructure and crops should take into account location in relation to the backshore, local knowledge, topography and any habitat evidence of localized flooding. Localized bunding may be prudent and cost beneficial. Elsewhere, the report generates information that 'coastal defense' is not justified at foreseeable levels of investment and return.

### 1.7 Water Quality and Environmental Variables

This section makes clear that design and management precautions are necessary for wastewater disposal and other potential runoff of pollutants in order to preserve coral reef communities.

The primacy of the coral reefs in coastal protection and productivity is well known and fully argued in the report.

### 1.8 Climate Change

My general assessment on global warming follows.

Global warming and consequent rise of sea levels on a world-wide basis is a serious concern, particularly in low-lying coastal areas (where a disproportionately large number of the world's human population lives and works) and for low-lying islands such as Chagos.

The Intergovernmental Panel on Climate Change in its second assessment report projects a global average temperature increase by the year 2100 on the order of 1.5 to 4.5 degrees C, accompanied by sea level rise on the order of 15-95 cm. An IPCC mid-range scenario (IS92a) predicts a sea-level rise of about 50 cm by 2100, leading to coastal erosion, land loss, increase in flooding, and intrusion of salt water. To adapt to such change requires prudent planning, sound environmental management, and the capacity for sensible investment in countervailing responses.

The Diego Garcia military base excepting, the Chagos economy, at foreseeable levels of investment, will not justify large-scale coastal defenses. The requirement is for careful land use planning and management, with strong components for coastal management and reef health.

The challenge of global warming is meaningful but not to the extent it should preclude resettlement of the Chagos in prudently planned fashion.

The Phase 2B report states:

“... it is projected that sea level will rise by an average of 5mm per year over the next 100 years. The implications of these predictions for resettlement of the Chagos Archipelago are considerable, given that mean elevation of the islands is only two metres.” (Vol. 1 page 18)

“... most islands will experience increased levels of flooding, accelerated erosion, and seawater intrusion into freshwater sources.” (Vol. 1 page 18)

“Although the risks are not easily established the implications of these issues to resettlement in the outer atolls of the Chagos Archipelago are outlined briefly below.”

The report states the implications to be:

- 1) seawater intrusion into freshwater lens
- 2) increased storminess
- 3) increase pressure on biological systems, especially the corals
- 4) fisheries
- 5) human settlement

#### Seawater Intrusion into freshwater lens

Seawater intrusion into freshwater lens is self-clearing, although this may take months. The potential for such intrusion reinforces the importance of a soundly planned and managed rainwater capture system.

If flooding becomes permanent or land containing lens of freshwater is eroded, that freshwater resource will be lost.

#### Storminess

“It has been predicted that the flooding severity for a 1 in 50-year storm event with a 0.5m of sea level rise is almost as high as the present day 1 in 1000-year event.” (Vol. 1 page 18)

Increase in storminess is a risk to be addressed in land use planning, management, settlement infrastructure siting and design.

## Biological Systems

"Coral reefs are one of the most important ecosystems likely to be affected, and their ability to cope will depend upon the rate of sea-level rise relative to their growth rate. The Chagos coral reefs were severely affected by the 1998 El Nino event, therefore any future sea surface warming would increase pressure on already stressed coral reefs. The added pressure of human interference within the marine environment would further weaken the ability of these systems to cope with climate change." (Vol. 1 page 19)

The corals of the Chagos were severely stressed by the 1998 El Nino. They are no longer being so stressed and are indeed, thankfully, recovering. The interference/stress as a result of responsibly managed settlement will not be a major stressor. It is not the straw that breaks the camel's back, but the over-loading in the first place.

It would certainly be useful to do a survey of the coral reefs of Diego Garcia in order to get a feeling for how a responsibly managed settlement (~3000 persons), with immense potential for pollution, is affecting the reefs. Diego has been reported in the press, variously, to have berths for two nuclear submarines, a 12km strip for intercontinental bombers, with supplies (e.g. fuel and ammunition) and support for 'two brigades'.

## Fisheries and Aquaculture

The report (Vol. 1 page 19) sees downside risk. My feeling is the book is still open on the fisheries effects of global warming.

## Human Health, Settlement and Infrastructure

The report sees sustainability in food and water availability as among the most pressing needs. I feel this is hardly likely to be the case, and find no evidence to support this conclusion of the report, in other volumes (II, III, IV) of the report.

This part of the report ends with a section titled Vulnerability and Adaptation which contains many positive suggestions for coping with global warming, e.g.

- i) integrated coastal management as a key planning framework,
- ii) siting of infrastructure in low risk areas and use of appropriate designs,
- iii) robust pollution and waste management controls.

I regret the report does not emphasize the importance of involving the Ilois at all stages of planning to address the negative effects of global warming. Well-informed citizens are the best decision makers. Citizen involvement is a key component of integrated coastal management as presently practiced.

## 1.9 Environmental Appraisal of Resettlement

The report acknowledges that the impact assessment is generic and lacks scale in the absence of "... settlement demography, livelihood strategies, and socio-cultural characteristics...".

That said, the report provides a useful framework for future, more detailed assessment and management of impacts.

The report acknowledges that: (i) negative impacts can be minimized through sound land use planning and good environmental management practices, (ii) tourism has not been a subject for this Phase of work "... but as an obvious choice for income generation it has been considered as part of the environmental appraisal.", (iii) a core element for environmental management must be participation of "... those involved in the resettlement in the development and implementation of land use plans and resource development strategies." (Vol. 1 page 21)

Vol. 1 ends with a set of "Overall Conclusions"

### Water

The report concludes there is groundwater on Boddam and Coin to support between 1,500 and 3,000 persons at usage of 100 litres/person/day, if the folks were dependent on groundwater alone.

The assumption of sole supply from groundwater doesn't make sense. *phew*

### Soils and Agroforestry

The report concludes (i) the soils are atypically fertile but must be husbanded within an appropriate system to maintain their fertility, (ii) local cropping can meet some of the nutritional requirement of a resettled population but basic carbohydrates such as rice and cereals would have to be imported; (iii) the potential for commercial cropping ventures is limited.

### Fisheries and Mariculture

"It is likely that fisheries and possibly mariculture would become an important provider of livelihoods and income."

## Vulnerability

This section is interesting.

"Under the present climate, it is assumed, based on historic meteorological patterns and observations, that the islands are already subject to regular overtopping events and flooding, and erosion of outer beaches. As global warming develops, these events are likely to increase in severity and regularity. In addition, the area is seismically active, and the possibility of a tsunami is a concern. These events would threaten both the lives and infrastructure of any people living on the island. Whilst it might be possible to protect the islands to some extent in the short-term through coastal defense measure, it is likely to be cost-prohibitive and non-pragmatic to consider this form of defense in the long term." (Vol. 1 page 24)

First, the vulnerability conclusions are grossly exaggerated. Chagos stacks up as a fine place for the Ilois to return. I'm confident many if not most will feel similarly when the facts and arguments and speculations on vulnerability are laid before them.

Second, an implicit conclusion seems to be that the environment is just too susceptible to human disturbance:

"The environment of the Chagos Archipelago is highly diverse and yet very susceptible to human disturbance. Coral reefs, which are one of the most important ecosystems within the Archipelago, are already exhibiting signs of stress from increased sea surface temperatures and other climatic phenomenon. Predictions from climate change experts indicate that mass mortality of reef building corals in the Indian Ocean will likely occur as global warming increases, may be as soon as within the next 20 years. This will not only have huge implications for the long-term coastal defense of the islands, and hence their very existence, but will also adversely affect livelihoods, particularly fisheries and tourism, which are likely to be the mainstay of any settled population. Human interference within the atolls, however well managed, is likely to exacerbate stress on the marine and terrestrial environment and will accelerate the effects of global warming. Thus resettlement is likely to become less feasible over time."(Vol. 1 page 24)

The paragraph quoted immediately above is breath-taking its apocalyptic vision.

First, the authors and editors of this report seem not to have pondered, or investigated, the well managed Chagos settlement, of similar magnitude to that proposed for Illois repatriation, but which has immensely more pollution and pollution potential, and which is apparently having limited downside effect on the Chagos environment outside its own immediate settlement area. I speak of the military base at Diego Garcia. Second, the consultants have not addressed the limited proportion of Chagos coral habitat likely to be impacted by the proposed resettlement.

The report now proceeds to a general conclusion, which I quote in its entirety, and finally to recommendations.

#### General Conclusion (Vol. 1 page 24)

"To conclude, whilst it may be feasible to resettle the islands in the short-term, the costs of maintaining long-term inhabitation are likely to be prohibitive. Even in the short-term, natural events such as periodic flooding from storms and seismic activity are likely to make life difficult for a settled population."

The history of the Chagos, including the experience of the Diego Garcia military base over the last ~30 years, makes it probable this general conclusion is nonsense. Further, there is no apparent justification for the conclusion which is at variance with the evidence and appears to lack objectivity.

The recommendations that terminate Vol. 1 are:

- i) more feasibility study, but this time to include studies of financial viability and costs of "... generic resettlement needs.;"
- ii) "... consultation with those wishing to resettle the islands ... to incorporate their needs and aspirations into the resettlement debate.;"
- iii) an environmental monitoring programme.

The second recommendation would have been started from the get-go, if this set of studies was designed and done to international standard. Had this been the case, cost analysis would already have been well underway, as its absence from a feasibility study is an omission that borders on the bizarre. A right-sized monitoring programme, designed specifically to support environmental management would be appropriate.

## 4.2. Volume II: Resources Assessments

### 4.2.1. Preface (by JJ)

In my review of Volume II, I have tried to limit repeating observations I made on Volume I. My review does expand on the material where I reckon that is useful.

### 4.2.2 Introduction (Phase 2B report)

The report is confined to Peros Banos and Salomon Atolls. A balanced feasibility study for repatriation of the Ilois should cover all of the Chagos, including Diego Garcia. Although all, or the strictly military part of Diego Garcia, may be off-limits for settlement by Ilois in the near to medium term, Diego should be a valuable hub for Chagos-wide communications and transport, as well as a market for Ilois goods and services. Lesser out islands of Peros Banos and Salomons, especially, should be vital to economic development of Ile du Coin and Ile Boddam.

### 4.2.3. Background to the Feasibility Study

This section refers to not being tasked to (i) do costs and benefits, or (ii) consult with the Ilois.

The terms of reference appear in the volume of appendices (Vol. IV). These terms of reference are inadequate for a resettlement feasibility study. For guidance on international practice in this subject, the BIOT Administration could have referred to relevant ‘guidelines’ from, for examples, the World Bank, African Development Bank, the EC or DFID.

It is usual practice for a consultant to comment on terms of reference, with a view to clarifying the work expected and to improve its quality. In fact the terms of reference (5.1. under reporting in Vol. IV) state:

“Within one month of commencing the assignment, consultants will submit a brief inception report stating progress to date and any revision of their appreciation of the study objectives and the programme required to achieve them.”

Since professional consultants would be expected to know that international standards require consultation with those being resettled, the objectivity of the report might have some light cast upon it by the production of “the appreciation” and the “brief inception report”, which are referred to at paragraph 5.1 Vol. VI.

A surprising reference appears in Vol. II page 9

“... this report... has not been tasked with investigating the financial costs and benefits associated with resettlement, nor has it engaged the Ilois in a discussion on their ambitions and proposed livelihood strategies. These are important elements of the resettlement debate, and should become subject for a possible future phase.”

Using as an excuse for inadequate work, that better can be done in a “possible future phase.” may be excusable once, but not twice. Both the Phase 1 and Phase 2B terms of reference were similarly unbalanced and inadequate. A Phase 3 TOR of similar nature would be a travesty.

#### 4.2.4 Overall Methodology

The terms of reference for the consultants state: “... aerial photography taken over the past two decades should be used if available....” (Vol. IV 4.2.1)

In fact, try as they did, the consultants were not able to secure such photography.

