4.0 Natural Resources (Plants, Fish and Wildlife)

4.1 Introduction

An ecosystem includes all of the organisms in a given area as well as the abiotic factors with which they interact, or a community of organisms and their physical environment. An atoll is defined as " . . . a more or less continuous emerged or slightly submerged calcareous reef surrounding a distinctly deeper lagoon or several such lagoons without emerged volcanic islands, which stand apart from other islands, and whose upper seaward slopes rise steeper than the repose angle of loose sediments from a generally volcanic foundation too deep for the growth of corals (Wiens, 1962)."

The entire atoll of Diego Garcia constitutes as an ecosystem, with the two main components being the terrestrial and marine communities. Atolls can be biologically diverse and also vulnerable to harmful environmental impacts. Because of their relatively small size and isolation, seemingly minor environmental impacts can produce significant adverse consequences. Also, due to their isolation, recruitment of replacement organisms tends to be very slow. Globally, tropical marine communities, and atoll communities in particular, are suffering environmental degradation on an unprecedented scale. The relatively pristine marine community at Diego Garcia, therefore, is especially significant. In light of the increasing scarcity of intact atoll reef communities, maintaining and enhancing Diego Garcia's marine community is a priority.

This chapter is organized into two sections, 1) Terrestrial Natural Resources (4.2) and 2) Marine Natural Resources (4.3). Terrestrial Natural Resources describes the current status of the terrestrial vegetation and wildlife within the atoll, while the Marine Natural Resources will cover marine species within the lagoon and on the outside of the atoll.

4.1.1 Previous Surveys for the Natural Resources Management Plan

Two avifaunal and mammal field reconnaissance surveys were conducted on Diego Garcia in March and July of 1995 and one botanical survey was completed in March of 1995. The restricted land on the east side of the atoll (access controlled by the BRITREP) was also investigated in 1995 for comparative purposes. The West, Middle, and East Islets at the northern end of the atoll were also briefly surveyed from a boat. Please see Appendices E 1 and F1 for complete survey information.

4.1.2 Surveys Conducted for this Update

Four studies were accomplished during the July 17 – 24, 2003, field surveys. Bird surveys were conducted along the length of the atoll at 51 count stations. A study to determine the distribution of the recently introduced garden lizard (*Calotes versicolor*) was accomplished at and around the Sea Bee Beach Park. A coconut crab study was conducted at two locations on the main island. Additionally, beach surveys for turtle nesting activity were completed along the ocean side of the island.

Six studies were accomplished on the main island and the three islands at the north end of the atoll were visited during the March 9-15, 2004, field surveys. Bird surveys were conducted along the length of the atoll and on the islands at 53 count stations. A coconut crab abundance study was conducted using both quadrats and transect lines along with an abundance study of the rats in the area past Minni Minni (the BIOT restricted area). A mark and recapture study of the donkeys living on the island was conducted and beach surveys for turtle nesting activity were also made along the ocean side of the island along with the three islands at the north end of the atoll. The major vegetation types on the main island were delineated using GPS and maps were produced in ArcGIS 8.3. Additionally, all locations of locally important native vegetation were mapped along with any introduced species of concern. These studies can be found in Appendices E2, F2 (a & b) and G-K.

Marine field surveys were conducted July 28 - August 18, 2004. Standard procedures for coral reef investigations were utilized and fishes were surveyed using Roving Fish Counts and Belt Transects. Incidental observations were also noted. Please see Appendix O for a detailed description.

4.2 Terrestrial Natural Resources

There is no one key limiting resource in a terrestrial environment. Potential limiting factors include substrate/soil quality, wind velocity, light (intensity and quality), temperature, humidity, air quality, water (availability and quality), noise levels, food availability, species composition, suitable shelter and breeding areas. Availability of vital resources may become scarce through natural events such as a drought or through the accidental introduction of an alien species that uses up the available resources.

4.2.1 Vegetation

The 2004 survey focused not on preparing a species list for the main island, as one had been completed in previous surveys, but to look for significant changes in vegetation type, threatened and endangered species, significant native species and invasive species. However, species lists were generated for the three islands at the mouth of the atoll: East, Middle and West Islands (Appendix E2).

This section is divided into two parts, Vegetation Description and Introduced Vegetation. Vegetation Description describes vegetation types found on Diego Garcia Atoll and lists the plants that are indigenous to the area (species that are native to Diego Garcia and are also found elsewhere in the world). There have been no endemic species of plants found on Diego Garcia (those species that are confined to a specific, relatively small geographic area [species occurring on Diego Garcia and no where else in the world]). Introduced Vegetation describes species that have been purposefully brought in for landscaping or food or through accidental introductions. These species are not native and may have the potential to adversely affect native species.

Figure 4.1 Vegetation along the shoreline of the lagoon.

4.2.1.1 Vegetation Description

Over 200 native and non-native floral species have been recorded on Diego Garcia during previous surveys (Atoll Research Bulletin 1971, Whistler 1996 and Topp & Sheppard 1999). There are 42 native plant species listed for Diego Garcia

(Topp & Sheppard 1999), comprising twelve tree species, five shrub species, thirteen dicot herbs, four grass and sedge species, four vine species, and five fern species (Table 4.1).

Table 4.1 Probable native plant species found on Diego Garcia (all species from Topp & Sheppard 1999).

Native Tree Species		**Native Shrub Species**	
Common Name	**Latin Name**	**Common Name**	**Latin Name**
fish-poison tree	*Barringtonia asiatica*	gray nickers	*Caesalpinia bonduc*
true kamani, Alexandrian laurel	*Callophyllum inophyllum*	pemphis	*Pemphis acidula*
coconut	*Cocos nucifera*	premna	*Premna obtusifolia*
cordia or kou	*Cordia subcordata*	naupaka or scavvy	*Scaevola taccada*
guettarda	*Guettarda speciosa*	suriana	*Suriana maritima*
ifil tree	*Intsia bijuga*		
lantern tree	*Hernandia sonora* L.	**Native Vine Species**	
Indian mulberry (noni)	*Morinda citrifolia*	**Common Name**	**Latin Name**
fago	*Neisosperma oppositifolium (Neiosperma oppositifolia)*	St. Thomas bean	*Canavalia cathartica*
pisonia	*Pisonia grandis*	false dodder	*Cassytha filiformis*
beach heliotrope	*Tournefortia argentea*	beach morning-glory	*Ipomoea pescaprae*
ironwood	*Casuarina equisetifolia*	-	*Ipomoea macrantha*
Native Herb Species		**Native Fern Species**	
Common Name	**Latin Name**	**Common Name**	**Latin Name**
achyranthes	*Achyranthes aspera* var. *velutina*	-	*Asplenium longissimum*
-	*Lagrezia micrantha*	-	*Asplenium macrophyllum*
-	*Lagrezia oligomeroides*	bird's nest fern	*Asplenium nidus*
water hyssop	*Bacopa monnieri*	marsh fern	*Cyclosorus interruptus*
boerhavia	*Boerhavia repens*	a fern ally	*Psilotum nudum*
portulaca	*Portulaca mauritiensis*	**Native Sedge Species**	
portulaca	*Portulaca oleracea* L.	**Common Name**	**Latin Name**
sida	*Sida pusilla*	-	*Eleocharis geniculata*
sea grass	*Thalassodendron ciliatum*	-	*Fimbristylis cymosa*
-	*Triumfetta procumbens*	**Native Grass Species**	
-	*Lippia nodiflora*	**Common Name**	**Latin Name**
-	*Vigna marina*	-	*Lepturus repens*
		-	*Stenotaphrum micranthum*

Vegetation types for the mapping portion of the 2004 study were classified in the field based upon dominant canopy species (Figures 4.8 - 4.13). In addition to this classification, a listing was made of the other major species in the vegetation type. Ten categories were determined for the main island as follows.

Calophyllum Forest: This forest type is found in several areas throughout the island, but is mostly concentrated on the eastern, undeveloped side of the atoll near Minni Minni and East Point Plantation. It is dominated by true kamani or Alexandrian laurel (*Calophyllum inophyllum*), a tree with a trunk diameter that can grow in excess of 6.6 feet (2 m). This forest often contains other species such as lantern tree (*Hernandia sonora*), coconut (*Cocos nucifera*), guettarda or panao (*Guettarda speciosa*) with premna (*Premna obtusifolia*) along the edges. When found on the beaches, true kamani and fish-poison trees (*Barringtonia asiatica*) often extend over the lagoon water and provide substrate for nesting red-footed boobies (*Sula sula*).

Figure 4.2 True kamani

Cocos Forest: The coconut forest type is almost entirely composed of coconut trees. Mature coconut trees dominate the canopy and the understory is primarily coconut seedlings.

Cocos-Hernandia Forest: Two canopy species; coconut and lantern tree dominate this vegetation type.

Cocos-Guettarda Forest: This forest has two principal canopy species, coconut and guettarda. The understory is comprised almost entirely of fago, a tree (*Neisosperma oppositifolium*). Scaevola, also known as naupaka (*Scaevola taccada*), and beach heliotrope (*Tournefortia argentea*) are on the beach edges.


Figure 4.3 Hernandia forest

Hernandia Forest: The dominant canopy species of this vegetation type is the lantern tree. The best remaining forests of this species are found on the westernmost point of the northwest part of the island, the south part of the island, and in the area around and north of East Point Plantation. The most representative areas of this forest type are on the eastern, undeveloped part of the atoll. True kamani and coconut are often associated with this vegetation type. Understory species in this forest are often Indian mulberry or noni (*Morinda citrifolia*), coconut seedlings and bird's nest fern (*Asplenium nidus*). Occasionally, *N. oppositifolium* and guettarda are also found in this forest type.

Premna Shrubland: This vegetation type has been observed to occur primarily between marshy areas and forested areas near the developed areas of the atoll, particularly in the areas where the wells are located. The most conspicuous species is premna, with ironwood (*Casuarina equisetifolia*) and scaevola on the margins. The dense groundcover consists of species such as a sedge, *Fimbristylis cymosa*, morning glory (*Ipomoea pes-caprae*) and a herb, *Triumfetta procumbens*.


Figure 4.4 Littoral scrub with naupaka (scavvy) in the foreground.

Littoral Scrub: This vegetation type begins at the top of the beach slope above the high tide mark and lines almost the entire seaward shore of the island. It is dominated by naupaka, which sometimes exceeds 32 feet (10 m) in height, but also contains scattered coconut trees, guettarda and pisonia (*Pisonia grandis*). On the seaward side, it also contains beach heliotrope and suriana (*Suriana maritima*). On the lagoon side, it may also be comprised of a grass, *Lepturus repens*, *Triumfetta procumbens*, and a sedge, *Cyperus ligularis*. There are also large pockets of fish-poison tree on the eastern edge of the lagoon near Minni Minni and East Point Plantation.

Maintained Ground Cover: These areas are found in developed areas such as around buildings, antennae fields and wells. They are regularly groomed and mowed.

Mixed Native Forest: This forest type has a diversity of canopy species with none of the above described forest species being dominated by any particular tree species.