“The field base maps were 1:10,000 island outlines, which were derived from SPOT and Landsat 7 imagery. ... The satellite images are too coarse and pixellated to be useful aids for soil boundary identification at this scale. (Vol. II page 97)

“The only remotely sensed imagery that was useful for soil mapping is a photocopy of a single 1:20,000 panchromatic aerial photograph of Ile Boddam, even though it lacks stereo pairs and dates from 1973. New and large scale (>/- 1:10,000), high quality, stereoscopic aerial photography is absolutely essential for any further studies of terrestrial resources or the environment in these atolls.” (Vol. II page 97)

The client should ensure large scale photography is available for future environmental assessment and settlement planning.

In the absence of consultation with the Ilois, the consultants were forced to develop a set of hypothetical development scenarios to use in their analysis. These hypothetical options are realistic and useful, but limited. They appear in Appendix B and were certainly useful, especially given client-imposed constraints on consultation with the Ilois.

#### Development Scenario 1(quoted in full)

“This scenario assumes small-scale development that is largely centered on a population meeting most of their subsistence needs from agroforestry production and reef and lagoon fisheries exploitation, and depending on groundwater and rainfed tanks (NB one of the few references to this possibility in the report-JJ) for water resources needs. Economic independence will rely on fisheries exploitation, probably in the form that currently exists within the Archipelago, i.e. on a seasonal basis with know

gears and exploitation methods and a reliance on a mothership to freeze and export the fish. Small amounts of income might be generated from the sale of goods and services to the visiting (and seasonal) yacht trade. There is likely to be seasonal economic migration from the islands during periods when the fishery is not being commercially exploited. It is assumed that the resettled population would meet their animal protein needs from fishing and some limited livestock production, and would be able to produce sufficient green-leafed vegetables and fruit. Whilst some of the carbohydrate and fat requirements could be derived from local produce, the bulk of the carbohydrate and fat needs would have to be imported.”

“Resettlement needs will include:

- a) Single-story housing, with rainwater tanks and suitable wastewater disposal systems, and community buildings;
- b) A jetty on the inhabited island(s) to enable ease of access and egress, and permit the loading and offloading of material;
- c) Limited dredging of a navigable channel to the inhabited island(s);
- d) A transport system to maintain a monthly supply of goods to meet requirements for (i) the provision of primary carbohydrate (e.g. rice) and fat requirements, and other foodstuffs; (ii) building materials; (iii) fuel for vessels and power generators; (iv) bottled gas for cooking and lighting needs; (v) medical supplies; and (vi) other essential goods;
- e) Community services including basic healthcare facilities and medical assistance; primary school education (at least); basic levels of governance; a postal service; a general store; and electricity;
- f) A communications system appropriate to the buying power of the population;
- g) Appropriate sewerage and waste disposal system.” (Vol. IV first page)

#### JJ Comment on Scenario 1

On social and economic grounds, a scenario that expects labour migration is inadequate, even dangerous. Otherwise, Scenario 1, with modifications to meet Ilois demand, seems to me a good start to pioneer as preparations for more developed settlement are underway.

My impression is the Ilois look for a robust communications system, even one that exceeds households' buying power. Such a system may in any case be necessary for social service delivery.

Once-a-month transport is not adequate for development, or for health. The pioneer settlement might commence with a mix of air and sea transport.

Energy sources should be planned to build on local sources and to limit the recurrent expense of imported fuels. The same applies to building materials.

## Development Scenario 2

"The second development scenario assumes a higher level and greater diversification of investment to support a medium level of income generation on the islands. Essentially the core elements of resettlement and exploitation of resources for subsistence needs will be the same as for Scenario 1, but additional livelihood activities might also take place, which would offer more economic and employment opportunities. These could include diversification from the current fisheries configuration to enable some processing and storage of frozen fish on the islands (thereby increasing labour demand and income generating opportunities within the population), perhaps with alternative marketing channels to that offered by the mothership venture....."

"... other livelihood options might include the development of mariculture. Mariculture practices that might be suitable in a remote location ..... could be seaweed ... and possibly pearl oyster..... . Other activities that might occur could include self-contained boat-based tourism..., there is obviously demand for recreational diving and 'eco-tourism' tours around the Chagos Archipelago (operating from Seychelles, Maldives, Mauritius).... (Vol. 4 Appendix B second page)

In addition to the infrastructure of DS1, DS2 adds:

- h) An ice making facility and cold storage;
- i) Vessel repair/maintenance facilities;
- j) Fuel bunkering and storage area;
- k) Materials and storage area for mariculture (marine-and shore-based);
- l) Facilities to support low levels of seasonal boat-based tourism;
- m) Appropriate sewerage and waste disposal facilities;
- n) Increased demand for freshwater.

### JJ Comment on Development Scenario 2

DS2 is reasonable, but unambitious. I don't feel it's useful to comment further. The Ilois and potential private investment need to be involved.

### Development Scenario 3

“... assumes high levels of income-generation and correspondingly high levels of investment, focused mainly on island-based tourism and offshore fisheries development (marketing high-value fresh products). ..... the biggest current obstacle to the development of these options ... is the lack of an airport. Rapid access to markets (both tourist and fish markets) would be essential to ensure that economic opportunities were maximized.”

“In addition to the resettlement needs outlined in a-g above, other requirements would include:

“An airport built to international standards, with runway length of (say) 2 km. ....

- o) Tourism accommodation;
- p) Accommodation for resort staff;
- q) An additional ‘fisheries’ jetty/pier which will allow the berthing and offloading of a fishing ‘dhoni’-sized vessel (and associated access channels);
- r) Fisheries processing, chilling and packing facilities, preferably close to the airport;
- s) An air-freight facility;
- t) Appropriate waste disposal system, which would address sewerage, grey water and solid waste disposal.

JJ Comment on Development Scenario 3.

The important issue in this scenario is the necessity for a comprehensive transport study, responding to the reality of the archipelago’s isolation, and meant to achieve economically integrated surface and air transport.

Air transport takes us back to Diego Garcia and requires a comparative analysis of the costs to the resettlement if the air transport hub, in particular, is based in the Maldives as opposed to Diego. The study needs to cover in what degree air transport can be a mix of land based and float planes, and what role exists for STOL or float planes to minimize land absorbed into airstrips.

#### 4.2.5 Groundwater Resources Assessment

The greatest componential effort in the Phase 1 and 2 studies has been the comparatively elaborate study of groundwater, on Boddam and Coin in particular. The reason appears on page 15 of Vol. II:

“The sustainability and quality of groundwater resources has been recognized as a key constraint to the level of possible resettlement and development within the Peros Banos and Salomon Atolls, particularly in relation to the major island of each atoll, namely Ile du Coin and Ile Boddam.”

The reason- groundwater is a key constraint- is false. Water on atolls must be properly husbanded. Pan-Tropic experience and analysis are amply available in the literature and key documents are referenced in the Phase 2B report. At the low levels of industrial development expected in Chagos in the near and medium term, groundwater is most certainly not a key constraint on the resettlement, because much, if not most, of the water should be got from direct capture of rain. Rainfall is abundant in the Chagos, and as in other atolls, groundwater is easily over-pumped and easily polluted.

The groundwater study has been oversized in relation to what hasn't been studied in other sectors but should have been, as well as in relation to what has been studied. Otherwise, the technical work is informative, well-documented, and with useful recommendations for development and management. (e.g. Vol. II pages 86 and 87)

Fecal contamination of both wells and tanks was characteristic and needs to be addressed in the resettlement. (Vol. II pages 91 and 92)

The author(s) reckon the unit cost of supplying water from rain harvesting is likely to be higher than supply from wells. The author(s) also note:

"However, when other factors such as possible need for treatment of groundwater are taken into consideration, the conjunctive use of rainwater and groundwater has been found to be an appropriate water supply solution for populations living on small islands, particularly where the rainfall is relatively high." (Vol. II page 78)

"... mean annual rainfall (MAR) estimates for Peros Banhos (Ile du Coin) and Salomon Atolls (Ile Boddam) are approximately 4,000mm and 3,750mm. These data are based on 14 and 15 years of data respectively." (Vol. II page 70).

#### Feasibility analysis of rain capture is outstanding.

The author(s) note difficulty in getting appropriate data from Diego Garcia. (Vol. II page 69)

#### 4.2.6 Soil and Land Resources

"The soil investigations reported here address the two needs identified: firstly to provide a basis for decision-making on the feasibility of resettlement; and secondly to provide an adequate and reliable basis for developing land use plans for the main islands on each atoll." (Vol. II page 94)

The first 'need' is unnecessary since the feasibility of resettlement is apparent in: (i) history of settlement in the same islands, (ii) present settlement in comparable atolls, and (iii) Ilois desire to resettle. The second reason is sound and welcome. The soils information will be of great use for land use planning.

The author(s) provide much welcome information and have a balanced approach, given the constraints of the TOR:

“The absence of data on the aspirations, agricultural skills, and the material and financial resources available to the potential resettlers precludes the identification of specific LUTs for formal FAO-style land evaluation. Also the locations of water supply and other infrastructures, and the areas to be excluded from agroforestral activities are not yet known. Therefore formal land evaluation cannot be undertaken at this stage or presented in this report. However the practical implications of the soil survey results are discussed in terms of production potential for cropping systems and crop types within the context of three hypothetical development scenarios (Appendix B). Soil susceptibilities to various forms of damage are also assessed.” (Vol. II pages 94 and 95)

During a stop-over in the Maldives, the author realized that:

“...households farming on atolls often have their holdings and crops distributed on several islands. Evaluations of agroforestral potential therefore should not be confined to single islands and need to consider the land resources of the atoll as a whole. ... The other islands could therefore be important .... And more (6) were included in the reconnaissance soils investigation that estimated in the proposal (4).” (Vol. II page 94)

The Phase 2B analysis is, on the whole, more optimistic about the soils than was Phase 1.

The soil surveys of Coin and Boddam were detailed (as defined by density of conventional, systematic observations).

Evidence of ‘overtopping’ the storm ridges on the ocean side of the islands is clear:

“On the ocean side of all islands the sand deposits are overlain by coarser rubble, ranging from fine gravel to boulders. ....The rubble deposits are attributed to overwash from the ocean side by modern and sub recent storms. This process appears to be ongoing, and further rubble deposition is possible.” (Vol. II page 99)

“The islands are young and their formation has been dated as post-6 ka BP...” (Vol. II page 101).

There is no land above 3m a.s.l. in either Coin or Boddam.

“The immaturity and dynamism of island formation means that islands can be divided as well as joined. Detailed geomorphological studies may reveal which current inter-island channels have been created recently and also identify sites on the current land areas where new channels might form.” (Vol. II page 101)

The report covers the major vegetation types encountered in the soil survey.

The predominant vegetation of the islands is coconut- plantation or self-seeded (Bon Dieu).

Coconut has replaced most of the original climax vegetation dominated by broad-leaf trees, except where this has been protected for timber harvesting, or the soils are not good for coconuts, or the islands are comparatively inaccessible.

Consultants examined vegetation and foliage for nutrient deficiency, which was evident in native species, but only on non-humic sandy wash soils. By contrast, nutrient stress was widespread in introduced fruit tree species.

Phase 2B seems to be the first systematic soils investigations in the Chagos. (Vol. II page 106)

The soils of Peros Banhos and Salomon "... have higher than usual contents of organic matter, mainly because of the lack of harvesting or management of the coconuts for the past 30 years." (Vol. II page 108)

"Virtually all the soils are completely non-saline, even within distances of a few metres from beaches." (Vol. II page 109) "The only exceptions were a very few of the soils in lakes and channels, which are affected by overtopping, inflow or seepage of seawater."(Vol. II page 114)

I think the above evidence on the issue of overtopping indicates that overtopping is a regular phenomena occurring and affecting only limited areas, and for the most part, these can be identified and incorporated in the land use plans.