Figure 4.5 Mixed species marsh

Marsh/Wetland Type: Wetlands, as described, are based upon the type of vegetation that occurs in the area and have not been delineated. The marshes are of three different types: cattail (*Typha domingensis*), mixed species and wetland species marshes. Cattail marshes are comprised primarily of cattails and tend to be man-made reservoirs or drainages. Mixed species marshes have a highly variable species composition and usually have no standing water. Additionally, the vegetation in these areas is a mix of typical wetland species and others. Wetland species marshes have standing water and are comprised entirely by obligate wetland species. The wetland indicator species found in these three marsh/wetlands are: the obligate wetland species (requiring saturated soil or standing water during all phases of the life cycle) water hyssop (*Bacopa monniera*), cattail, a sedge, *Eleocharis geniculata*, marsh fern (*Cyclosorus interruptus*), and swamp cabbage (*Ipomoea aquatica*); the facultative wetland species (requiring saturated soil or standing water during some phases of the life cycle) knot grass (*Paspalum vaginatum*) and dayflower (*Commelina diffusa*); and two facultative species of sedges, *Kyllinga brevifolia* and *Pycreus polystachyos*. On Diego Garcia, these species are all found in saline or brackish water.

Some native species that are not very common on the atoll are the woody herb *Achyranthes aspera* var. *velutina* and a tree, ifil (*Intsia bijuga*). Four other native but uncommon species on Diego Garcia are gray knickers (*Caesalpinia bonduc*), St. Thomas bean (*Canavalia cathartica*), two purslanes (*Portulaca mauritiensis* and *P. oleracea*), and pemphis (*Pemphis acidula*). None of these species are of global or regional concern.

Figure 4.6 *Intsia bijuga* flower

Cassytha filiformis, a native parasitic vine, is problematic on Diego Garcia. It is often seen covering scaevola and other native species, particularly near the shoreline. This vine has been included on species lists for Diego Garcia on all previous botanical surveys. However, on Okinawa it is considered rare enough to list on the Okinawa Prefecture Red-List for protection. While this plant is a part of the natural ecosystem, natural resources managers on Diego Garcia have noticed that in some areas along the shoreline, where *Cassytha* is thick, there has been a reduction in plant cover to the point where coastal erosion is a concern.

Figure 4.7 *Cassytha filiformis* vine

N

0 0.5 1 2 Kilometers

0 0.25 0.5 1 Miles

UTM, Zone: 43S, Datum WGS84

FIGURE 4.8 VEGETATION MAP 1
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.9 VEGETATION MAP 2

Diego Garcia

Final Integrated Natural Resources Management Plan

Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

N
0 0.4 0.8 1.6 Kilometers
0 0.25 0.5 1 Miles
UTM, Zone: 43S, Datum WGS84

FIGURE 4.10 VEGETATION MAP 3
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.11 VEGETATION MAP 4
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.12 VEGETATION MAP 5
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

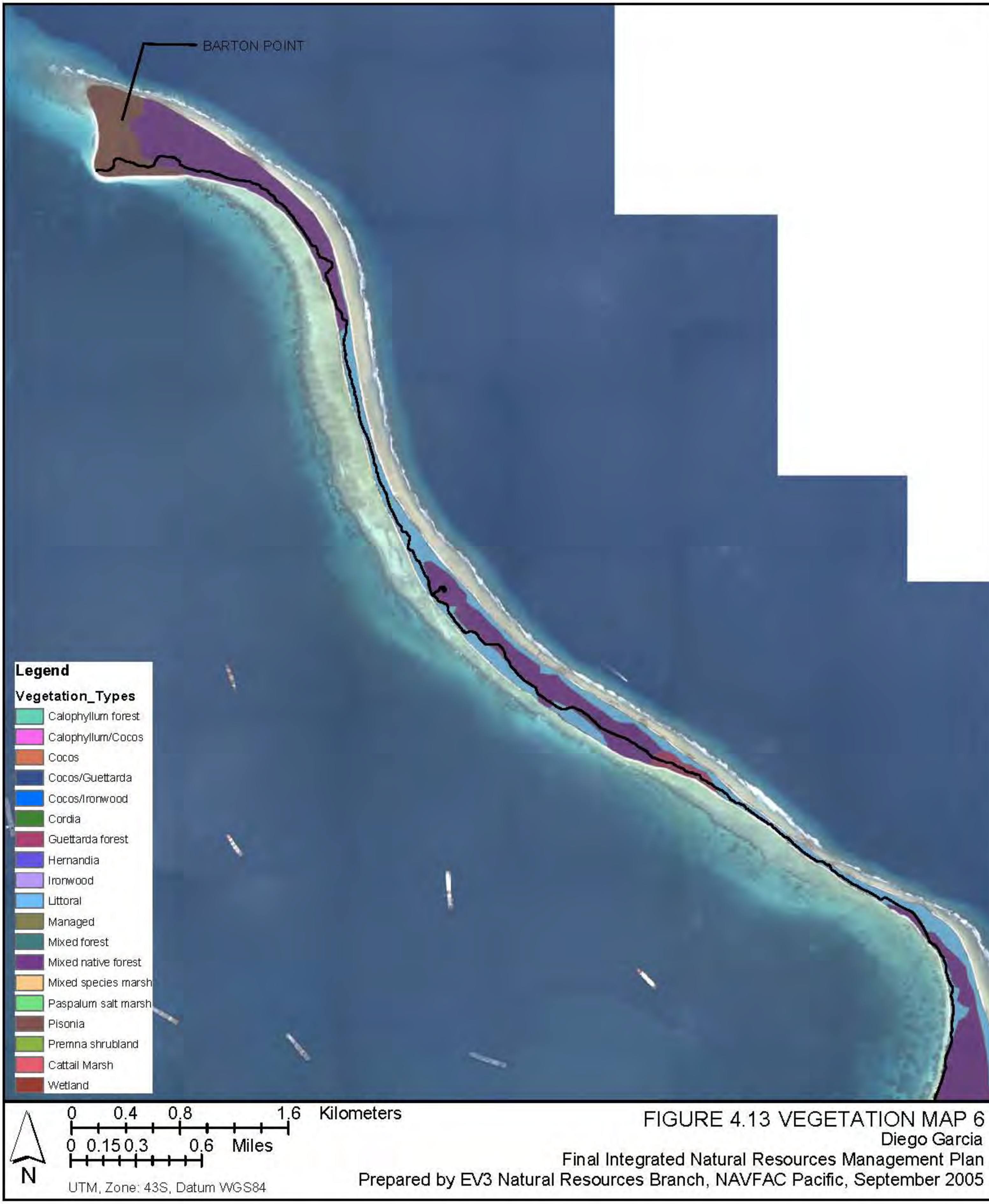

FIGURE 4.13 VEGETATION MAP 6
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

Barrier Islands

West Island

Figure 4.14 West Island

The canopy of the small forest towards the center of the island is composed mostly of pisonia (*Pisonia grandis*) with a few coconuts. Also within this area is a large patch of *Achyranthes aspera* var. *velutina*. Along the littoral edge of the island, pisonia is the dominant species with the majority of the rest of the littoral vegetation being beach heliotrope. The ground cover on the island includes *Portulaca oleracea, Cyperus ligularis* (a sedge), *Stenotaphrum micranthum* and *Lepturus repens* (grasses), crowfoot grass (*Dactylocentium ctenoides*), *Boerhavia repens* (a herb), and *Sida pusilla* (a mallow).

Middle Island

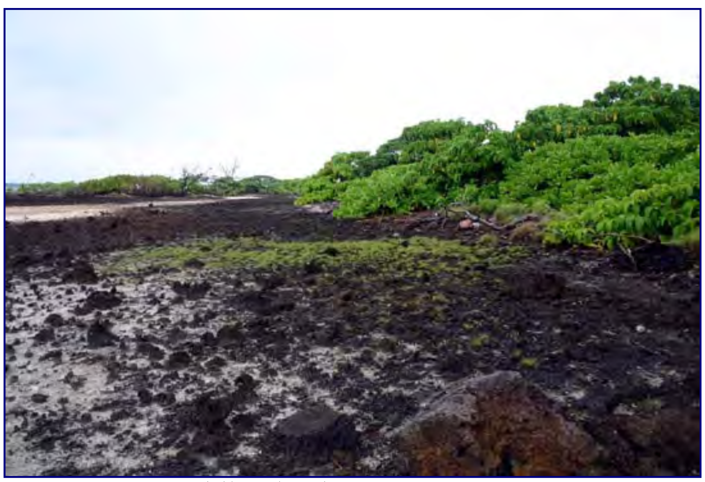

Figure 4.15 Middle Island

Middle island is a small island that has a large protected cove on the southern edge. The canopy is predominantly pisonia, with scattered coconut, several guettarda, one *Neisosperma oppositifolium* and one Indian mulberry. The northern corner also has a patch of cordia or kou (*Cordia subcordata*) that also forms the littoral edge along the high tide line. Other than the area with the patch of cordia, the littoral vegetation is primarily composed of pisonia and scaevola. There are patches of *Achyranthes aspera* var. *velutina* scattered throughout the island. The understory is composed primarily of bird's nest fern and coconut seedlings. Other ground cover includes mulberry (*Pipturus argenteus*) seedlings (no adult trees were found), *Boerhavia repens*, *Cyperus ligularis*, *Stenotraphrum micranthum, Dactylocentium ctenoides*, *Sida pusilla*, coral berry (*Rivina humilis*), *Portulaca oleracea*, and *Lepturus repens*.

East Island

Figure 4.16 East Island

This island is the largest of the three islands. It has the most topsoil, the most species diversity and the most non-native species. The canopy consists largely of pisonia and coconut. Other canopy trees include scattered lantern tree, one guettarda and scattered *Neisosperma oppositifolium*. The center of the forest also includes a large scattered patch of papaya (*Carica papaya*) trees. The midstory contains mulberry and beach heliotrope. Scaevola, beach heliotrope and pisonia make up the littoral edge. Ground cover is comprised of *Asplenium nidus*, *Portulaca oleracea, Cyperus ligularis, Stenotaphrum micranthum,* crowfoot grass, *Boerhavia repens, Sida pusilla,* coral berry, and *Lepturus repens*. *Fimbristylis cymosa* was found only on the eastern coast of this island.

4.2.1.2 Introduced Vegetation

Human activities have altered the vegetation of Diego Garcia. Cultivation, construction, and intentional introduction of exotic species for landscaping have all contributed to the damage of the indigenous atoll flora. Exotic species may arrive on the island by seeds carried on equipment or material shipped in from other locales, by seeds carried in imported sand used for construction, as intentionally introduced ornamentals for landscaping or as new crops.

Figure 4.17 Mayflower tree plantings.

Ninety-two species of cultivated plants were inventoried on Diego Garcia (Appendix F-1). These comprise food plants, such as beans and papaya, and ornamentals, such as croton (*Codiaeum variegatum*) and red hibiscus (*Hibiscus rosa-sinensis*). These ornamentals are not of much concern unless they become naturalized (escaping cultivation and management and forming self-sustaining "wild" populations). Some ornamental plants, such as the mayflower tree (*Tabebuia pentaphylla*), while attractive, are tenacious pests that can crowd out native plants. These trees dominate East Point Plantation, which might otherwise be prime native littoral forest habitat. Relatively high numbers of new introductions have been accidentally brought to Diego Garcia over time. Imported sand and fill material has also introduced large quantities of unwanted weed species and seed. The 1995 botanical survey of the island (Whistler, 1996) recorded 31 newly introduced weed species, for a total of 130 weeds, which showed a 33% increase of non-native species surveyed prior to 1995.