The soils tend to be sandy, alkaline, and patchy (as opposed to large areas of the same individual class), have low cation exchange capacity; N varying with organic matter content; P can be high (apparently due bird dung and by another route (?)) associated with soils that were under coconuts for more than a century); K low; micronutrients usually low to extremely low.

The soils are broadly similar to coral soils elsewhere, but have some favouring characteristics e.g. unusually high organic matter in surface horizons, absence of hardpan, and are non-saline.

"In summary, most Peros Banhos and Salomon atoll soils have a better soil fertility and soil water availability than expected." (Vol. II page 121)

But, "... any decline in soil organic matter will be matched by a decline in soil fertility." (Vol. II page 121) "SOM management is therefore fundamental to the feasibility and sustainability of resettling the atolls." "... soil fertility, ....will be rapidly lost unless sustainably managed." (Vol. II page 122)

The report now turns to the implications and appropriateness of a complex agroforestry and horticultural system, generically characteristic of atolls, that "... provides a good basis for sustainable agricultural production ... for local consumption and possibly some marketing (e.g. to long range yachts and tourist/dive vessels)." (Vol. II page 125)

"The evidence suggests that there are few agronomic obstacles to food crop production using atoll adapted crops and technologies under the atolls current soil conditions." (Vol. II page 126)

"Locally grown root (taro, yam, and sweet potato) and tree (breadfruit) food crops could substitute some grain imports, but this potential will depend on the food habits of the settlers." (Vol. II page 126) The author(s) see coconut as the best candidate for commercial crop production on a large scale but doubt the abundant coconut of the Chagos can compete with the large-scale and efficient ("... producers in India, Thailand and the Philippines who have existing excess capacity." even if prices and yields increase. (Vol. II pages 125 and 126).

The coconut is an extremely useful tree and will doubtless become a centerpiece of Chagos agriculture. It would be worthwhile to examine the potential of this crop, as part of a mixed-crop, small-scale farmer rather than as an estate export mono-crop. In view of the abundance of coconuts on the islands, it is surprising that limited positive assessment of the potential of this crop has been made. A pilot study was provided to BIOT by Vinay Chand Associates referring to experience of Kiribati, but appears to have been overlooked.

The report refers to such systems (Vol. II final two paragraphs of page 127) and for tree crops notes:

"... 20 of the 24 trees recommended by Winrock (1992/95) for atoll AF systems are already present in the Chagos Archipelago; 11 of these 20 are given as probably native species (Todd and Sheppard, 1999). As a result, AF systems can be introduced with a minimum introduction of exotic species." (Vol. II page 128)

Once more I note the impact of no consultation with the Ilois on the salience of this report:

"No information is available (NB JJ comment- "No information is available" only because the consultants were not tasked to gather it) as to the agricultural knowledge, aptitudes and capabilities of the potential settlers. Understandably there are no estimates of the availability and opportunity costs of labour for a potential resettlement scheme. Thus it is suggested that these issues be assessed, in conjunction with other capabilities, attitudes and aspirations of the potential settlers. This could be done as a participatory decision-making exercise in a further phase of the resettlement of the Peros Banhos and Salomon atolls feasibility study." (Vol. II page 127)

Again, there is the suggestion work to be done in a further phase of the feasibility, which could and should have been done in both phases 1 and 2.

I was surprised to find reference to DFID standards in this section of the report (page 128). The application of DFID standards to the TOR would doubtless have been an improvement.

For sustainable soil fertility management (SSFM), the reports recommendations are:

- i) an integrated approach (trees and shrubs- wild and domestic, surface and root crops, domestic livestock (milk cattle, chickens, pigs), and presumably wild birds and fish products
- ii) a profitable system, with competitive returns
- iii) land tenure that provides sufficient security for individuals, groups and communities to recover investment in SSFM
- iv) adaptive research and extension
- v) stakeholder participation “in the design, implementation and monitoring of resettlement.” (Vol. II page 129)

In the next few pages the report describes in more detail the possible system components to species level for the main food crop species.

The report notes perennials are on the whole more suited than annuals; nevertheless, “... on the humic soils in the wet seasons the production of an adequate range of vegetable crops should be possible.” (Vol. II page 131)

The report does not avoid recommending introductions, albeit under strict control e.g.:

“The introduction of exotic fodder legumes will be important for increasing nitrogen levels and cycling...” (Vol. II page 131)

“... the observation that good stands of broadleaf forest can be supported by the soils of Peros Banhos and Salomon where coconut management has allowed ... suggests that the supply of fuelwood and timber will not be problematic.” (Vol. II page 132)

The section rounds up with an optimistic conclusion, based on reason and comparative evidence for other atolls, as to the capacity of land resources to support Development Scenario 1 if the settlers are keen and a good system is put in place. The report produces figures suggesting a supportable population of 1,500 to 2,600. (Vol. II page 134 and Vol. IV D5 Calculating Potential Agroforestral Human Carrying Capacity).

The report acknowledges the proximate nature of carrying capacity figures given the unknowns as to the future economy of the Chagos resettlement; nevertheless, the author(s) cannot resist being prescriptive and indulging in a carrying capacity form of government:

“The planned population should not exceed a safe estimate of the sustainable carrying capacity of the soil resource base under the likely agroforestral technology and support conditions.” (Vol. II page 134)

I wonder what the result would be if this simplistic model (basing legal population on agroforestry and support conditions) were used to prescribe the population of the Channel Islands? The economic conditions that result in well-fed populations cannot be encompassed by likely agroforestral technology and support conditions.

The report provides cautions on land use for Development Scenario 2

The report raises a concern that in Scenario 3 an airport could occupy about 12% of the land of the combined atolls (Vol. II page 135)

#### 4.2.7 Fisheries Resources Assessment

Given the limitations of the TOR, the Phase 1 fishery study was of outstanding quality; and so is the Phase 2B study.

The Phase 2B study begins with a summary of the Phase 1 study; states six recommendations for future work given at that time; and records that four of the recommendations are addressed in the Phase 2B feasibility:

- i) more study of the diversity and extent of potentially exploitable invertebrates
- ii) assessment of sea weed and pearl oyster mariculture and estimate of potential yield
- iii) investigation into suitable fisheries exploitation methods
- iv) consideration of environmental implications associated with fisheries development-

but notes that two of the recommendations-

- v) consultation with the Ilois
- vi) a social and economic assessment of the feasibility of identified development options (including marketing, required infrastructure and training, and regulatory framework)-

“...are to be undertaken at some later stage.” (Vol. II pages 137 and 138)

The fisheries study took place over four weeks in Peros Banhos and Salomon atolls. Systematic transect surveys of sea cucumber, top shell, giant clam were done with snorkel only as use of scuba seems not to have been permitted; although, as is true of the absence of appropriate aerial photography, the reasons are unclear. Water temperature, clarity, current measurements and various nutrient levels were investigated.

Desk review of experience in the Chagos and similar atoll environments, BIOT fisheries data, and experience from the Seychelles were used in various assessments.

A review of the regional fisheries scene (Mauritius, Sri Lanka, Maldives, is provided in order to avoid repeating past regional mistakes and "...to ensure a realistic and forward thinking strategy for the Chagos Archipelago." (Vol. II page 139)

The review is full of relevant observations: e.g.

"In recent years a new industry has developed in Maldives, for the export of fresh yellowfin on ice by air. This business takes advantage of the availability of tourist flights with low cargo demand to fly to mainly European markets. Fresh fish on ice requires low cost packing facilities and is a rapidly moving business. Values of whole fish gilled and gutted in the UK market average US\$ 8,000 per tonne (CIF) London, and is less dependent on world tuna commodity prices."

There are several Seychelles operators who have successfully developed small-scale long line operations for high value yellowfin and bigeye tunas and billfish for fresh on ice air flown export. These activities are the most profitable forms of fishing in Seychelles."

Both of the above quotes are Vol. II page 144.

The report defines several regional themes.

"Demersal fisheries on reefs and coastal waters are over-exploited in all countries and in no case has there been an example of fishing reef-associated fisheries in a sustainable manner. This is principally due to the longevity and low fecundity of the species .... And also do to limited habitat and recent bleaching damage to coral reefs. The aggressive south-east Asian markets of Singapore, Hong Kong and PRC have panned across the region in the past decade searching out the high value species for the live fish air flown trade. ... , these buyers have left a trail of devastated fish resources and bankrupt national operators in their wake."

"The exceptions are the banks of Saya de Malha off Mauritius and BIOT, ... The BIOT Administration has attempted to protect the reefs of the atolls and the banks from fishing effort and has retained the resources in near pristine condition, though some depletion has occurred, particularly in the shark fishery."

Both of the above quotes are Vol. II pages 144 and 145.

Pelagic fisheries are the largest in the region, especially the Skipjack fishery. Sri Lanka and Maldives have artisanal Skipjack fisheries, but most are taken by European purse seiners operating out of the Seychelles. Second largest is a long line fishery for Yellowfin and Bigeye tuna undertaken by Asiatic vessels using ultra low temperature snap freezing that results in very high prices on the Japanese market.

"Island atolls and oceanic plateaus generally provide favorable environments for some forms of aquaculture, being openly flushed systems and yet offering relatively sheltered environments. However, the number of commercially successful aquaculture ventures in these settings is mainly limited to low input, low yield ventures..." (Vol. II page 146)

However, "... extensive culture of seaweed and shellfish has shown some remarkable success stories in the Indian and pacific Oceans." (Vol. II page 146)

The report now proceeds to an overview of the Chagos fishery:

"The northern Chagos atolls have been a traditional fishing ground for the people of Addu in the southern Maldives for over 1,000 years. The atolls were run as copra plantations, with fishing being mainly for subsistence although a small trade in dried fish also existed. With the evacuation of the early atolls in the 1970s, fishing has continued to take [place, largely out of Mauritius. Three fisheries are recognized within the 200 nautical mile Fisheries Conservation and Management Zone (FCMZ) of the Chagos Archipelago:

- Commercial reef and bank-associated fishery for demersal and epi-pelagic species;
- Offshore pelagic-based fishery, mainly for tunas; and
- Recreational fishery targeting both demersal and pelagic fish, currently mainly prosecuted by personnel based at Diego Garcia and visiting yachtsmen." Vol. II Page 147

The Phase 2B study now focuses on the reef and bank fishery (deemed 'the Inshore fishery') as appropriate for providing livelihoods in the resettlement.

This fishery is seasonal (maximum of 6 x 80 day licenses, fishing only April through October), undertaken by Mauritian freezerships that put out dories for handlining, in depths <70m. Nearly 9,000 km<sup>2</sup> are suitable for this fishery. The fishing pressure is low.

"... the combined potential yield from the inshore fishery is estimated at a precautionary 1,102 tonnes per year, being 859 and 243 mt per year for the shallow (<70m) and deeper (70-150m) inshore fishery respectively. This is roughly three times greater than the current average annual catch from the inshore fishery over the past decade." (Vol. II page 149)

The report now turns to the tuna fishery, judged not appropriate for the resettlement, but for reasons that are never specified beyond:

“As European and East Asian vessels, rather than Mauritian vessels, have traditionally dominated the offshore fishery, it is not discussed in the context of this feasibility study.”

This is a curiosity that should be queried. It seems reasonable to suppose that Ilois might also invest in the tuna fishery. In any event, the entire participation of the Ilois in fisheries regulation, including licensing and revenue, needs thorough review and negotiation. The tuna fishery in particular must be a substantial source of revenue to the BIOT Administration.

The recreational fishery is based on hook and line, as nets and guns are prohibited. The take is 1/3 game fish, 1/3 reef edge, and 1/3 lagoon species.