There are five invasive species of concern on the main island of Diego Garcia Atoll: 1) tangan-tangan (*Leucaena leucocephala*), 2) giant sensitive plant (*Mimosa invisa*), 3) dwarf sensitive plant (*Mimosa pudica*), 4) Star of Bethlehem (*Laurentia longiflora*) and 5) coral berry (*Rivina humilis*). Tangan-tangan is an invasive species that is found on many tropical islands including the Marianas and Hawaii. It thrives in open canopy areas, particularly those that are disturbed by development or clearing. If uncontrolled, this species can completely overtake all other species and ultimately create a monotypic scrub. Tangan-tangan was found in four relatively small areas near Pt. Marianne and adjacent to a parking lot south of the airport. Both sensitive plant species were introduced to the island in a shipment of aggregates in the 1980s. The Star of Bethlehem is believed to be naturalized on Diego Garcia and has been observed around the East Point Plantation. It is a small herb with an attractive white flower has poisonous milky sap. The coral berry was observed within the conservation area in small patches. This particular plant produces a large number of seeds and has the potential to become the dominant understory species. In addition, an observation of a pothos vine (*Epipremnum pinnatum)* under cultivation in the villages and outside of one of the Bachelors Officer Quarters near the Officers' Club was noted. Pothos is known to be a very invasive species in tropical environments and should not be encouraged to grow on Diego Garcia.

Figure 4.18 Star of Bethlehem

4.2.2 Wildlife

4.2.2.1 Birds

At least 77 species of birds have been observed on Diego Garcia or in the general vicinity of the island within the last 20 to 30 years. Of these, 37 are seabirds, 26 are migratory shorebirds, four are migrant and vagrant waterbirds, and ten are resident waterbirds and land birds. A total of 33 species of birds were observed during the 2003 and 2004 surveys (See Appendix F2 a & b). Bird surveys were conducted at point count stations around the atoll. During a visit by NAVFAC Pacific biologists in January 2005, incidental bird sightings were also recorded.

4.2.2.1.1 Indigenous Bird Species

Figure 4.19 White-breasted waterhen

Indigenous bird species on Diego Garcia include seabirds, migratory shorebirds, residents, and migrant and vagrant waterbirds. There are no game birds on the atoll. Two of the ten resident bird species are native. The white-breasted waterhen (*Amaurornis phoenicurus*) was observed during the 1995, 2003 and 2004 surveys in wetlands and forested habitat. Previous surveys (1971 and 1975) had suggested that either the moorhen (*Gallinula* sp.) or the white-breasted waterhen was present on Diego Garcia. This species forages on the reef in the Maldive Islands and could be the source of the birds that have colonized Diego Garcia. The other resident native is the little green or striated heron (*Butorides striatus*), which has been reported in abundant numbers and at various locations throughout atoll.

The wetlands and intertidal habitats on Diego Garcia are perhaps the most vulnerable to disturbance. Virtually every marsh/wetland type habitat examined on the biological surveys supported resident and migrant waterbirds. At low tide the exposed lagoon sand flats provide foraging opportunities for many migrants and residents, like the little green heron. While fewer birds frequented the fringing seaward reefs, sanderlings (*Calidris alba*), whimbrels (*Numenius phaeopus*) and little green herons were oftentimes observed.

Figure 4.20 Common greenshank (*Tringa nebularia*), a common migratory shorebird.

The number of red-tailed tropicbirds (*Phaethon rubricauda*) nesting on Diego Garcia has increased in recent years. The first nesting pair was observed under naupaka bushes behind the Fleet Recreation Area in 1996 and by 2001 (during the cat eradication program) the number of nesting pairs increased to at least sixteen (Figure 4.20) (Guzman, pers. comm.). Red-tailed tropicbirds nest on the ground and breed all year round on Diego Garcia, with the peak occurring between December and March (Figure 4.22). Another ground nesting seabird is the wedge-tailed shearwater (*Puffinus pacificus*), which nests in the downtown area in two locations (Figure 4.23).

Figure 4.21 Red-tailed tropicbird on an egg.

N

0 0.05 0.1 0.2 Kilometers

0 0.025 0.05 0.1 Miles

UTM, Zone: 43S, Datum WGS84

FIGURE 4.22
RED-TAILED TROPICBIRD NESTING AREA
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

0 0.02 0.04 0.08 Kilometers

0 0.01 0.02 0.04 Miles

N

UTM, Zone: 43S, Datum WGS84

FIGURE 4.23 WEDGE-TAILED SHEARWATER NESTING AREA

Diego Garcia

Final Integrated Natural Resources Management Plan

Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

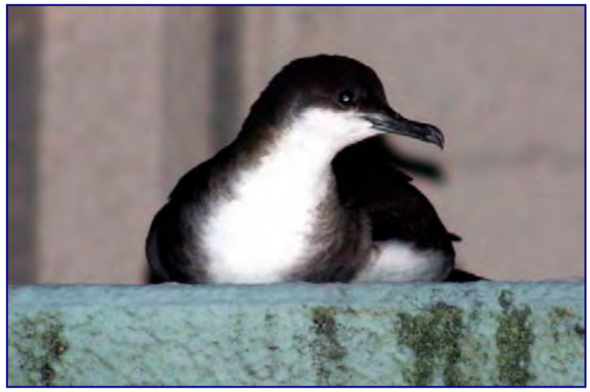

Figure 4.24 Audubon's shearwater

The species of greatest interest observed during the 2004 survey was the Audubon shearwater (*Puffinus iherminierii*) that was sighted in the vicinity of BEQ 02 across the street from the open-air theater in the tops of coconut trees. This species has not been observed or heard since 1995, but it has most likely been overlooked since then because of its unusual call, limited distribution and seemingly short calling period. Now that this species has been noted, vocalizations have been heard at Camp Cummins and in the vicinity of the Seaman's Club and the Water Plant.

Figure 4.25 Black-naped terns

A breeding colony of black-naped terns (*Sterna sumatrana*) was observed on the roof of the two-story Pier Utility Building (Bldg. 428) on the fuel pier. Nests and chicks were observed in September 2004.

Figure 4.26 Red-footed booby

The northeastern sector of Diego Garcia (the conservation area) has developed into a secondary forest habitat composed of tall trees such as the lantern tree, the coconut, and guettarda. The red-footed booby (*Sula sula*) nesting colony has increased in numbers and range as roosting and nesting activities have been observed farther south. In 1995, birds were observed only around the Barton Point area while during the 2003 and 2004 surveys, birds were abundant to about 6 miles (9.7 km) south of Barton Point and extend as far south as Shark's Cove (about 1.2 miles (2 km) north of GEODDS) in smaller numbers.

The barrier islands were also visited during the 2004 survey and a description of each of the islands follows:

West Island

Figure 4.27 Brown noddy

The island is principally coral limestone and rubble with littoral scrub vegetation comprised primarily of naupaka and coconut palms. There is widespread ground nesting by seabirds including brown noddies (*Anous stolidous*), red-footed boobies and bridled terns (*Sterna anaethetus*). Ground nesting seabirds are a good indicator that there are no rats on West Island. Additionally, bridled terns were only sighted at this location.

Middle Island

Figure 4.28 Lesser frigate birds

Middle Island is wider than West Island and has a more developed tree canopy. There is also a tidally influenced, shallow pond on the east side of the island. The pond may provide foraging and loafing habitat for both resident and migratory shorebirds and wading birds. Twelve species of birds were recorded on this island, with red-footed boobies being the most numerous. Red-footed booby nests were observed with eggs, chick and juveniles. Lesser frigatebirds (*Fregata ariel*) were observed roosting in trees and soaring overhead. No ground nesting birds were observed on this island.

East Island

Figure 4.29 White (fairy) tern

This island is the largest of the three barrier islands. It also supports the most extensive and diverse vegetation community. A total of eleven species of birds were recorded during the visit. Red-footed boobies were the most numerous and no ground nesting birds were observed.

4.2.2.1.2 Vagrants

Isolated islands or atolls are excellent areas for traveling birds to rest and forage for food. Instances when a traveling bird may use an island are when it is blown off course or it is migrating from one continent to another. Birds that are not normally associated with an area (i.e., do not nest or live in an area) and just pass through are called vagrants (Table 4.2).

Figure 4.30 Dimorphic egret

Table 4.2 Vagrant bird species observed on Diego Garcia.

Common Name	Latin Name	Dates Observed	Number Observed
glossy ibis	*Plegadis falcinellus*	1995 to 2003	1
purple heron	*Ardea purpurea*	Nov. 2000 - Feb. 2001	1
house crow	*Corvus splendens*	May 2002 – Feb. 2005	1
amur falcon	*Falco amurensis*	Nov. 2002 - Dec. 2002	1
peregrine falcon	*Falco peregrinus*	BASH Nov. 21, 2002	1
Australian shelduck	*Tadorna tadornoides*	Sept. 2002	5 juveniles
		Oct. 2002	2 adults
dimorphic egret	*Egretta dimorpha*	Jan. - Feb. 2005	1

4.2.2.1.3 Non-Native Bird Species

Figure 4.31 Madagascar fody

All of Diego Garcia's resident land birds are non-native species. They were, for the most part, introduced by humans at various times in Diego Garcia's history. Common exotic resident species include the cattle egret (*Bubulcus ibis*), common Indian mynah (*Acridotheres tristis*), Madagascar fody (*Foudia madagascariensis*), domestic fowl or chicken (*Gallus gallus*), zebra dove (*Geopelia striata*) and Madagascar turtle dove (*Streptopelia picturata*). The introduced birds live in both forest and urban habitats. While exotic species can cause ecological harm to the environments where they are introduced, they sometimes may have beneficial effects. On Diego Garcia, two of the exotic resident bird species, the cattle egret and the common Indian mynah, are of special benefit to humans because both consume large quantities of insects. The cattle egret is highly effective in eliminating fly larvae, and the mynah is a carrion eater that will eat nearly any type of protein-rich refuse. However, it should be noted that the presence of these species near the runway presents a potential BASH problem. Chickens are found in the developed areas of the atoll, where they are allowed to roam freely. The capture and removal of chickens around the developed areas is permitted on a scheduled basis and seems adequate to control the chicken population.

Figure 4.32 Common mynah

4.2.2.2 Coconut Crabs

Figure 4.33 Coconut crab

The coconut, or robber, crab (*Birgus latro*) has a wide distribution, and ranges from Eastern Africa through the Indian Ocean islands and to the Pacific Ocean islands. It is the largest terrestrial invertebrate in the world. Due to its large size, ease of collection and palatable flesh, the coconut crab is often over harvested when it is easily accessible. British law protects the population on Diego Garcia and no legal harvest takes place (British Wildlife Protection Regulations of 1984). Poachers of coconut crabs are subject to stiff fines.

Crab populations within two areas on Diego Garcia were studied (See Appendix G). One area was within the Minni Minni Conservation Area and the other was on the south end of the island. Of the 194 coconut crabs measured, 117 were males and 77 were female. The average thoracic (the round, main part of the body) length of the males and females in both study sites was about 1.6 inches (40 mm). The average weight for males and females was 1.5 pounds (680 g). The average thoracic lengths and weights for coconut crabs within in the Minni Minni Conservation Area were larger than for the area south of the Donkey Gate.

Abundance indices (catch rates for coconut bait station transects) were established for the area south of the Donkey Gate and at the Minni Minni conservation area. Absolute population densities were documented at the Minni Minni conservation area. At Minni Minni, the average calculated densities for coconut crabs within coconut forests were 137 crabs/acre (339 crabs/ha) and 52 crabs/acre (128 crabs/ha) in *Pisonia*/*Ficus* forest. The overall average density of coconut crabs was 94 crabs/acre (233 crabs/ha).

Due to the isolation of Diego Garcia and restricted access, the Minni Minni area (and most likely East Island) is one of the few places in the world with an essentially, unharvested coconut crab population. Overall densities on Diego Garcia appear to be some of the highest recorded for this species. For example, on an unharvested crab population, Chauvet and Kadiri-Jan (1999) reported a density of 77 crabs/acre (190 crabs/ha) on the uninhabited Taiaro atoll in French Polynesia. By contrast, the densities of harvested populations have been reported at 11 crabs/acre (27.5/ha) on Lifou (Loyalty Islands, New Caledonia)

(Kadiri-Jan 1995) and 3.6 crabs/acre (9 crabs/ha) at the Haputo conservation area on Guam (USFWS 2001). There also appears to be differences between the conservation area population and that on the inhabited side of the island. On the inhabited side, the average crab size is smaller than the crabs in the protected area.


Figure 4.34 Coconut crab at a husking station

No coconut crabs were observed on West Island. East Island was unique in that it supports a sizeable population of coconut crabs with different age classes. Coconut crabs have been observed on Middle Island, but not in as great of numbers as on East.

4.2.2.3 Donkeys and Horses

Donkeys (*Equus asinus*) were used during the plantation era to haul coconuts. They were turned loose after 1938 when transportation on the island became mechanized. The number of donkeys originally set loose is unknown, however, the BRITREP estimated the number of donkeys at 250 in 1970. Horses (*Equus caballus*) were also released on the island at some time in the past and, in the previous NRMP, one horse had been observed alive near the Plantation House at East Point. No horses have been observed or reported to natural resources personnel on Diego Garcia for some time.


Figure 4.35 Donkey

The present donkey population appears to have decreased from previous years (See Appendix H). In 1998, 41 donkeys were counted between the donkey gate and the GEODDS building (Guzman pers. comm.). However, during 2001, the number of donkey carcasses recovered from the antennae fields sharply increased. Throughout the March 2004 surveys no more than 9 donkeys were seen at any one time in this area. The current population estimate is 20 donkeys (with 95% confidence limits of 17-36 donkeys). While the estimate is 20 donkeys, it is important to remember that the levels around the estimate are from 17 – 36 donkeys. Therefore there is a possibility that there may be at least as many as 36 donkeys on Diego Garcia. While NAVFAC Pacific biologists were visiting the island in 2005, two juvenile donkeys were observed in the antenna field area, indicating that the population is still viable. Donkeys in the conservation area may be having an adverse affect on some native species of Diego Garcia. Several trees had evidence of donkeys browsing on them, non-native grasses could be spread, and turtle eggs could be destroyed should donkeys trample nests while traversing the beach.


Figure 4.36 Donkeys

4.2.2.4 Rats

The roof (ship or black) rat (*Rattus rattus*) is approximately 6 – 8 inches (15.2 – 20.3 cm) long with a 7 – 10 inch (17.8 – 25.4 cm) long tail. They have soft, smooth fur, a pointed muzzle and large eyes. Their color varies from brown to gray/black and they like to nest in high places (e.g., trees), but will nest in burrows. A female roof rat may have 4-6 litters per year with 6 – 8 young in each litter. No census data was gathered during the 1995 surveys, but an attempt to quantify rat densities was made during the March 2004 survey. The estimated population density of rats was 10 rats per acre (25 rats/ha) with a 95% confidence interval of 7 – 15 rats per acre (17 – 37 rats/ha).


Figure 4.37 Rat

Introductions of various rodents to the earth's islands during centuries of exploration and colonization have been recognized worldwide as a major conservation problem (Atkinson 1985). On Diego Garcia, roof rats were probably introduced when European ships first landed at the atoll. Rats, in particular, have had significant effects on islands in that they have caused the severe decline or extinction of native terrestrial animal species (e.g., ground-nesting birds). Additionally, rats are known to take eggs from sea turtle nests (Meir & Varnham

2004). Due to their wide ranging tastes in eating fruits, seeds, and seedlings, rats can cause a significant decrease in the regeneration of some coastal plants (Wilson *et. al*. 2003; Campbell & Atkinson 2002; McConkey, *et. al*. 2002; Campbel & Atkinson 1999). Rats on Diego Garcia have been observed eating kamani seeds.

Figure 4.38 Kamani seed eaten by a rat

Barrier Islands

No signs of rats were found during the visits to West, Middle and East Islands in 2004. This is most likely the result of the water barrier around these islands as well as the current BIOT administration's "off limits" policy for personnel.

4.2.2.5 Cats

There is a self-sustaining population of feral cats (*Felis catus*) on Diego Garcia, and they are found in all areas of the main island of Diego Garcia. Feral cats are defined as cats that have returned to an untamed state from domestication or those that survived in the wild after escape from a domestic environment. These animals may have 2 - 4 litters each year with 5 - 9 kittens in each litter. Along with this high reproductive rate, cats are extremely adaptable carnivores and have the ability to survive with limited access to water, obtaining enough moisture from their prey to survive. It was once believed that cats provide a benefit by helping to keep rat populations in check, however, it has since been learned that food availability is the primary factor limiting the growth of a rat population.

Feral cat predation on native species has had a widespread and significant effect on native species populations, and they are included on the lists of the world's 100 worst invasive species (Nogales, et. al., 2004). Their predation on island fauna has been devastating and has been directly responsible for numerous island extinctions of mammals, reptiles and birds (Nogales, et. al., 2004). They are excellent and nondiscriminatory predators that can destroy birds and their young, especially some of the seabird species nesting on Diego Garcia.

However, seabirds, are less frequently driven to extinction because they may nest on other islands that are free of cats (Nogales, et. al., 2004, Moors & Atkinson 1984). For example, on Marion Island in the subarctic Indian Ocean, a single cat may have killed more than 200 seabirds per year (Moors & Atkinson, 1984). Additionally, cats could also pose health and nuisance problems to the human population.

4.2.2.6 Miscellaneous

Surveys for reptiles and amphibians conducted in July 2003 documented three lizards and one toad. These include: house gecko (*Hemidactylus frenatus*), mourning gecko (*Lepidodactylus lugubrus*), garden lizard (an agamid) (*Calotes versicolor*) and marine toad (*Bufo marinus*). The house gecko was found only around or on buildings around the cantonment area. The mourning gecko was found in and around buildings and in forest habitat around the island. There is a small, but expanding population of the garden lizard near the Beach House 292 area. The garden lizard is a recent introduction and was first documented in May 2001 (Guzman pers. comm.). In March 2002 a gravid, foot long female was discovered after it had been electrocuted. At that time these lizards had colonized a 300-500 foot (91.4 – 152.4 m) radius around the Beach House. As of February 2005, the garden lizard was seen around the Officer's Club and near the fishing hole at Camp Justice. It will presumably spread island-wide in the future and it is difficult to predict the impacts of this exotic lizard.

Figure 4.39 Garden lizard

Within the last 15 years there have been a number of snakes caught at the ports of entry. As of 2005, environmental staff trains port workers on the capture and identification of exotic species twice each year. Descriptions of recent snake sightings follows:

- A viper (probable *Echis* sp.) from the Middle East.

- A was snake found in a warehouse on Diego Garcia on August 14, 2003. The carcass was sent to NAVFAC Pacific and was forwarded to the Bishop Museum in Honolulu for identification. It was a *Lycodon* species, most likely *Lycodon capucinus*, a species found throughout Southeast Asia.

Figure 4.40 *Python reticulatis* caught on November, 4, 2003

- A snake was sighted on November 4, 2003, at the FAC 729-Cold Storage slithering between two banana boxes that had arrived from Singapore via an AMC flight. It was killed and photographs were sent to the Bishop Museum for positive identification, where it was identified as *Python reticulatis*.

- There was also a probable brown treesnake sighting near the airfield but the specimen was not collected.

- A snake that has been observed around the more populated areas since at least 1992 is a type of blind snake from the Family Typhlopidae [probable Brahminy blind snake (*Ramphotyphlops braminus*)].

4.2.2.7 Marine Turtles

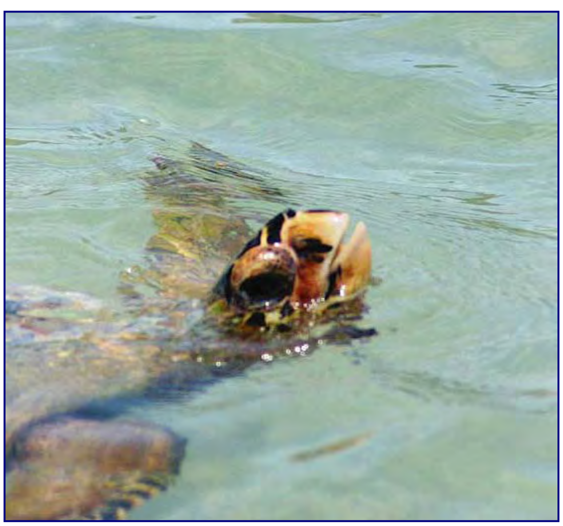

Figure 4.41 Hawksbill turtle

This section will cover both the terrestrial and marine habitats of marine turtles. There are two species of marine turtles that are common in the Western Indian Ocean: hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) (Frazier 1975). Diego Garcia atoll provides regular foraging and nesting habitat for these two species.

Other species that may be encountered are loggerheads (*Carreta carreta*), olive ridleys (*Lepidochelys olivacea*) and leatherbacks (*Dermochelys coriacea*).

Turtle beach nesting surveys were conducted in July 2003, March 2004, and modified surveys in January and February 2005 (See Appendix K). Nesting activity information was observed and noted while walking beaches on Diego Garcia.

Species Descriptions

<u>Hawksbill Turtles</u>

Figure 4.42 Swimming hawksbill turtle

Hawksbills are listed as 'endangered' under the Endangered Species Act and are listed as 'critically endangered' on the IUCN Red List. They are one of the smaller marine turtles, with a narrow head and a hawk-like beak. The carapace has thick, overlapping scutes and a very serrated posterior margin. Hawksbills can also be differentiated from green turtles by a pair of prefrontal scales (located at the front of the head, above the eyes) instead of one prefrontal scale. At Diego Garcia, immature hawksbills are most readily observed near the southern end of the lagoon in Turtle Cove, and have been observed by Mortimer (1999) within the cove foraging on algae. Although hawksbills will nest during the night and/or the day, in the Western Indian Ocean, they are characterized as diurnal nesters; this behavior is considered to be common throughout the Chagos Archipelago, but has not been quantified (Mortimer and Day 1999). Peak nesting at Diego Garcia has been reported to be from November to February by Frazier (1977) and December to March by Stoddart (1971). During their surveys, Mortimer and Day (1999) observed significant nesting in February and March of 1996.

Green Turtles


Figure 4.43 Green turtle

Green turtles are listed as 'threatened' under the Endangered Species Act and as 'endangered' on the IUCN Red List. Green turtles are one of the larger marine turtles of the five species, with a smooth carapace with four pairs of lateral scutes and a coarsely serrated lower jaw-edge. They are occasionally observed during the day within Turtle Cove and they nest mostly on seaward beaches during the night. Green turtles nesting can occur during any month at Diego Garcia and is believed to peak between June and September (Bourne, 1986, Frazier 1977).