“Of concern is the slow growth and possible intermittent recruitment of these target species, which can render them susceptible to rapid depletion.... This is particularly pertinent to the reefs around Chagos, which are relatively undisturbed, by human activities...” Vol. II page 154.

This passage raises the general challenge to the resettlement of returning to biologic windfalls on sea and land. The initial marine abundance of harvestable individuals can elicit over-harvesting unless education and local controls are in place from the get-go.

The report now turns to invertebrates:

“This section provides an outline assessment of the presence and abundance of three commercially valuable invertebrate resources with Peros Banhos and Salomon Atolls, namely holothurians (sea cucumbers), Tridacna (giant clams), and Trochus (top shell). These invertebrates all have fisheries and/or mariculture potential, and are important components of income generation, foreign exchange and subsistence in many parts of the world, particularly atoll environments of the Pacific.”(Vol. II page 155) NB. Pearl oyster will be covered in a separate section.

Nine species of sea cucumber were found in the strictly shallow water Phase 2B survey, and include the majority of species with high commercial value in world markets. The species are variously distributed by preferred habitat and tend to be in patches rather than uniformly spread.

“... Peros Banhos and Salomon Atolls have a diversity and abundance of commercially-valuable holothurians comparable with other areas of the Indo-Pacific, although the diversity of species observed was slightly lower. Certain species occurred in much higher densities than noted elsewhere in the Indo-Pacific, ..., which are the slower growing and highest value holothurians.” (Vol. II page 160)

Giant clams live in areas of shallow coral reef. Their distribution is patchy and both numbers and distribution were limited in Peros Banhos. They were abundant in the Salomons, although not especially abundant for an unexploited area.

"Only a very few specimens of Trochus were observed during the field surveys, and these mostly comprised dead shells." (Vol. II page 161). The conclusion is: Trochus, for whatever reason, "... are not abundant in the areas in which they are most likely to inhabit." (Vol. II page 162)

The fisheries section now proceeds to the hypothetical development scenarios-

DS1 Minimal infrastructure and investment, Mauritian mothership dory fishing seasonally and subsistence fishing outside the commercial period.

JJ comment: This is too restricted except for pioneer start-up. This scenario has a very limited horizon.

DS2 More ambitious medium scale inshore fishery plus mariculture commences.

DS3 Given an airport, comes the addition of high value fresh fish export, with appropriate support facilities- ice-making, bigger landing and berthing facilities, and a packing plant.

JJ comment: A combination of 2 and 3 can probably can be programmed to start early during the resettlement.

The philosophical/strategic basis of the fisheries recommendations is conservative:

- i) conserve the present pristine condition of the marine environment;
- ii) maximize the value of fishery products;
- iii) invest the returns in the community through income, food security, and sustainable management of the resource base.

The proposed subsistence and local sale fishery would mainly be in waters less than 30m

and within 20 nm, using 5-8m outboard skiffs, with expected take between 52 and 114 mt/yr. This would provide for 100kg/person/year for ~500 to 1,150 persons (assuming a high dependency on fish to meet protein requirements). The take/fisherman day would be on the order of 1.9kg/hr for handlining. Other techniques may be necessary to increase take/unit effort but their implications need to be thought through and their effects monitored. (Vol. II pages 163 - 165)

Fishing in the lagoons is currently banned and would need to be opened, with appropriate regulation. An important first stage will be an atoll fisheries management plan based on community-agreed parameters (e.g. spatial zoning, and seasonal management to protect spawning and nursery habitats).

"If the community were sufficiently involved in the design of the management framework, administration and enforcement could be largely left to the communities themselves. The fisheries management plan should be adaptive, allowing the testing of management mechanisms on limited areas before being extended to other atolls." Vol. II pages 165 and 166.

The options examined for a commercial reef and banks fishery (waters of 30-150m) are:

- i) continue with the present mother ship system (would provide seasonal employment for up to 360 persons for <80 days/yr);
- ii) link an atoll based, multi-day fishery designed to supply high quality fresh fish for international markets, with air transport developed to provide for tourism.

JJ comment: the second option is attractive and highlights the good sense of planning fisheries investment in terms of the wider resettlement economy.

"The inshore (<150m) fisheries resource base is currently under-exploited. Catches are currently about one-third of the predicted potential annual yield of 1,102 mt." (Vol. II page 166)

"With the possible exception of nearby Victory Bank and Blenheim Reef, the main fishing banks are out of reach of a single day visit... and would therefore require a multi-day approach. The richest fishing areas are Speakers Bank as well as the western and northern sections of the Great Chagos Bank (between 30 and 70 nautical miles from Peros Banhos and Salomon Atoll." (Vol. II page 167)

"Access ... would require the use of multi-day boats utilizing a variety of gears that target species at different depths and substrates. Experience in the Seychelles ... suggests that 10-12m diesel-engine multi-purpose fishing vessels (MPV) capable of the open sea passages and the rough seas round the banks entrances would be appropriate. Fishing methods would include hand-lining, drop lining and bottom set gill netting. The same boats with a drum system could operate up to 1,000 hooks a day on a long line system for high value tunas. These boats would have a crew of around 5-7 persons and operate over 5-6 days with a range of around 200 miles, sufficient to cover the entire Chagos Archipelago. All produce would have to be marketed fresh in order to achieve a reasonable return, thus requiring substantial investment in infrastructure. (Vol. II pages 168 and 169).

"... up to ten vessels could operate the outer banks fishery.... The main focus would be the deeper areas because (i) yields of the high value fish in the comparatively nutrient-rich waters of the plateau margins tend to be higher; and (ii) the shallower, coral rich waters will be conserved." (Vol. II page 170)

"These prices would give the outer reefs and bank fishery a market value of around US\$ 3.75 million per annum should the ten boats produce just over 800 mt of fresh fish ... This is in strong contrast with the value of then existing frozen fish production of around 300 mt, which is valued at around US\$ 600,000 ... These figures should be treated as purely indicative and of course do not reflect the different costs involved. The requirement for a more detailed financial analysis is outlined in the recommendations given in Section 11." (Vol. II page 172)

"All products would need to be sent fresh to regional and international markets. This would therefore require both primary processing and packing facilities to be based within the atolls, together with a regular airlink to international hubs (such as Dubai) via the Maldives(6)"

"6) Either via Male or from Gan (280 miles from the islands) in the southern Maldivian atoll of Addu, which is currently being upgraded to international status".

Both of the above quotes from Vol. II page 172.

"... experience in the southern atolls of the Maldives shows that the combined development of a controlled low volume, high value banks fishery with upper-end eco-tourism may together justify such an investment. A small airport sufficient for 20 and 36 seater aircraft with an alternative 5 tonne pay load in Salomon Atoll would cost about Eng Pound 5 million. Much of the funding could be achieved through private investment, probably through a Buy-Operate-Transfer (BOT) investment approach. However this would need to be demonstrated through detailed economic and financial analysis which is outside the scope of the report."

"This activity could provide a full-time livelihood for up to 60 professional fishermen. Additional shore-based employment would also be created in the chandlery, vessel maintenance, ice production and primary processing support."

The two above quotes are from Vol. II page 173

JJ comment: This proposition is very attractive, and needs to be examined along with tourism and transport and discussed with potential investors. It is a shame that such obviously necessary subjects as tourism and transport are not covered by the Phase 2B study.

The fisheries section now moves to sustainable management suggestions useful for marine land use planning and revision of the present BIOT conservation regulations.

The report rejects examination of Fish Aggregating Devices (recommended for further examination in the Phase 1 study). The reasons should be re-examined; e.g.

“During discussions with the FCO prior to the start of the phase 2B study we were advised that offshore FADS were not an option for investigation.”  
(Vol. II page 174)

It is surprising that FAD’s have been ruled out without clear explanation.

The consultant now turns to mariculture:

“Seaweed and pearl oysters are potential candidates for culture on an extensive scale in Chagos. Both have similar characteristics and demands, in that once established they require little husbandry; are based upon simple skills that can easily be adopted; and require little capital expenditure or infrastructural support. In either case the product is reasonably easily stored and can be transported in bulk by sea with only a basic level of primary processing.” (Vol. II page 174)

“...nearly 300 hectares of seabed may be suitable for seaweed culture.... With a low estimate of 10 mt per hectare per year this means a possible annual production capacity of nearly 2,250 mt worth over US\$ 1.3 million per year.

“However, despite the potential area for seaweed culture, measurements taken in the field indicate that culture conditions would not be ideal. Current speeds in the lagoon were low (always less than 30cm/sec) and water temperatures high (up to 31oC during survey). Given these conditions growth is likely to be poor and the risk of mortality high, especially during El Nino years. Should predicted climate change result in higher water temperatures, potential productivity could be further reduced in the future.”  
(Vol. II page 176)

“... any attempt to undertake seaweed production should involve pilot trials to substantiate whether this option is technically feasible.” (Vol. II page 177)

“Seaweed culture has the potential to become an important economic activity to atoll households. In Kiribati it is now the main form of rural income and is favoured because it is less time consuming and hard work than either copra production or indeed fishing ... In the early stages of production, the planting of the stakes and preparation of plants may take up to six hours per person per day for six days in a week, depending on the tide. Once the plants are established, daily husbandry rarely takes more than one or two hours a day. A typical farming unit is a husband and wife team who may own a farm of anywhere in between 5,000 and 25,000 plants. This is sufficient to achieve an income of around US\$ 25-75 per week.”

"Seaweed culture is generally considered a low impact activity and is frequently used to absorb excess nutrients in effluent waters from intensive aquaculture."

The last two quotes are from Vol. II page 178.

If the Chagos were to develop a tourist industry, the visual impact of wide-spread seaweed culture would be substantial and probably detrimental. Small-scale, artisanal operations would be more acceptable and a tourist attraction in their own right. Seaweed aquaculture would therefore need to be included as a potential seabed user in the atoll fisheries management zone." (Vol. II page 179)

"Previous studies ... indicate that black-lipped oysters (*Pinctada margaritifera*) and the penguin oyster (*Pteria penguin*), which are both subjects of pearl oyster culture, are present within the Chagos Archipelago. The presence of these species and the suitable shelter offered by the lagoons of the outer atolls indicate that the environment might be suitable for the culture of these species." (Vol. II page 179)

The consultant recommends more observations and trials for pearl oyster.

The report now moves to invertebrates- sea cucumber (for beche-de-mer), topshell, and giant clam.

"... beche-de-mer is an important livelihood strategy for many of the remote atoll communities that lack rapid access to markets or refrigeration. Its value lies in the low technology employed to process the Holothurians, usually involving sun-drying or smoking, and the ability to store the product without refrigeration for several months. Another advantage offered by holothurian fisheries is the comparative ease with which the animals can be harvested ..." (Vol. II page 181)

"Beche-de-mer fisheries are almost totally occupied by small-scale producers, providing a livelihood and income to hundreds of people. These fisheries are often twinned with copra production, whereby holothurians are smoked or dried in the copra driers during periods when the copra is not being processed ..."

"Since the 1970s ... over-fishing has plagued the sustainability of the industry and governments have been forced to impose severe management regulations, which are generally compromised by demand from markets in the Far East and poverty within fishing communities."

"Trochus and Tridacna are also among the most important non-fin fish foreign exchange earners in the Pacific region, and to some extent within the Indian Ocean. Both contribute significantly towards income generation of coastal communities. Trochus shells yield high quality mother-of-pearl, which is used in the garment industry for making buttons and in the furniture industry for decorative inlay work. Tridacna are important for their meat and adductor muscles, which are not only used for subsistence purposes in the Pacific region but also as an export commodity; shipped dried or live to East Asian markets. The live trade in Tridacna is also increasingly expanding into the home aquarium market, where the brightly coloured mantles of certain species fetch high prices."

"The importance of these species to economies of many part of the world, coupled with their slow growth rates, low natural mortality and sessile nature have rendered them highly susceptible to over-fishing. In fact, such has been the demand for these invertebrates over the past century that many stocks have been wiped out."

The four quotes above are from Vol. II page 182.

"Given the resource potential ... a holothurian fishery could be well adapted to the remote conditions presented by the outer atolls of the Chagos .... and might contribute towards the livelihood strategies of a resettled population."

However, sea cucumbers "... appear capable of sustaining only light to moderate exploitation." Vol. II page 184

"There are few examples of sustainable holothurian fisheries; those that are owe their existence to some powerful controlling force, such as the Ontong Java Atoll, Solomon Islands, where the customary marine tenure and chief rule prevails over resource exploitation..."

"... it would be advisable to seek the views of those who wish to return to the islands on their interest in developing such a fishery."

The development of the fishery should be nested within an effective and tightly controlled management system to ensure its long-term sustainability. Training in the production of high quality product, which dramatically affects price, is likely to be required, and should be encompassed within the overall training needs assessment and programme design for fisheries as a whole.'

Above three quotes from Vol. II page 185 and 186.

Trochus is not taken further because of the low natural stocks plus vulnerability to over-exploitation, but the report acknowledges a potential to test the economy and ecology impact of artificial seeding as the basis for a small industry.

Tridacna is probably not economic if prepared dried or frozen because the returns are not substantial. Returns improve in the presence of air transport, that can reach market

in <30 hrs with live clams. The potential returns from the aquarium market are substantially larger:

“... clams retailing at between Eng Pounds 8.50-43 for live clams between 5cm and 20cm in length” (Vol II page 188)

The consultant reckons a sustainable harvest of Tridacna would only be possible with a hatchery programme; so, the economic feasibility of a fishery based on re-seeding needs study.

This excellent section ends with a summary of conclusions and a summary for each of the fisheries recommended.

The issue of FADS is addressed again, with an inadequate explanation for ignoring them:

“Essentially FADS do not increase productivity but simply aggregate fish that may lead to over-fishing (juvenile fish are particularly vulnerable).”

Harvesting techniques, as opposed to aquaculture, are intentionally designed to catch fish economically, not to increase productivity. Over fishing comes from over-effort and misplaced targeting, and can be regulated, and that regulation can include not taking juvenile fish.

“... inshore FADS are mostly employed to gather bait fish for ‘pole and line’ tuna fishing, an activity that is not considered appropriate for Chagos within the short to medium term.”

The reasons for not being appropriate are not given, although earlier in the text the consultant mentions the Maldives have a >2000 year tradition of pole and line skipjack fishing and that this fishery is not presently well-managed as a component of overall reef fishery management. (Vol. II page 143)

#### 4.2.8 Natural Environment

This section commences with a discourse on corals, then fish. It notes that breeding populations of hawksbill turtles (especially concentrated on Peros Banhos and Diego) and green turtles (commonly on Egmont Atoll) occur in the Chagos.

The Chagos are spoken of as a “... critical site for seabird nesting in the Indian Ocean- with main nesting areas the Great Chagos Bank and Peros Banhos Atoll.”

“It is thought that the populations of sea birds have been recovering since the islands were depopulated but one of the major factors threatening their existence are the large numbers of rats that remain on the islands.” (both quotes Vol. II page 194)

The rat populations deserve special study (JJ)

The consultant now proceeds to the astounding 1998 Indo-Pacific coral reef 'bleaching'. The bleaching is due to loss from coral of symbiotic, photosynthetic micro-algae and is associated with extremes of temperature, solar radiation or pollution. In the Chagos, percent live coral is reported to have dropped from 75% (1996) to ~12% (1998); in this event, lagoon reefs fared better than seaward reefs. Recolonization by fast growing coral species is well underway three years after the event "However, at the same time there was evidence that on seaward reefs the reef structure had been reduced by up to 1.5m due to breakdown of dense coral thickets (Vol. II page 195)

The consultant refers to more detail on coral bleaching in Appendix F, but such detail is missing in my copy at least, although there's the observational detail on coral presence.

The consultant repeats pertinent evidence on global warming as reflected in analysis of Chagos climate data.

Study purpose is given as:

- i) to assess the current status of the lagoon reefs and their associated fauna and flora;
- ii) to generate information against which to evaluate the nature of the anticipated environmental impacts associated with the possible resettlement of the Chagos Archipelago;
- iii) to test site specific protocols and validate survey methods to provide a rationale basis for the design of a long-term monitoring programme.

Under 5.2 Methodology, there's reference to why Scuba was not used which ends with- "... health and safety issues in a remote location would have compromised the overall methodology."

The naturalist(s) is used to using Scuba, and expected to use Scuba; and for some reason is trying to justify why this did not affect the systematic, underwater surveys. It did radically affect survey design as it confined them to snorkel survey depth (this was typically 1-3m only) and totally eliminated any transect sampling of coral and fish in deeper water.

"...the survey design for the detailed assessment concentrated on a limited number of stations around lagoon reefs near existing landing sites at Ile du Coin and Ile Boddam ..."

(Vol. II page 196)

The report then turns to findings and harkens back to work of Sheppard(1980); then refers to assessing two knolls in Salomon lagoon with observations below 7m (still with surface diving I assume) and then turns to information generated in the transects.

Ile Boddam- "Overall live coral cover was relatively high within all sites ranging from 42.5 to 57.5%" (Vol. II page 209)

I find it notable that "The greatest coral cover and diversity was located to the south-east of the old jetty in a shallow bay (1-3m depth) within 20m of the shore". What could be the explanation for the greatest cover being in an area which must have had high human influence?

Northern Islands- considerable variability in reef structure and biological communities, much topographical relief and reef fish species richness although fish abundance was only moderate. Large numbers of juvenile Tridacna suggested " a recent recruitment event..... when bare space had become available. It is possible that this could be associated with the recent coral bleaching event, although there is no data to substantiate this." (Vol. II page 210)

The report continues with results of the fish surveys. Much of this is relevant to science and monitoring but has limited connection to resettlement feasibility per se.

Surveys also covered the terrestrial environment. Most of the terrestrial data and information generated appear in summary tables in Vol. IV, Appendix F.

The section ends with Environmental risk associated with future settlement.

"A characterization of the nature of anticipated environmental impacts associated with future resettlement (see sections 1 and 9) indicates that near-shore shallow water habitats close to the existing jetties at Ile du Coin and Ile Boddam would be most at risk from coastal construction practices (i.e. sedimentation, sewerage and filling near-shore areas). An analysis of the biological results reported above in tandem with the environmental assessment suggests that those sites identified as being most at threat from coastal impacts are of particular conservation interest as they have the best developed reefs with the highest cover and number of coral genera present. Should resettlement proceed it will be necessary to adopt measures to mitigate against these impacts."(Vol. II page 220)

The consultants should examine the hypothesis that the richness near the jetties is anthropogenic in origin and associated with the jetties.

When all is said and done, the best this section can offer is:

"The information gathered in these preliminary surveys have served as a foundation for the design of an appropriate and robust sampling programme." (Vol. II page 221)

#### 4.2.9 Coastal and Oceanic Processes

This section deals with waves (currents and overtopping) and sediment with the focus being:

“Low-lying islands, such as the Chagos Archipelago, are at risk of inundation from the sea, by large waves or increased water levels.” (Vol. II page 222)

“The wind speeds in the region tend to be relatively low; the maximum recorded during a thirty-year period at Diego Garcia was approximately 40 mph (35 knots) (Vol. II page 222)

“The wind and wave climates .... show a close, but not exclusive relationship.” (Vol. II page 222)

“On the basis of wind speed data it is therefore concluded that it is unlikely that a cyclone has passed over the Chagos during the last 30 years.” (Vol. II page 228)

Barometric records from Diego support the conclusion of ‘no cyclone’ over the last 30 years. (Vol. II page 230)

Cyclone tracks from 1980 to 2002 (see Figure 6.8 following page 232) show no cyclones in the Chagos during this period- not a hurricane/typhoon/cyclone of any degree. Amazingly, some came close to the south and southeast, but none passed through the Chagos.

So, in the matter of cyclones a more forthright and accurate statement, and one less shrouded with implications of risk would be: there is no evidence of a cyclone in the Chagos in the last 30 years of continuous weather recording, and only one reference to a cyclone ever occurring in the Chagos. That refers to a cyclone in 1891 “When great damage was caused- Admiralty Pilot”

Unusual rises and falls in sea level (surges) are associated with the immediate vicinity of cyclones. The consultant studied tide records from Diego Garcia (record 1988 to 2000) and found:

“... at Chagos the actual tide level has not varied significantly from the astronomical tide level during the period 1988 to 2000.”

To be frank, Chagos is blessed with being free of major tropical storms. Most atolls don't have that blessing.

Long period ‘swell waves’ generated by cyclones and other sources are a characteristic of the Indian Ocean and between 10 and 15 April 1987 caused severe

flooding in the Maldives. There was similar flooding in the Maldives in June and July 1988 (Vol. II page 232)

The consultant now makes a marvelous leap, in the total absence of evidence:

"It is very likely that Chagos experienced the same events, and it is likely that such events are not infrequent." (Vol. II page 232)

A conclusion such as the above makes me doubt the objectivity of the author(s). If indeed the events were "experienced", they certainly were not of the magnitude and nature experience in the Maldives. The events apparently passed Diego without causing any damage. What is worthy of inquiry is what dampens such 'events' so they aren't noticeable in the Chagos.

The author now turns to tsunami, and present evidence on one (one only because that seems to be all the author(s) turned up) sizeable earthquake (7.8 on the Richter scale in 1983). This powerful earthquake did significant damage to a number of buildings in Diego, and was accompanied by a tsunami, with substantial rise in water level that caused significant wave damage to the southwest tip of the island where a wooden pier was destroyed. (Vol. II page 234)

So, the tsunami accompanying the only powerful earthquake provided as evidence in this report caused significant wave damage to the southwest tip of Diego. It would have been useful for the consultants to have had a full report of this damage from BIOT and/or the military authorities.

Suffice it to say, dangerous as tsunami have proven to be in many areas, the Chagos cannot be included on the basis of any historical evidence or logical extension from earthquake activity, as a risky area for tsunamis.

Now the author(s) come to conclusion:

"... if a cyclone did occur, the combination of a significant tidal surge combined with large waves, would be devastating."

JJ comment: More to the point, what are the buffering effects of the Chagos that have apparently resulted in no major floods in the Chagos historical (as opposed to geologic) record?

"... Chagos does experience earthquakes, some of which are severe, and that at least some of these generate tsunamis. However, the risk and potential magnitude of similar events recurring in the future cannot be predicted with any certainty, given the current baseline information." (Vol. II page 234)

JJ comment: An 'n' of one severe earthquake suggests more than one; nevertheless, all historical evidence at hand indicates earthquakes and accompanying tsunami are rarely problematic in the Chagos.

The report now turns to inshore wave modeling for Peros Banhos and Salomon atolls in terms of interest in shoreline stability, overtopping and sediment transport.

The consultants use a Dutch Model- SWAN

I do not understand the source of the data set for “offshore wave climate”. What is clear is that it is not NOAA or UK Met Office The text says: “Visually observed data provides a much longer time series and consistency of the reported swell waves with actual records. The dataset was therefore used in determining the offshore wave climate.” (Vol. II page 236)

“From June to November the climate is dominated by waves from the southeast, with almost no wave energy from any other direction. For the rest of the year there are a greater proportion of waves from the northwest, but these do not completely dominate the climate.” (Vol. II page 236)

“Waves within the lagoons must enter through channels and over shallow reef areas and so the amount of energy entering the lagoon will be significantly dependent on the state of the tide. At low tide, water depth over the reef flats is very small and so wave propagation into the lagoon is very limited, whereas at high tide (1m water depth) large waves are able to enter the lagoons. To assess the influence of water level on propagation into the lagoons, the models were run at two water levels: 0.1CM (MLWS) and 1.2CD (MHWS). Two wave climates were produced for each wave model output point within each lagoon, representing the conditions at MHWS and MLWS.”