Habitat Utilization


Figure 4.44 Turtle cove

Hawksbill turtles (typically juvenile) can be observed foraging most days within Turtle Cove. Occasionally, adult green turtle are also observed in the cove. Turtle Cove is the local name for an area of the lagoon called, Barachois Sylvain. The barachois is an indentation, usually 1.2 – 2.5 miles (2-4 km) long, of the lagoon shore enclosing areas of intertidal sands and gravels (Stoddard 1971). The indentation consists of tidally influenced branching arms fringed by terrestrial vegetation (Fig 4.41, 4.48 for aerial view of the barachois [the white-ish, shallow area at the south end of the lagoon]).

The majority of turtle nesting occurs in several areas on Diego Garcia (Figures 4.42 – 4.53). In order to show all potential nesting habitat (utilized within the last 10 years), maps were generated off of the GPS points collected during the recent turtle surveys and from work previously completed by Mortimer (2000). There are some seasonal fluctuations in the locations and species of turtles nesting. Nesting activity observed in the June/July timeframe consisted primarily of green turtle activity (Figures 4.42 – 4.47). Hawksbill and green turtle activity was recorded during the February/March timeframe and beaches used were slightly different (Figures 4.48 – 4.53). For example, nesting activity was recorded along the stretch of beach at Simpson Point during February/March and not during the

Figure 4.45 Green turtle on the beach.

June/July timeframe. During the July survey it was noted that the beach looked unsuitable for successful hatching, largely because the high tide line extended into dense vegetation and, in some areas, there was a precipitously steep beach slope. Significant nesting was not observed during the March, 2004 surveys. The majority of nesting activity was approximately one month old at the time of observation, indicating that the nests had been laid around the end of January. This observation was different from Mortimer and Day's (1999) observation of significant nesting during March.

During marine in-water surveys, turtles were seen during nearly all survey dives and while in transit between sites (Section 4.3). Positive species identifications were made of green turtles and hawksbill turtles and both juvenile and adult turtles of both species were observed during the study. A single specimen of a third species, the olive ridley turtle, was tentatively made. Turtles were observed in various behaviors including, surface basking or floating/breathing, eating (sponge), bottom resting, and general transit swimming.

Figure 4.46 Erosion at Simpson Point (Jan 05)

The December 2004, tsunami appeared to have had an adverse affect on marine turtle nesting. Any nests would have been destroyed due to the unusually high tide that occurred after the earthquake and as the result of the subsequent erosion of the beaches. This may be a temporary effect, as it appeared that sand was already being re-deposited in the area from the southern tip to Horsburgh Point. It appears that there are regular shifts in sand deposition along the beach from Cannon Point to the southern end of the fuel farm, so it seems probably that the area will be suitable for nesting during the next November through February time period.

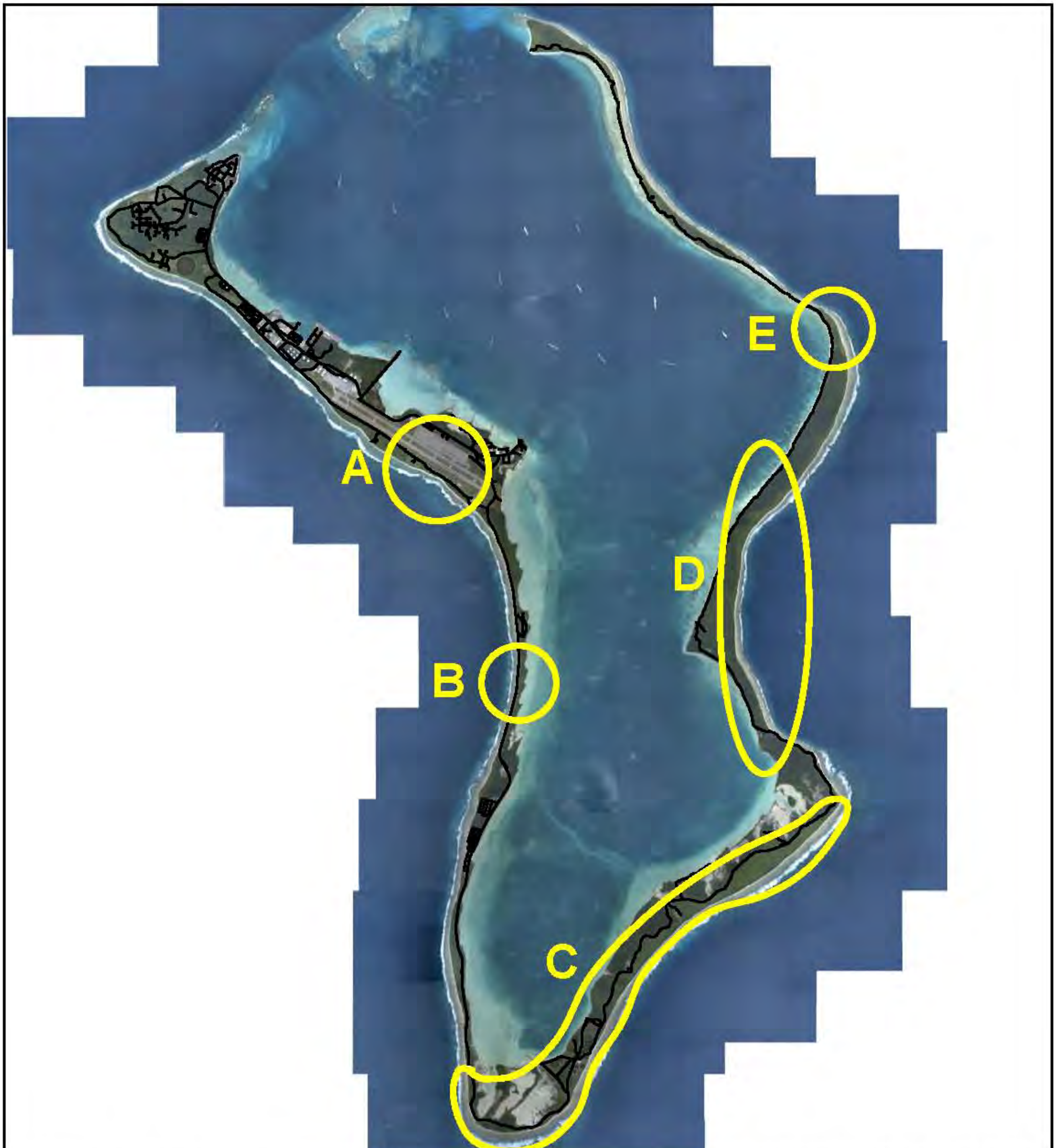

FIGURE 4.47 TURTLE NESTING KEY MAP
≈ JUNE - SEPTEMBER NESTING
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

0 0.4 0.8 1.6 Kilometers
0 0.2 0.4 0.8 Miles
N
UTM, Zone: 43S, Datum WGS84

FIGURE 4.48 TURTLE NESTING MAP
≈ JUNE - SEPTEMBER NESTING , AREA A
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.49 TURTLE NESTING MAP
≈ JUNE - SEPTEMBER NESTING , AREA B
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

0 0.5 1 2 Kilometers
0 0.3 0.6 1.2 Miles
N
UTM, Zone: 43S, Datum WGS84

FIGURE 4.50 TURTLE NESTING MAP
≈ JUNE - SEPTEMBER NESTING , AREA C
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.51 TURTLE NESTING MAP
≈ JUNE - SEPTEMBER NESTING, AREA D
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.52 TURTLE NESTING MAP
≈ JUNE - SEPTEMBER NESTING, AREA E
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

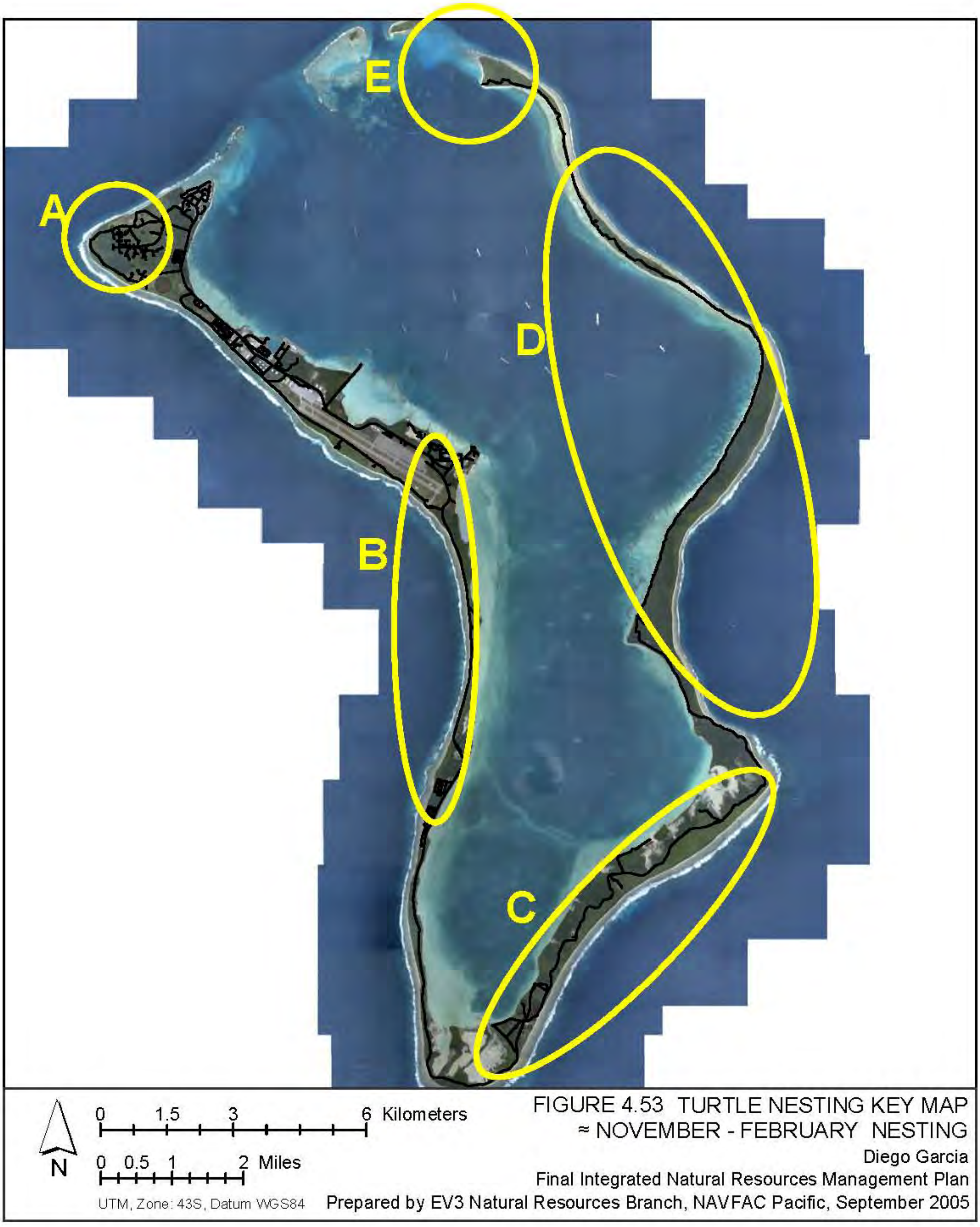

FIGURE 4.53 TURTLE NESTING KEY MAP
≈ NOVEMBER - FEBRUARY NESTING
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.54 TURTLE NESTING MAP
≈ NOVEMBER - FEBRUARY NESTING, AREA A
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.55 TURTLE NESTING MAP
≈ NOVEMBER - FEBRUARY NESTING, AREA B
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.56 TURTLE NESTING MAP
≈ NOVEMBER - FEBRUARY NESTING, AREA C
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.57 TURTLE NESTING MAP
≈ NOVEMBER - FEBRUARY NESTING, AREA D
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

FIGURE 4.58 TURTLE NESTING MAP
≈ NOVEMBER - FEBRUARY NESTING, AREA E
Diego Garcia
Final Integrated Natural Resources Management Plan
Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

4.3 Marine Natural Resources

Figure 4.59 Yellowback fusiliers (C*aesio teres*) and bluestreak fusiliers (*Pterocaesio tile*).