NB: The period of spring tides is the time each month when the tides are both highest and lowest. MHWS is average high of high tide during spring tides; MLWS is the associated height of low tide.

The model covered a large area to include the substantial effects of Great Chagos Bank, particularly on wave climate.

“The ocean climates at both Ile Boddam and Ile du Coin are dominated by waves from the southeast, corresponding to the dominant offshore wind direction. Ile Boddam has slightly larger waves from this direction, because the island is less protected by the Great Chagos Bank. Both climates also have some large waves from the northwest.

“At Ile Boddam the wave climates at high and low water within the lagoon both indicate a relatively calm environment.”

‘On the lagoon side of Ile du Coin the differences between the wave climate at high tide and at low tide are much subtler than at Ile Boddam. There is an overall reduction in waves energy and a lessening of wave dominance from the southeast.”

Above three quotes from Vol. II page 246

The section now proceeds to a juicy subject- “Extreme Waves”. Extreme events were calculated from 1/1 year to 1/1,000 years for use in predicting overtopping and sediment transport.

“On the ocean side of each island, the only significant waves are those propagating towards the islands from offshore. However, on the lagoon side of the islands, waves generated over the surface of the lagoon may be of comparable height to those that have propagated into the lagoon from offshore. The analysis was therefore split into two stages: calculation of inshore extreme wave height caused by offshore conditions and extreme wave height generated by the action of wind across the lagoons.”

JJ comment: First, the winds in the Chagos are moderate and the fetch in the lagoons limited- 30km for Peros Banhos (Coin) and only 7.5km for Salomon (Boddam). Moderate winds with limited fetch, passing over water with numerous coral heads, will not produce ‘extreme’ waves, except in a comparative, statistical sense.

“An extreme value analysis of the offshore wave data was undertaken to determine the wave heights associated with a range of return periods.”

“These waves were transferred to each of the inshore locations using SWAN.”

(NB JJ comment: appears to be one site each on the ocean and lagoon side of Coin and Boddam)

Table 6 (1 to 4) present the results of the SWAN runs for inshore waves generated by offshore extreme waves: e.g.

	Ile du Coin	Boddam
Inshore extreme wave height, ocean side	10.11m 5.54m	10.18 (1/1,000 yrs) 6.27 (1/1 )
Inshore extreme wave height, lagoon	3.04m 2.39m	0.71 (1/1,000 yrs) 0.54 (1/1 )

JJ comment: The inshore extremes on the ocean side, especially the 1/1 yr, do not appear to correspond to historic experience with the waves that actually beach on the backshore of these islands. The lagoon highs at Coin appear high (too high?) and also do not correspond with Ilois reminiscence of waves that actually hit the beach. These should be checked with Ilois.

“Waves within the lagoon originate from two main sources: waves propagated into the lagoon from offshore; and waves generated by the action of wind across the lagoon. The extreme wave heights calculated above correspond to waves originating offshore, whose height is greatly reduced by shallow reefs. For instance at Ile Boddam and Ile du Coin, the largest 1 in 50 year wave heights within the lagoon are 0.6m and 2.9m respectively and so wind generated waves within the lagoon could be significant.”

JJ comment: The results of calculations to reckon the waves generated within the Peros Banhos and Salomons lagoons appear in Figure 6.18, but my copy is not legible.

Summary conclusions of this section of the report are:

"On the ocean side of both islands locally generated wave are insignificant compared to the offshore ocean waves. Therefore, at these locations the extreme waves used are those described in Section 6.4.2."(Vol. II page 252)

The first sentence is clear. The second is not. Section 6.4.2 covers Methodology, Offshore Waves, Water Level, Model Extent, and Bathymetry. It doesn't cover extreme inshore waves whether ocean side or lagoon side. Figure 6.4 concerns Ile Boddam only.

"At Ile Boddam, the locally generated waves for any particular return period are larger than those that have propagated into the lagoon from the open ocean. Therefore, at these locations the extreme waves used are those described in Section 6.4.2." (Vol II page 252)

These two sentences don't make sense to me; what am I missing (?):

- i) Ile Boddam is part of the smaller of the two atolls and has a limited fetch. Locally generated waves cannot be substantial.
- ii) Section 6.4.2 covers Methodology, Offshore Waves, Water Level, Model Extent, and Bathymetry. It doesn't cover extreme inshore waves whether ocean side or lagoon side.
- iii) Table 6.4 contains information on Ile Boddam inshore lagoon side extreme waves, which are comparatively small.

"At Ile du Coin, the lagoon side of the island is relatively exposed to waves propagating through the large gaps in the ring of islands and so the ocean waves are larger than the locally generated waves for any given return period. Therefore, the extreme waves used in other areas of this study are those calculated in Section 6.4.2

At this point of the analysis, I have become wary and feel we need specialist review. This exercise is entirely theoretical. The report does not systematically compare the model with observations on the ground in Coin, Boddam, or Diego. Diego could have been included for comparative purposes: i.e. for observations of actual wave heights as opposed to heights predicted from the models.

The report now turns to a section on OVERTOPPING.

"This Section describes work undertaken to establish the rate of overtopping at Peros Banhos and Salomon due to storm wave events. Over topping is most likely to occur on the ocean side of the island because the wave energy is much greater than that on the lagoon side. This is supported by the fact that beach material, including quite large boulders, was found on dry land up to 20m from the ocean shore, whereas no evidence of previous overtopping was found on the lagoon side. The overtopping calculations have therefore been performed at a number of locations on the ocean facing sides of Ile Boddam and Ile du Coin."(Vol. II page 254)

JJ comments: It would be useful to know the amount/volume and not just the rate of overtopping. Are we dealing with trivial or significant amounts however defined?

It is important to appreciate that THERE IS NO EMPIRICAL EVIDENCE OF OVERTOPPING ON THE LAGOON SIDES OF THE ISLANDS. Therefore, the height of waves calculated for the lagoon sides are not associated with evidence of overtopping on the lagoon shores.

"The width of the reef in front of ocean facing beaches is one of the factors most likely to influence the amount of over topping. Much more wave energy will be dissipated over a wide reef compared to a narrow one, and so overtopping will be correspondingly less. The profiles analyzed were therefore chosen to represent lengths of coast protected by a range of reef widths." (Vol. II page 254)

Return periods were 1/1, 1/50 and 1/1,000 years. A numerical model named AMAZON-WAVEWATCH was used. AMAZON seems to take much into account but has an identified weakness:

"... it is important to bear in mind that it does not take into account any effects longitudinal to the beach (i.e. at a right angle to the plan in which it operates). For instance the model will simulate wave set-up, but the prediction is only strictly correct for an infinitely long and straight coastline. In the case of an island, actual wave set-up towards the end of the island will be less than predicted because of the flow of water parallel to the beach and around the ends of the island."

"The qualitative (NB my underline for emphasis) behaviour of the model accorded with observations made on site, although significantly smaller waves were observed during field studies.(NB my underline for emphasis) The model shows waves initially breaking on the outer edge of the reef before surging forwards across the flat foreshore and running up the beach. A manual calculation was undertaken using a method described in the Shore Protection Manual (1984) which also produced similar overtopping rates to those predicted by AMAZON-WAVEWATCH." (Vol. II page 256)

The author(s) has set the stage for the most interesting outcome.

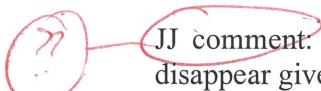
“Figures 6.20 to 6.24 summarize the mean overtopping rates per metre of coast during a complete spring tide cycle. The area under the graph represents the volume of water being deposited onto the island during a spring tide cycle. The results are summarized in Figure 6.25.”

The observations in the report are:

“The calculated total volume deposited onto the island, even for the 1 in 1 year event, is very large and would almost certainly cause significant flooding.” (Vol. II page 256)

Again, the figures in my copy are not completely legible. No matter, the consultants seem to feel the volumes are unrealistic and immediately proceed with:

“However, the actual volume of water flowing onto the island would be less than predicted because of the dissipation of wave set-up, and the dense vegetation immediately inshore of the beach, which would restrict the flow of water onto the island.”

 JJ comment. It must be dissipation of wave set-up because the vegetation would disappear given the model predictions for overtopping volumes/metre of beach.

“The overtopping quantities at Ile Boddam are between 60% and 85% less than those predicted at Ile du Coin. This is because the ocean side wave climate at Ile du Coin contains larger waves from the west and southwest directions, which directly approach the coast. Overtopping rates with sea level rise were between 20% and 50% higher than the corresponding existing situation.” (Vol. II page 256)

The problem is not the reality but the model, and this the consultants proceed to acknowledge.

“The principle reason for the pessimistic overtopping results is probably the fact that both AMAZON-WAVEWATCH and the manual calculation do not take into account effects parallel to the beach. The main cause of the very high overtopping rates predicted is the high wave set-up, which is in excess of that observed in the Maldives during the 1987 flood event. In reality, flow parallel to the beach and around the ends of the islands would significantly alleviate the build up of water immediately in front of the ocean side defenses.” (Vol. II page 263)

So, after the considerable effort in modeling, the models produce results that are at odds with reality. And at last the author(s) acknowledges this:

“The fact that the Ilois survived this environment for some eight generations (JJ NB ~ 240 yrs), and that copra was cultivated on a commercial basis during this time, suggests that the islands have not, historically, been subject to frequent inundation by seawater (JJ NB So much for the model ‘predictions’). Alongside this, there is a record (JJ NB A record not records) of severe cyclonic damage in 1891 (JJ NB I’m not sure there exists a record of this damage bar the passing comment in the Admiralty document. It would be worth checking with the Ilois for any folk history of such an event (s)), together with more recent events as the flooding event that occurred in the Maldives in April 1987 (JJ NB For which there is no Chagos evidence of flooding). In the future we can expect flooding to be more frequent as sea level rises, thus lowering the threshold event that can result in overtopping the ocean coastal ridge.” (Vol. II page 263)

The author(s) now proceed to sum up.

“Summing up, it is likely that overtopping caused by wave action on the ocean side occurs regularly (e.g. more frequently than annually) but this does not necessarily lead to inland flooding. From time to time, when the sea is elevated, principally through wave set-up, severe flooding over a significant proportion of the island can be expected to occur. The return period for such an event is not known, however, from available (very limited) evidence this might be expected to be in the order of tens of year.”  
(Vol. II page 263)

In the above quote from the report, the first sentence fits the evidence. The second and third are sheer speculation in the face of no information that such events have happened in the historical record. No such event has been remarked save for one reference to one cyclone in 1891. Inundation in the Chagos is not supported by the historical record and evidence on the ground. Limited overtopping- affecting limited areas and without chronic destructive effects save as evidenced in restricted areas of saline soil- is part of the record. The possibility of future inundation should be assessed with an approach that attempts to correlate on the ground and marine observations with modeling and tries to expand the corpus of historical information, especially from Diego.

The author suggests a topographic survey to assist with infrastructure location and suitable designs for infrastructure in case of flood. These make sense.

The author(s) state:

“The analysis has highlighted that overtopping and the subsequent flooding is potentially a very serious problem for any resettlement scenario.”

JJ comment: This is similar to saying: a meteor falling on New York is potentially a very serious problem for the community.

"However, the magnitudes of such events are likely to be strongly influenced by flow parallel to the beach, which is not accounted for in this study."

JJ comment: This is an indirect way of acknowledging that the model calculations do not correspond with ground truth.

The report continues:

"In order to quantify the overtopping rates and subsequent magnitude of any flooding it would be necessary to combine two-dimensional modeling with topographic mapping of the islands. Consultation with the Ilois to derive anecdotal evidence would also assist with calibrating the models."

JJ comment: The model cannot quantify the overtopping rates and subsequent magnitude of flooding. Maybe the Ilois have information the consultants don't, but should have to make reasonable conclusions!

The report now changes topic to Sediment Transport.

Purpose is: "... to develop a conceptual model of the movement of material along the beaches and nearshore areas around the Ile du Coin and Ile Boddam."

"The lagoon side beach is generally characteristic of a low energy environment ... The lagoon side beaches on both islands appear to be healthy, ..." (Vol. II page 265)

Along some lengths of the ocean side coast there is a small cliff, up to 1m high, between the top of the beach and the island level. In many instances the cliff face appears fresh and tree roots exposed; in some instances coconut trees have been undermined and have fallen." (Vol. II page 266)

The author(s) now make a leap:

"This (NB the previous quoted material) suggests that much of the ocean side coast is retreating."

But how much, what proportion has cliffs? How much is retreating? Is this a process of uniform retreat, or retreat here and advance there as is typical of many beach fronts?

"... if the conditions are severe, or there is insufficient material on the beach, then the ridge may be overtopped and/or completely washed away. This would result in beach material being deposited behind the line of the beach. There was widespread evidence of this amongst the vegetation behind ocean beaches on both islands." (Vol. II page 266)

The report refers to a model used to calculate longshore sediment transport.

“... on average, material is transported towards the north/northwest ends of both islands. However the wave climate exhibits a 180 degree seasonal rotation: from May to November the climate consists largely of waves from the southeast, whilst for the rest of the year there are more waves from the northwest. ... This may also be the reason why there are spits at both ends of the islands.”(Vol. II page 268)

“... to restore or sustain the natural reef barrier, the new coral growth must equal or outpace the combined effect of continued erosion of the weakened reef and sea-level rise. Whilst there is uncertainty as to the outcome of this ‘race’, Sheppard points out that reef growth is, in any case, much slower than that of its constituent coral, being only 0.2 to 3mm/year. As such, it may be less than current predicted estimates of sea level rise (See Section 8).” (Vol. II page 275)

Conclusions seems to be:

- i) Ocean side is retreating.
- ii) The lagoon side is fairly stable.
- iii) Global warming is likely to make things worse.

The report now turns to currents- of relevance to sediment and effluent dispersion and sediment transport analyses.

Tidal range is limited- between 1.2 (mean high water spring) and 0.1m (mean low water spring).

In the lagoons:

“.. the predicted velocities are small and comparable with measured currents.” (Vol. II page 278)

Discussion follows of oceanic and wind driven currents; and of Peros Banhos and Salomon currents in general and in terms of measurements.

At this point we come to Conclusions-

“The most important conclusion is that both Ile Boddam and Ile du Coin are likely to experience severe overtopping. Even though the overtopping is significantly lower at Ile Boddam it is still likely to cause significant flooding, particularly during the longer return events.”

No empirical evidence is produced of severe overtopping with significant flooding ever having taken place in the historical record. The entire assertion is based on a model which the consultants recognize as flawed in exaggerating the amount of ‘overtopping’. Overtopping is a normal event affecting small areas along the ocean beaches.

"If development were to proceed, then flooding would need to be managed to prevent damage of property, infrastructure and possibly loss of life."

Fact is: there is no substantial flooding on anything approaching a regular basis. The best way to avoid the off-chance of damage is to site infrastructure in sensible fashion on the lagoon sides. The mention of loss of life is ludicrous. Chagos is actually a very benign place. If flooding were a threat to life, you can bet the Ilois, having spent eight generations on the islands, would be well informed of the dangers. The consultant is conjuring danger where danger does not exist.

"Sea level rise would reduce the freeboard and lead to even greater overtopping in the future." (Vol. II page 284)

This is a possibility that needs to be, and can be planned for and managed.

"Cyclones have been shown to occur in the region, although the frequency is very low (1891 was the last cyclone reliably reported). However, if such an event did occur then severe flooding would be likely."

JJ comment: Disaster management planning is prudent. Fixing on rare events to constrain life is not realistic. Plan and manage to cope as necessary. That's the ticket.

"An investigation of other severe events has highlighted the risk of earthquakes and associated Tsunami. Such events have been shown to have occurred in the past and are likely to occur in the future. It is not possible to estimate the frequency posed by such events. However, Tsunami have struck other parts of the world without warning and caused severe damage and loss of life. The earthquake risk should be further investigated prior to development of the islands. Apart from the effects of Tsunami, assessment should be made that suitable seismic design parameters are employed for all construction works." (Vol. II page 284)

As with cyclones, the consultants have uncovered one earthquake and one tsunami in the Chagos record and are extrapolating. Cyclone, earthquake, and tsunami do not seem to have impeded development and operation of the military base on Diego. Is this scare mongering meant to hinder/postpone repatriation of the Ilois?

"... ocean side of the islands is generally eroding, but it has not been possible to quantify the rate of erosion. It is important to establish this prior to considering any plans for future development. Failure to do so could result in development in inappropriate areas and lead to a high burden of coastal defense for future generations." (Vol. II page 284)

Whether the ocean sides are generally eroding and if so at a threatening pace has NOT been established. The lagoon sides are certainly not eroding. Lagoon sides, for excellent reasons are the locations for infrastructure in the past and for the resettlement. It would be daft to build on the ocean side edge as to walk into rush-hour traffic with a blindfold. That is not going to happen. At foreseeable levels of investment/settlement/infrastructure, ocean side sea defenses could not be justified and won't be built.

This section ends with a plea for either long term monitoring or "... a series of historic aerial photographs (which are known to exist but were not available to the study)."

JJ comment: Long-term monitoring would be comparatively expensive, and air photography comparatively inexpensive means to generate relevant information. It is surprising that aerial photography was not provided by BIOT or the military authorities.

#### 4.2.10 Water Quality and Environmental Variables

This section appears most concerned with water quality issues that affect coral, of which the most important proximate influences are said to be light, wave action, sediment load, salinity and tidal range, but on a broad scale, nutrients, temperature, and sea floor topography. The purpose is stated to be measurement of key variables-water temperature, salinity, turbidity, sedimentation and nutrients in the near-shore waters of Coin and Boddam. (Vol. II page 286)

High levels of N and P are detrimental to coral, as is eutropication in general.

Samples were taken.

Notable conclusions.

"The results of the spot sampling indicate that phosphate concentrations at all stations were above the critical threshold reported to cause a decline in coral reefs, although nitrate values were below the critical threshold. ... There is no obvious explanation for the high concentrations of phosphate in coastal waters in the Chagos." (Vol. II page 299)

And:

"To resolve this issue, further studies are required with more extensive sampling."

"If the nutrient concentrations reported here are correct then this has important implications if the Chagos Archipelago were to be resettled. High concentrations of critical nutrients in nearshore coastal water necessitate that special management precautions would be needed for the discharge of wastewater and land based run-off in order to preserve coral reef communities." (Vol. II page 299)

"On the basis of the above, the sedimentation rates at Ile du Coin could be considered as damaging to reefs. However, the results of spot sampling must be interpreted with caution." (Vol. II page 300)

We now come to a summing up that seems to me to obscure inadequate work on the one hand, and to generate more work for the consultant on the other:

"The information gathered in these surveys has helped to identify the natural variability in key environmental parameters, which is essential for the formulation of any future long-term monitoring programme. However, results from spot sampling over short-time periods can be misleading and it is essential that data be collected over longer periods of time to ensure that the full range of natural variability is quantified." (Vol. II page 300)

I agree with the consultant's second sentence and reckon that a programme of at least five years, perhaps with monthly and more frequent sampling, would be necessary to get some handle on what is happening. The question is: why was this work done at all when the time and effort available were not commensurate with the requirement? I'm sure the consultants appreciate much of what should have been done, that was not, and must have moments of misgiving about what was done that probably shouldn't have been done given the time available.

Volume II finishes with a useful bibliography.

## 5. **Volume III: Resettlement Issues**

### 5.1 Climate Change and Implications for Resettlement

"Climate change, derived from the atmospheric build up of greenhouse gases is supposed to become evident by the middle of this century." (Vol. III page 315)

The report presents relevant information from the International Panel on Climate Change (IPCC), 2001:

- i) During the 20<sup>th</sup> C, global temp increased by 0.6+-0.2 deg C; and sea level rose 0.1 and 0.2m; precipitation increased by 0.2- 0.3% between 10 degrees N Lat and 10 degrees S Lat.; El Nino- the Southern Oscillation has become more common in the last third of the century. Change in storm activities remains uncertain.
- ii) During the 21<sup>st</sup> C, global average surface and sea temperatures will increase; and sea level rise. El Nino phenomena will stabilize at present levels.
- iii) "...global mean surface temperature and rising sea-level from the thermal expansion of the oceans are projected to continue for hundreds of years after the stabilization of greenhouse gases owing to long time-scales on which the deep ocean adjusts to climate change." (all the IPCC material from Vol. III page 316)

The report now moves to implications for small island states and bias is apparent:

“Characteristics that increase their vulnerability (the report is referring to small island states “ like the Chagos Archipelago”) to the projected impacts of climate change include their small size, limited natural resources, relative isolation, proneness to disasters and extreme events, and the fact that they are surrounded by large expanses of ocean.”

Having set the stage reasonably, the report goes off-track.

“Large populations with high growth rates and densities, poorly developed infrastructure, and limited human resources and skills exacerbate these physical attributes. Together, these factors limit the capacity of the islands and their people to mitigate and adapt to future climate change.”(Vol. III page 316)

I think it unlikely the citizens of, say, Bermuda, the Falklands or the Hebrides, Hawaii, Seychelles or Maldives would as a rule characterize their societies as generally being of high growth rate and density, with poorly developed infrastructure, and limited human resources and skills.

The report continues:

“At the present time it is not possible to quantify the risk associated with climate change for the Chagos islands as there is a lack of information for the Indian Ocean in general, and in particular the central Indian Ocean Islands.” (Vol. III page 317)

The report now refers to the IPCC Climate Change 2001: Impacts, Adaptation and Vulnerability as identifying the following “key issues as priority concerns of small island states, particularly those still in developmental stages”

“ . . . Development and equity issues;

JJ Comment: Except for the fisheries section and to a lesser degree the soils section and some infrastructure observations, development has been a peripheral concern of this resettlement feasibility study, and equity has not featured at all.

“ . . . Sea level rise and implications for coastal vulnerability and water resources;

JJ Comment: Sea level rise and coastal vulnerability have been very much in focus in this report. As for water resources, the report has been silent on rain harvesting as a strategic response to sea induced threat to groundwater.

“ Biological systems and diversity;

JJ Comment: These have been adequately addressed in the report.

“ Fisheries and aquaculture;

JJ Comment: These too have been adequately, even admirably, addressed in the report.

“ Human health, settlement and infrastructure.

JJ Comment: Health has not been addressed at all. Settlement and infrastructure have been address in a cursory fashion, totally inappropriate for a resettlement feasibility study.

So, in reflecting on the IPCC concerns it becomes apparent that the natural phenomena have attracted interest in this study but major humane issues have not.

The report now assesses the IPCC issues for the Chagos.

1) Development and equity.

This rates two sentences in the report:

“Developing countries generally have a lower capacity to adapt and are therefore likely to be more vulnerable to the effects of climate change. A resettled population within the Chagos Archipelago will require skills, or access to specialist advice, to enable them to plan and manage their infrastructure and livelihood strategies in such a manner as to limit their vulnerability.”

JJ Comment: I wonder how the consultants would rate their work in terms of its contribution to issues addressed in the second sentence.

2) Sea level rise and implications for coastal vulnerability and water resources

Having a mean island height of 2m, Chagos as other Indian and Pacific Ocean atolls, have an increase in flood risk. Landloss per se may become a problem. Groundwater may be more vulnerable to salt water intrusion on a temporary basis (freshwater lens clear themselves of salt water in a matter of months depending on the recharge characteristics), or in the case of land loss, then total loss of the contained groundwater.