Diego Garcia's marine flora and fauna are broadly categorized as belonging to the Indo-Pacific biogeographic region. More specifically, the faunal characteristics of Diego Garcia and the Chagos Archipelago have close affinities to both the East African faunas and the Indonesian faunas; the latter region supports the most diverse coral reef ecosystems in the world (Spalding, et al. 2001). Sheppard (1999) and Spalding et al. (2001) have postulated that the Chagos Archipelago probably plays a significant role as a stepping-stone between the eastern and western portions of the Indian Ocean, for many marine species. It is interesting to note, that the approximately 220 reef building stony coral species identified in Chagos is one of the highest in the Indian Ocean. Winterbottom and Anderson (1999) listed 778 fish species. This number is lower than the Maldives, but this may be primarily a reflection of more limited collections than an actual lower number of species. Spalding (2002) believes that the number of fish species in the Chagos may actually be over 1000.

The marine natural resources of Diego Garcia are considered to be of global significance. Spalding et al. (2001) consider that "…the reefs of the Chagos and parts of the Adaman and Nicobar Islands are among the least impacted coral reefs worldwide… Studies on water quality in the Chagos Archipelago suggest that these may be some of the least polluted waters in the world…" Diego Garcia has, in fact, been considered for nomination as a World Heritage Site, based upon the diversity, abundance and health of the marine community there.

As a result of the December 2004 tsunami (which devastated portions of the Adaman and Nicobar Islands, but largely spared Diego Garcia) the global significance of the Chagos Archipelago marine resources may be even greater than before. Marine field surveys were conducted between July 28 and August 18, 2004 (Appendix O).

4.3.1 Introduction

The four primary objectives of these marine field surveys were:

- Complete a rigorous assessment of marine natural resources for use in updating the Integrated Natural Resource Management Plan.

- Assess and evaluate the condition of marine natural resources relative to on-going and proposed operations and activities.

- Address the request of the British Government to provide a current, detailed evaluation of Diego Garcia's marine natural resources, with particular emphasis on identifying existing or potential threats to those resources.

- Document existing conditions at one of the world's biologically most important atolls, as part of the DoD's Coral Reef Protection Implementation Plan.

To meet these objectives two teams of divers and scientists were deployed. Team 1 (Navy team) was comprised of two marine biologists from the NAVFAC and divers from the Underwater Construction Team (UCT 2). Team 2 was comprised of three marine biologists from Geo-Marine International, Inc (GMI team). Both teams collected qualitative and quantitative biological data. The GMI team also collected physical and chemical oceanographic data at each study site they surveyed (Figure 4. 56). Six broad habitat types were investigated during this study: i) ocean/seaward side of atoll, ii) main pass, iii) anchorage area, iv) replenishment zone, v) northern half of the lagoon outside the anchorage area and vi) southern half of the lagoon outside the anchorage area and replenishment zone.

The marine resources/conditions investigated were divided into the following broad categories:

- Corals and coral reefs

- Fishes

- Threatened and Endangered Species and Species of Concern (excluding marine mammals)

- Hazardous materials, hazardous wastes, pollutants and debris

0 1.25 2.5 5 Kilometers

0 0.45 0.9 1.8 Miles

N

UTM, Zone: 43S, Datum WGS84

FIGURE 4.60 MARINE SURVEY POINTS

Diego Garcia

Final Integrated Natural Resources Management Plan

Prepared by EV3 Natural Resources Branch, NAVFAC Pacific, September 2005

Appendix O provides a detailed description of the methods utilized. Standard, internationally accepted procedures for coral reef investigations were used. Corals and other macroscopic benthic organisms were primarily studied using the Line Point Intercept Method as described by Liddell and Ohlhorst (1987), Ohlhorst et al. (1988), Aronson and Precht (1995) and Geo-Marine, Inc. (2004). Fishes were surveyed utilizing Roving Fish Counts and Belt Transects as described by Bohnsack and Bannerot (1986) and Schmitt et al. (1998). In addition, incidental observations, still and video photographs were recorded and analyzed.

The Navy Team completed a total of 181 dives over 18 diving days. Maximum dive depths were 100 feet (31 m). At least one Navy marine biologist participated in every dive. The GMI team completed 66 dives over 10 diving days and their maximum dive depths were 60 feet (18 m).

4.3.2 Coral Reef Communities

As previously noted, approximately 220 coral species, 58 coral genera, and 14 coral families occur in the Chagos Archipelago (Sheppard 1999a). The relatively rich diversity of corals biogeographically positions the Chagos in the western Indian Ocean coral sub-province (west of Sri Lanka) (Sheppard 1999a). The Chagos have more coral species in common with locations to the east and west (Australia and Red Sea) than to the north and south (India/Arabian Gulf and Madagascar) which indicate that the Chagos serve as a stepping stone for the east to west flow of coral species in the Indian Ocean (Sheppard 1999a).

In the 1970s, coral cover on Chagos seaward and lagoon reefs was 50 to 80% to depths of 131+ ft (40+ m) (Sheppard 1999 b). Scleractinia represented most of the coral cover. From 131 to 197 feet (40 to 60 m), coral cover was 25%. Coral diversity was highest at a depth of 66 ft (20 m) on both seaward and lagoon reefs. Many shallow fore reefs were dominated by Acroporidae (*Acropora palifera*, *A. hyacinthus*, *A. clathrata*) which were established in distinct zones. Blue corals dominated coral cover in some turbulent reef fronts. By 1996, overall coral cover (all depths combined) in the Chagos had decreased from 59 (±2.9 standard deviation [*SD*]) to 36.4% (±2.5). Sponge cover increased from less than 1 (±0.2) to 3% (±1.1), red algae cover increased from 6.7 (±1.2) to 12.5% (±1.4), and soft coral cover increased from 11.9 (±1.8) to 16.3 (±2.1). The main contributor to the overall decrease in coral cover was the decline of Acroporidae cover in shallow water. The reasons for this decline were not clear (Sheppard and Seaward 1999).

Figure 4.61 "Bone yard" of dead coral fragments in the lagoon.

In 1999, only 12% coral cover remained on Chagos reefs surveyed by Sheppard; he reported dead coral substrate covered 80% of the seafloor in some locations. The cause of the abrupt decline in coral cover was the severe El-Niño Southern Oscillation (ENSO) of 1997-1998 which caused the anomalous and prolonged warming of sea surface temperature (>29.9 °C [85.8 °F]) in the Indian Ocean. This ENSO event triggered the mass bleaching and mortality of Scleractinia in the northern and central Indian Ocean (including the Chagos), East Africa, Sri Lanka, and India (Linden et al. 2002). Reefs of the northern Chagos were not as badly affected, but hard and soft corals in the southern atolls of the Chagos were affected down to a depth of 115 feet (35 m) (Sheppard 2001). Seaward reefs were more affected than lagoon reefs (Sheppard 1999b). Soft corals were almost entirely removed down to a depth of 49 ft (15 m). Sponges, worms, and algae bioeroded the dead coral substrate and generated large amounts of coral rubble and entire dead colonies of Acroporidae were removed from the reef. Diego Garcia was one the sites where branching Acroporidae were severely affected (Sheppard 2001). Surveys conducted in March of 1999 (Smith, 1999) showed that in spite of the massive die off, there were large specimens from all the major scleractinian families, both in and outside the Diego Garcia lagoon, which survived the bleaching event and appeared to be in good health. However, the death and bioerosion of Chagos reefs caused significant negative changes in reef topographic complexity (rugosity), which will probably result in shifts in the biological communities.

Assessments of the condition of reefs in the Chagos conducted since the mass mortality event show that Scleractinia are recolonizing damaged reefs. The recovery of the affected reefs will depend on the stability of the underlying substrate and the acclimation of newly established colonies to future anomalous warming events (Sheppard 2002, 2003). Deeper parts of the reef front (>164 ft; 50 m) may be sheltered from large temperature fluctuations occurring near the sea surface and may have retained pre-1998 characteristics.

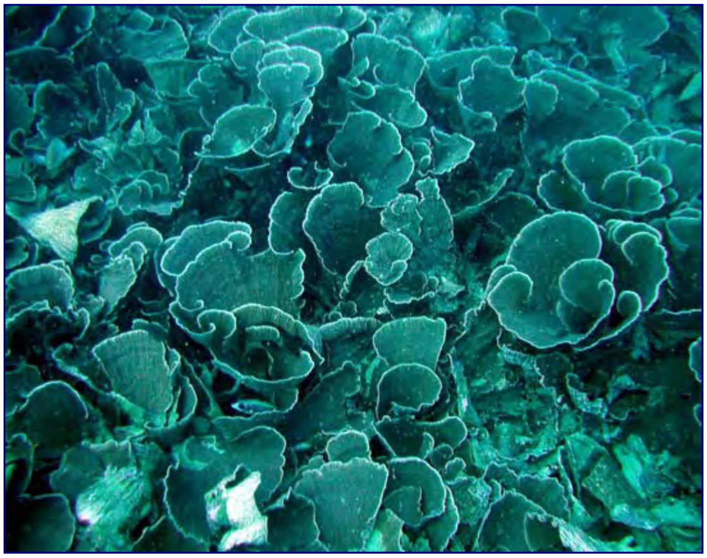

Figure 4.62 Example of the monospecific reef (*Leptoseris* tentatively *yabei*), near Channel Marker Buoy #5.

Evidence of massive Scleractinia mortality was still a common characteristic at most of the sites we surveyed at Diego Garcia in July and August 2004. The most notable exceptions were encountered at three Anchorage Area sites (L-N-An-1, 2 and 3) and at the deep study site in the Main Pass. The monospecific reef (*Leptoseris* tentatively *yabei*) found in the anchorage area at L-N-An-2-Nv showed no evidence of bleaching.

Likewise, the mixed Scleractinia assemblages at L-N-An-1 and 3 showed no evidence of mortality or significant bleaching. All three of these sites were at or below a depth of 75 ft (23 m). The deep study site in the Main Pass was strongly dominated by large specimens of the a hermatypic Dendropphylliidae *Tubastraea micrantha;* there was no evidence of bleaching or significant coral mortality in the Main Pass at depths below 65 ft (20 m).