JJ comment: Land loss may be inevitable and should be planned for. Loss of groundwater can be planned for in combination with strategic attention to rainwater harvesting.

3) Implications of sea level rise and increased storminess in the Chagos Archipelago

The report acknowledges:

- i) There is No Consensus in the IPCC on the issue of increased storminess, and
- ii) The Chagos lies just north of the boundary of the cyclone belt.

Nevertheless, the author (s) speculate that:

“... a very small northern shift (2 to 3 degrees) in the boundary of the cyclone belt could result in a dramatic increase in the frequency of cyclones likely to affect the Chagos..... the main consequence of a cyclone is likely to be widespread flooding of the island” (Vol. III page 320)

JJ comment: the report fails to give equal consideration to the implications if there is no movement in the cyclone boundary, or that, rather than move north, the boundary moves south. The resettlement should certainly plan for storms; but, on the basis of objective analysis, storms should not be a principal concern.

The report acknowledges the picture is not entirely bleak:

“In the short term, the lagoon shore may not be significantly affected. The increased rate of erosion of the ocean coast would produce more material, which would then supply the end of island spits and hence the lagoon side beaches. Provided the supply of material to the lagoon side beaches was sufficient, they may be able to keep pace with the rising sea level. However, this natural balance will only function for small changes in sea level rise.”  
(Vol. III page 320)

Given rise in sea level, overtopping events would increase in frequency and quantity. The quantitative nature of this phenomena remains obscure. Historically, overtopping has not been a problem for Chagos settlement and economy; nevertheless, the potential for overtopping that floods to the lagoon side should be planned for and can be managed with modest investment.

4) Biological systems and diversity

“Coral reefs represent the most important natural habitat in the Chagos Archipelago, their diverse habitat providing shelter and a source of food as well as breeding grounds to support a large number of fish and invertebrate species. They also provide a variety of services, the main ones being the production of beach sand and a natural defense (breakwater) along the coast of low-lying islands. Currently coral reefs are facing severe threats from both climate and non-climate stressors. A recent global assessment considered that 58% of coral reefs are considered at risk from human activities ... In the Chagos Archipelago, due to the absence of permanent populations, the reefs in the northern atolls would be expected to be healthy and therefore be less susceptible to threats associated with climate change compared to many Indian Ocean reefs...”

“In 1995, the IPCC suggested that healthy reef-flats would be able to keep pace with projected sea level increases..... However, the prognosis is now far less certain for many reef systems in the Indian Ocean where reef structures have been weakened by a variety of climate and human stressors....

“... projections suggest that the thermal tolerance of corals will be exceeded within the next two decades (IPCC 2001)....

“A severe coral bleaching event across the world in 1998 indicated that the incidence of coral bleaching is likely to rise rapidly with increase in surface temperatures ...

“There is considerable uncertainty about how climate change will affect biodiversity in areas such as the Chagos Archipelago ....

All the above quotes are Vol. III page 322.

5)      Fisheries and aquaculture

Climate change will have both positive and negative effects on both fisheries and aquaculture. Not much more than that can be concluded generally.

6)      Human health, settlement and infrastructure

This section gets four sentences-

“Due to their coastal location the majority of any future socio-economic activities, infrastructure and population are likely to be highly vulnerable to the impacts of climate change. ... The small physical size and low elevation means that virtually all infrastructure will be vulnerable to sea level rise and flooding and storm surges. Considerations for appropriate infrastructure design are provided in Section 9.” Vol. III page 323)

The report now proceeds to a more positive theme- adapting to vulnerability and, on the basis of experience in comparable settings, considers/recommends:

1)      Integrated coastal management

- “Avoid development in areas that are vulnerable to inundation- enforce development setbacks, especially on ocean sides;
- “Ensure that critical natural systems continue to function;
- “Protect human lives, essential properties and economic activities

2)      “Accommodation”- replace infrastructure and dwellings at a rate commensurate with island migration

- 3) "Protection"- coastal protection infrastructure- "This is likely to be the most costly strategy, and should be avoided through wise land use planning."

"Discussion of the possible response of coral reefs to sea-level rise indicates that at worst reef food and sediment resources diminish and at best they are maintained at similar levels or may even increase. The importance of reefs as both natural coastal protection structures and any human livelihood activities, should not compromise the health of the reef system. Minimizing adverse effects on reefs will require robust pollution control measures and effective waste management."

All references and quotes concerning (6) above are Vol. III pages 323-325)

The section concludes:

"... the Chagos Archipelago, and any future population settled on the outer atolls, will be vulnerable to (climate change). The main issue..... will be flooding."

"Climate change is a pressing issue facing most if not all atoll communities throughout the world. There is a considerable body of research into the adaptation responses that populations can embrace in order to reduce their vulnerability, at least within the next decades. .... The ability of a resettled population to reduce their vulnerability will very much depend upon the approach that is taken to plan and manage their infrastructure and activities. It is recommended that any resettlement programme within the archipelago adopts a framework for integrated coastal management, which will incorporate the principles of sustainable development. Recommendations for the development of an integrated coastal management plan are provided in Section 11." Vol. III page 326

I note the passage is silent on the fact that a first principle of integrated coastal management is full and transparent provision of relevant information to the people affected- in this instance, the Ilois.

And as an aside, my feeling is that many if not a majority of Ilois would prefer to exchange their familiar social and economic vulnerability in Mauritius, for the vulnerability to global warming in the Chagos.

## 5.2 Environmental Appraisal of Resettlement

"In the absence of a definitive picture of resettlement, in terms of numbers of people, infrastructure requirement and livelihood (and other) activities, a number of hypothetical development scenarios have been devised to guide this appraisal. ... Due to lack of specific information on resettlement, the issues outlined in this section are necessarily generic and broad."

“Environmental impact assessment (EIA), in all its forms, is a consultative and participatory process between scientists, environmental managers, developers, public bodies, government authorities and the public .... The formal document required by law or regulation is referred to as an environmental impact statement. The appraisal undertaken here does not constitute a strategic environmental assessment, as there is insufficient information on the basic resettlement proposals. ...

“As information on the specific details of the scale and technical specifications of the project is not available it is impractical to provide an accurate indication of potential impacts and mitigation measures. This appraisal is, therefore, by default based on consideration of generic issues rather than specific information.”

The preceding three quotes are from Vol. III page 327.

Impacts are said to occur during (i) construction and operation of infrastructure, and ii) day to day living and livelihood activities.

The generic observations of the consultants are for the most-part straight-forward and conventional. They cover buildings, roads, harbour facilities (jetties and docks, foreshore facilities, channel amendments and dredging) and rightly emphasize the importance of proper site selection and appropriate designs.

“... quarrying operations on the shallow reef flats for foreshore protection, harbour and airfield projects in the Marshall and Caroline Islands, Micronesia, have improved the value of the habitat for reef fishes and coral reefs. Corals, fish, and associated reef invertebrates are capable of rapid recovery in holes created by dredging and quarrying, particularly in clear waters subject to flushing from wave action or currents.... An evaluation of impacts of dredging in Diego Garcia found no evidence for any significant change to reef communities 7 years after completion of works...” (Vol. III page 332)

The living and livelihood issues include:

- i) sewerage and wastewater (with recommendations to treat both sewerage and wastewater and site outfalls appropriately), solid waste.

“It will be essential to consider a strategy for the development of an integrated waste management plan at the earliest phase of the resettlement proposal. ..... Mechanisms to reduce impacts include minimization, recycling, composting and possibly material recovery.” (Vol. III page 335)

- ii) fisheries- general growth in fishing pressure and expansion of activities to areas not previously fished commercially; over-exploitation of target species, ghost fishing gear and promotion of sustainable fisheries management, including education for the community; fish-processing facilities and dangers of pollution from water demand, fuel and waste water; mariculture scale that may lead to ecosystem imbalances.

iii) agriculture- dealt with in one paragraph because of the uncertainties as to what will be done.

iv) tourism- the information provided is much the same as in the Phase 1 study, but includes a short review of the development scenario implications, while cautioning-

“Any future development of tourism in the Chagos will be closely linked to biodiversity conservation and the sustainable management of the country’s coastal resources ..... Tourism development .... must be integrated into the overall coastal management plans...be accompanied by guidelines for environmental planning and design .... tourism laws and regulations

In so far as impact evaluation, the consultants state:

“At this stage a detailed evaluation of the potential positive and negative benefits of resettlement is not possible, as the former requires a full understanding of the socioeconomic characteristics of the population and the development activities to be undertaken, which is not currently available.”  
(Vol. III page 340)

### 5.3 Infrastructure Needs

This section is based on the hypothetic development scenarios “In the absence of awareness of the ambitions of the Ilois that may wish to resettle within the Chagos...”  
(Vol. III page 343) It covers jetties, sea defenses, effluent disposal, effluent and sediment dispersion. Some of the argument is based on measurement and observations made on site.

The section begins with reference to overtopping and coastal erosion, considered unlikely to be problems on the lagoon side of the islands. It considers coastal defense as impractical and unsustainable in view of predicted climate change, but continues “... on the assumption that defenses would be required...” (Vol. III page 344)

“Rather than dealing with overtopping at the coastal edge, it may be better, and more economical, to manage the flooding using bunds. These would not have to resist significant wave action, and in their simplest form could be an earthy bank. The bunds could be set back from the ocean side defense or located to defend specific areas of the islands, such as the fresh water zone, particular infrastructure or residential areas.

“The main problem along the lagoon shore is likely to be the dynamic pattern of erosion and accretion, rather than long-term persistent erosion.”

Above two quotes from Vol. III page 345.

The old Ile Boddam jetty is dilapidated but useable and would be relatively easy to repair; the Ile du Coin jetty is no longer useable. Both jetties are well sited. The author prefers mass gravity structure to piles because of the difficulty in piling through coral.

“A numerical model, CORMIX, was used to model a potential effluent plume and hence calculate the concentration of various pollutants at a distance downstream of the outfall. These concentrations were then compared with acceptable limits to assess the need for sewerage treatment.” (Vol. III page 347)

“The sensitivity analysis shown that the concentration at the downstream boundary increases if:

- Current velocity decreases (Significant);
  - Rate of discharge increases (Significant);
  - Depth of outfall decreases (Minor).”
- (Vol. III page 349)

Suggest use guidelines on sewerage discharge of the Great Barrier Reef marine Park Authority, as EC and IK guidelines are too lenient to ensure coral health.

Trial discharge locations and outputs suggest “... pollutant concentrations .... to be generally within acceptable limits for discharge into a coral reef environment. The discharge location has been assumed to be on the ocean side of the island to ensure dispersion of the plume into the ocean environment, rather than the enclosed lagoon. However, the location of an outfall along the ocean side should be chosen with care to ensure that the plume does not re-enter the lagoon through the channels at either end of the islands.” (Vol. III page 354)

However,

“The pollutant concentrations apply at a location 1500m downstream of the outfall. Locally around the outfall the concentrations are likely to be higher than the acceptable limits. To minimize the impact on the local area some form of treatment is recommended.” (Vol. III page 355)

Conclusions and recommendations on sewerage follow.

“At a distance of 1500m downstream of an untreated outfall discharging up to 200 m<sup>3</sup> per day the levels of most pollutants, including total nitrogen and phosphorus, are generally within acceptable limits for a coral reef environment. However, concentrations of Total Colliforms and Total Enteroviruses exceed recommended levels. Concentrations of all pollutants locally around the outfall are above the recommended limits.

“To reduce the impact on the local environment it is recommended that the effluent undergoes primary treatment and, preferably, also secondary treatment prior to discharge into the ocean, particularly if the areas likely to be affected by the effluent plume are used for bathing or fishing.