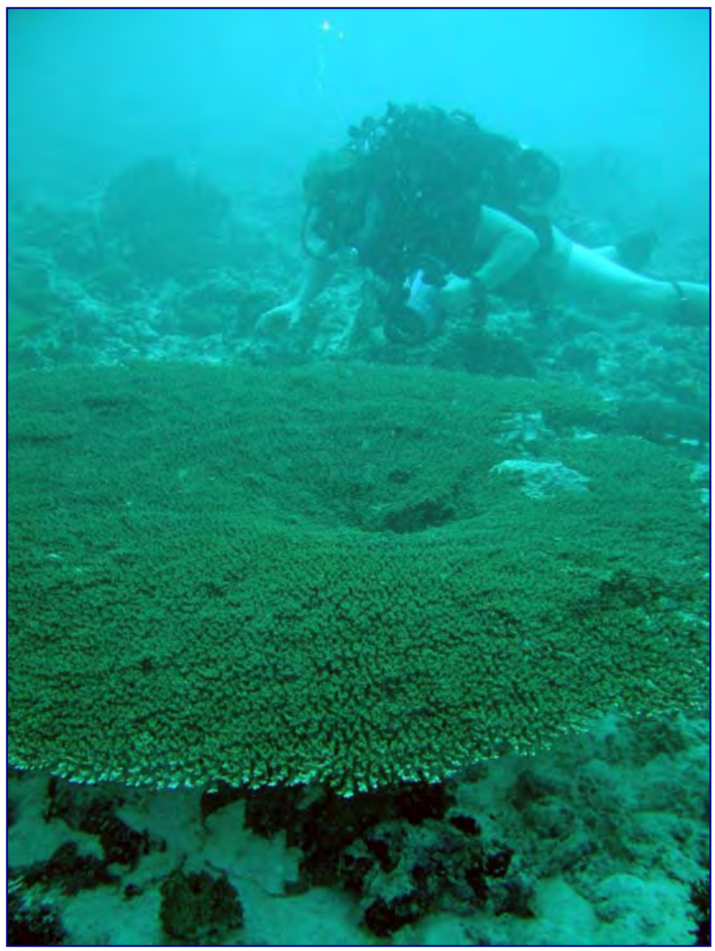

Figure 4.63 Large Acroporid coral that exceeded 1 meter in diameter within the anchorage area.

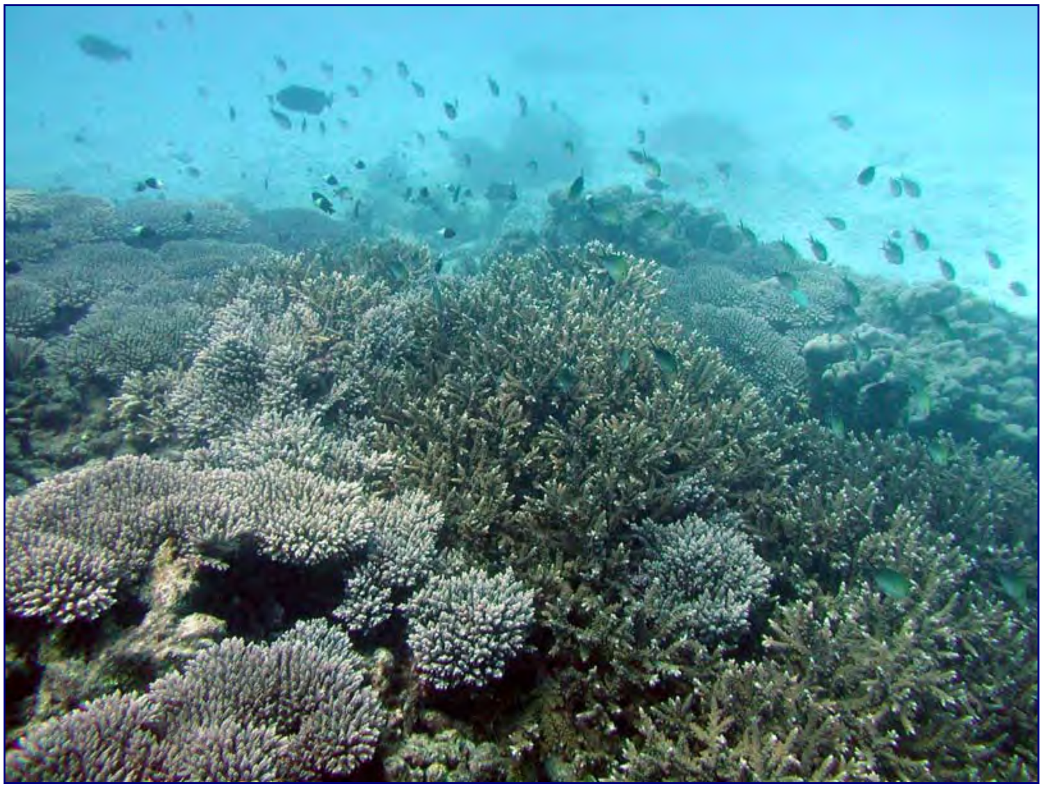

Figure 4. 64 The live coral present in and outside the lagoon was predominately healthy, with fewer than a half of 1 % showing signs of bleaching. The pictured patch reef is typical of the Replenishment Zone, which supports more than 70% live coral cover. Note the dominance of Acroporids.

With the exceptions noted above, there was abundant coral rubble covered by turf algae and/or encrusting calcareous algae at most of the ocean side and lagoon reefs. Turf algae amounted to as much as 57% cover on seaward reefs and 49% on lagoon reefs. Mean coral cover for all sites, except the Anchorage Zone, was 25.8% (± 13.7 *SD*). Mean Scleractinia cover on seaward sites was 34.5% (± 11.9 *SD*). Mean Scleractinia cover on shallow lagoon sites was 20.3% (± 12.1 *SD*). However, as noted in the caption (Fig. 4.60), many reefs within the Replenishment Zone supported much higher coral cover. The depth range at the seaward sites was 50 to 100 feet (15 to 30 m), and 10 to 49 feet (3 to 15 m) at shallow lagoon sites. On the fore reef terrace edge, the composition of Scleractinia cover was: Acroporidae (41.1% mean occurrence), Poritidae (43.4%), Faviidae (8.8%), Pocilloporidae (4.2%), and Agaricidae (2.5%). Scleractinia families represented on the shallow lagoon reefs were Acroporidae (46.9% mean occurrence), Poritidae (31.2%), Mussidae (10.7%), Faviidae (7.0%), and Fungidae (4.2%). Many of the Scleractinia recorded during our quantitative surveys on the seaward and lagoon reefs were juveniles measuring 6 inches (15 cm) or less in diameter. There were also large and medium-sized live Scleractinia (Acroporidae and Poritidae) on the seaward and lagoon reefs that survived the mass mortality of 1998.

Figure 4.65 Horny corals, Order Gorgonacea, were abundant at depths between 80 and 120 feet (24 - 37 m) on the drop offs at Cust, Barton and Cannon Points. Some specimens measured 10 feet (3 m) across.

Interestingly, macroalgae cover was relatively low (0 to 11.7%) and the crustose algae cover was relatively high (2 to 31% cover). Herbivory was obviously effective at controlling macroalgae cover on the seaward reefs. We frequently observed large schools of herbivorous fishes actively grazing on the reef. By consuming macroalgae, herbivores allow corals to expand and occupy grazed areas. In 1999, the coralline alga *Halimeda* was abundant on the fore reef terrace at Diego Garcia (Smith, 1999). In contrast, during our survey, only small patches of *Halimeda* were present. A possible explanation would be that the once abundant coralline algae supported the growth of the herbivore population which now effectively limits macroalgae cover. We observed few sea urchins in our belt transects on seaward sites and were led to believe that herbivores were mostly fishes. Yet, for the most part, fishes in the Chagos are planktivorous (Spalding 1999). Following the mass mortality of corals there may have been a regional but temporary surge in the availability of dissolved nutrients, which may have promoted the growth of macroalgae on the dead reef substrate. This, in turn, could have increased the abundance of herbivores on the reefs. For macroalgae to reoccupy as much cover on the seaward reefs of Diego Garcia as they did in 1999, there would have to be a decrease in the abundance of herbivores and/or a substantial supply of nutrients. The abundance of herbivores probably did decrease since the food source became depleted. The low macroalgae cover is now probably controlled by the lack of dissolved nutrients due to the remoteness of Diego Garcia from voluminous terrestrial supplies of nutrients.

Compared to Diego Garcia, reefs of the Seychelles have more herbivorous fish species and yet more macroalgae cover (Spalding 1999). The abundance of macroalgae at the Seychelles is thought to be linked to nutrient supply contained in terrestrial runoff (Spalding 1999). Sheppard (2000) noted that nutrient availability is naturally greater in lagoons compared to the seaward environment. In turn, primary productivity is also greater inside lagoons (Sheppard 2000). Shallow lagoon sites we surveyed at Diego Garcia contained very low and highly variable macroalgae cover: 1.4% (± 3.7 *SD*).

Crustose algae are known to generate an environment favorable for coral recruitment. Indeed, crustose coralline algae produce chemical signals that are recognized by planktonic larvae (including corals) and induce the settlement and metamorphosis of these organisms (Morse and Morse 1996). Low macroalgae cover and high crustose algae cover should help promote the recovery of the reefs at Diego Garcia through the continued establishment of the new Scleractinia colonies, the growth and expansion of juvenile Scleractinia, and the growth and solidification of reefs.

The reefs of Diego Garcia are currently recovering from the disastrous coral bleaching and mortality event of 1998. The topographic complexity of the seaward reefs changed drastically due to the loss (removal) of Acroporidae (Sheppard 2002). A large percentage of the Acroporidae were also lost within the lagoon as well as vast areas of Mussidae (tentatively *Lobophyllia hemprichii*). It is important to note, however, that on both the seaward and lagoon reefs, some ver large old coral colonies survived the 1998 event. Some of these colonies are estimated to be over 200 years old, based upon their size and growth rates from other regions. Large survivors from all the major coral families were sighted at all study sites. These large colonies and the abundance of young coral recruits are hopeful signs for the future of the reefs at Diego Garcia. Neveretheless, within the next 50 years, the future community structure (species composition and topographic complexity) of the reefs will probably be significantly different from that observed prior to the 1998 bleaching event (Sheppard 2002). The active bioerosion of the abundant dead coral substrate will probably delay the construction of a durable reef particularly if further mortality events occur more frequently in the near future (Sheppard 2003).

Turbidity on Coral Reefs at Diego Garcia

During our surveys we measured water column turbidity at three seaward and six lagoon sites. Turbidity on seaward reefs (edge of the fore reef terrace) was 0.20 (Nephloid Turbidity Units) NTU (± 0.05 *SD*). The mean turbidity at lagoon sites was 2.4 NTU (± 1.64 *SD*). Therefore, while highly variable, turbidity was greater in the lagoon compared to the seaward environment. Long-term residents of Diego Garcia informed us that the turbid waters we experienced during our dives both on seaward and lagoon reefs was a seasonal phenomenon. Our assumption, therefore, was that the Southeast Trades were probably causing the resuspension of fine sediments. Sites protected from the Southeast Trades (Simpson Point and Cannon Point) were indeed less turbid.

Mean turbidity at Diego Garcia (< 3 NTU) corresponded to turbidity levels that do not affect the photosynthesis and respiration of corals (Telesnicki and Goldberg 1995). By Caribbean standards, turbidity levels greater than 25 NTU are known to stress corals which respond by increasing their respiration rates (but not decreasing photosynthetic rates), maintaining expanded polyps as long as the water remains turbid, and increasing the mucus secretion to remove fine particles from the surface of colonies (Telesnicki and Goldberg 1995). Given that during the survey we did observe abundant release of mucus sheets by Poritidae in the lagoon, we assumed we were observing a stress response to sediment resuspension caused by seasonal winds. Since the seasonal response to sedimentation and increased turbidity potentially lasts from June through September each year, the photosynthesis to respiration ratio (P:R ratio) of coral colonies during that time could remain less than 1 and cause stress since more carbon would be consumed than fixed (Telesnicki and Goldberg 1995). Further, this prolonged production of mucus may stress corals to the point of making them more vulnerable to diseases (Bruckner 2002). Yet, corals in the lagoon have been naturally exposed to sedimentation on a seasonal basis and are probably acclimated to the seasonal recurrence of sedimentation. Tentatively, increased sedimentation could possibly affect these corals. Also the 1998 mass bleaching and mortality of corals may have weakened corals in the lagoon and reduced their ability to acclimate to increased sedimentation and prolonged turbidity.

Potential Human Disturbances

Human disturbances on reefs of Diego Garcia need to be closely managed assuming that negative impacts on the reef environments potentially exacerbate naturally-occurring disturbances including sedimentation, wave action, seasonal circulation patterns, and restricted tidal flushing (Menzie *et. al.*, 1980; McGee 1987; Miller, 1997). Human activities that may affect reef community function and structure at Diego Garcia include recreational fishing, excessive sediment production, water quality changes, and physical impacts caused by anchoring. The recommendations section of this report (Chapter 6) addresses concerns we have regarding fishing frequency and changes in local fishing success observed by long-term residents of Diego Garcia. We were told that fishing was once good within the lagoon and near the mouth of the lagoon. We were also told that fishing grounds gradually increased in size as the catch diminished close to port. Some of the recent reduction in catch per effort unit may be related to the ENSO of 1997-1998. Yet, diminishing fish populations does raise a concern, since declining fish communities will probably not help with the natural recovery of the reef ecosystem at Diego Garcia. Since fishing conducted at Diego Garcia is recreational and not a means of survival, limitations on fishing (landings and fishing areas) should be considered to promote the recovery of affected reefs.

Water quality changes that may be deleterious to coral reefs include the disposal of waters rich in nutrients (sewage) and the accidental release of hydrocarbons. Reefs are particularly vulnerable to both these impacts when they are degraded. The reefs of Diego Garcia were clearly degraded during the 1998 mass mortality. Hydrocarbons that are a particular concern because when they come in contact with corals they can cause coral mortality and reef structural changes (decreased topographic complexity) (e.g., Bak 1987; Guzman et al. 1991).

The designated Anchorage Area, although a necessity, is a potential source of increased sedimentation in the lagoon. Anchoring has by now probably leveled the majority of the reef substrate surrounding each of the designated anchorages (within the radius defined by the anchor chain length paid out onto the seafloor). The repeated anchoring and seafloor abrading by anchor chains probably produce fine carbonate sediments which when resuspended can intensify the effects on corals of the naturally-occurring sedimentation.

4.3.3 Fish

The reef fish communities of Diego Garcia as assessed in July and August 2004 appear to be robust in general, but not entirely pristine. Large individuals among several family groups were common. Previous quantitative descriptions of the reef fish communities at Diego Garcia do not exist. The best long-term description of some fish stocks come from fishing records and anecdotal reports of recreational fishing.

Several studies have looked at the biodiversity and community structure of Chagos reef systems. Comparisons of the reef fauna from around the Indian Ocean with the geographically isolated islands of the Chagos indicate that the Chagos Archipelago may function as an important biogeographic stepping-stone between eastern and western regions of the Indian Ocean (Sheppard 1999). Spalding (1999) examined ecological relationships of fish communities within some of the northern islands of the Chagos archipelago and found a surprisingly high degree of homogeneity (i.e., similarity) among the fish communities there. He suggests that the homogeneity in fish communities possibly exists as a result of the constant environmental conditions at the Chagos and the interconnectivity of the reef systems there. It is important to note that the isolation of Diego Garcia from the islands and banks of the northern Chagos and from reef communities of the wider Indian Ocean region place it at a greater than normal risk of experiencing slow recovery if the fish populations were to become depleted.

Species Richness

Winterbottom and Anderson (1999) catalogued 778 shore/reef and epipelagic fish species from the Chagos Archipelago. The remoteness and limited access to the Chagos and especially Diego Garcia have almost certainly hindered complete cataloguing of the fishes and it is likely that more will be identified. Spalding (2002) believes that over 1000 fish species may actually exist at the Chagos, although only time and further effort may tell. The nearest reef systems are those of the Maldives to the north where 1008 species have been documented (Winterbottom and Anderson 1999).

Nearly 200 reef fish species were recorded during this survey representing approximately 25% of all fish species listed by Winterbottom and Anderson (1999) from all habitats of the Chagos. During the recent survey, eight new occurrence identifications for fish species were made (Table 4.3). One of these new records is a fairly distinct and common fish, the orange socket surgeonfish (*Acanthurus auranticavus*). Also, *Paracanthurus hepatus* (palette surgeonfish), which had never been collected in the Chagos, and was sighted only once at Isle Anglaise to the north, was common in two of our study sites.

Spalding (1999) and his survey team counted a total of 201 species in 28 families on a survey encompassing 10 study sites on three atolls of Chagos (Salomon, Peros Banhos, and Chagos Bank) averaging 104 species per site. In contrast, a total of 151 species were recorded during the roving surveys in 2004 at Diego Garcia.

Table 4.3 New species records for the Chagos based upon observations made during the July/August 2004 Diego Garcia marine surveys.
(SS = S. Smith; PL = P. Leahy)

Common Name	Latin Name	ID by	Locations Sighted	Depths of Observations
Whitestreaked grouper	*Epinephelus ongus*	PL	Rambler Bay	13 ft (4 m)
			South Lagoon	14 ft (4 m)
			South Lagoon	10 ft (3 m)
Two-lined fusilier	*Pterocaesio digramma*	PL	Rambler Bay	40 ft (12 m)
Goldman's sweetlips	*Plectorhinchus goldmani*	SS	Barton Point	70 ft (22 m)
			Cust Point	70 ft (22 m)
Giant sweetlips	*Plectorhinchus obscurus*	SS	Barton Point	100 ft (31 m
Similar damselfish	*Pomacentrus similis*	PL	Rambler Bay	40 ft (12 m)
			South Lagoon	14 ft (4 m)
			South Lagoon	10 ft (3 m)
Banded goby	*Amblyogobius phalaena*	PL	Replenish. Zone	15 ft (5 m)
			Rambler Bay	13 ft (4 m)
			Eclipse Bay	24 ft (7 m)
			South Lagoon	14 ft (4 m)
Coral rabbitfish	*Siganus corallinus*	SS	Barton Point	55 ft (17 m)
Orange socket surgeonfish	*Acanthurus auranticavus*	PL	Aiport Site	50 ft (15 m)
			Cannon Point	55 ft (17 m)
			Simpson Point	54 ft (16 m)
			Cust Point	51 ft (16 m)
			Replenish. Zone	49 ft (15 m)
			Replenish. Zone	15 ft (5 m)
			Rambler Bay	13 ft (4 m)
			Rambler Bay	12 ft (40 m)
			South Lagoon	14 ft (4 m)
			South Lagoon	10 ft (3 m)

Fish Communities

Figure 4.66 Most commonly sighted big grouper (*Epinephelus multinotatus*) in the 0.8 to 1.2 m range.

Groupers (Serranidae), snappers (Lutjanidae), and emperors (Lethrinidae) were variably distributed among the reefs of Diego Garcia. Sites near points and passes of Diego Garcia had larger populations of these fishes as well as larger individuals. Groupers appeared to be most abundant in the Main Pass, at depths between 50 to 100 feet (15 and 31 m). The two most abundant large groupers were the saddleback or Chinese grouper (*Plectropomus laevis*) and the whiteblotched grouper (*Epinephelus multinotatus*). Specimens of the saddleback grouper over 3 feet (1.0 m) were seen at many dive locations, while specimens of the whiteblotched grouper up to 2.5 feet (80 cm) were also common. Three separate giant grouper (*Epinephelus lanceolatus*) were sighted; two in the Main Pass and one in the Replenishment Zone. The largest was estimated to be 5 feet (1.5 m) long. Predatory fishes may be concentrating at points where ocean currents converge with reefs, and are subsequently drawn from neighboring areas. This can produce a false sense of overall abundance of these fishes at Diego Garcia. Reefs of the Replenishment Zone also appear to contain an abundant amount of larger groupers and large aggregations of black snapper (*Macolor niger*) as observed near Middle Pass. These observations suggest habitat preference and that the “no-take” rules of the Replenishment Zone are having the desired effects. Another indication of the healthy fish population in this general area was the popularity of Main Pass as a recreational fishing spot.

Figure 4. 67 Emperor (*Lethrinus olivaceus*). These specimens were estimated to range from 80 – 100 cm total length.

Figure 4. 68 Steephead parrotfish (*Chlorurus strongylocephalus*) and the coral *Tubastraea micrantha*.

Surgeonfishes (Acanthuridae) as well as parrotfishes (Scaridae) are primary herbivores and represent important functional groups on reefs (Steneck 1988; Hay 1991). The abundance and diversity of surgeonfishes at Diego Garcia reflect a habitat with a good deal of supportive algal growth. Parrotfishes were somewhat less abundant and diverse than expected and the reason for this is not clear. While moderately abundant, parrotfishes (Scaridae) were dominated by a single species, the bullethead parrotfish (*Chlorurus sordidus*). At the predator side of the trophic spectrum, the overall high abundance and diversity of groupers, snappers, and emperors reflect healthy prey populations, sufficient to maintain and encourage the predator population.

The observed sizes of many of the fish species at Diego Garcia reefs were on the larger side of the size spectrum. Species such as yellowfin surgeonfish, longfin bannerfish, sweetlips, some parrotfishes, some groupers, snappers, and jacks/trevallys were observed at, or even above the high end of their respective recorded size ranges (Allen et al. 2003, Meyers 1999, Fishbase.org 2005). One reason for this may be the decreased shark population.

Species of Concern

As apex predators in the ocean, sharks are vital parts of healthy marine ecosystems. Sharks and barracudas were noticeably rare at the ocean side reefs, which is surprising considering previous reports of a moderate shark population at Diego Garcia (Smith 1999). Unfortunately it is in line with previous reports of an overall declining shark population in the Chagos (Anderson et al. 1998). A review of the recreational fishing logs at Diego Garcia for records of shark catches may shed more light on the state of sharks in the area. Several reasons for the scarcity of sharks could be further examined, one being a possible seasonal fluctuation in the vertical and geographical distribution of sharks. A more dire possibility, and likely reality, is that commercial fisheries, both legal and illegal, have been depleting shark populations, as suggested by Anderson et al. (1998). Fishing has taken a toll on sharks, and their populations have been decreasing worldwide. This 2004 Diego Garcia survey continues the downward trend of shark observations at Chagos in general. Many shark species are highly pelagic and observations made at Diego Garcia and Chagos may be reflecting the situation in the Indian Ocean as a whole.

Seasonal migrations may bring groups of sharks to the islands, accounting for the occasional observations of higher abundances. It is interesting to note that during March 1999 and April 2002 divers conducting operations in the vicinity of Main Pass, Middle Island, Barton Point and Cust Point encountered moderate numbers of aggressive sharks (Smith, 1999; Alling, 2004). Dives made at these same sites during this survey (July – August) showed very few sharks. The boat captains for both teams (Oscar Opolento and Ramon Espiritu), stated that sharks were always much more abundant during the March – April time frame than at other times of the year. Espiritu has served as a charter boat captain in Diego Garcia for 24 years. He stated that sharks over 13 feet long (4m) were often sighted outside the lagoon, and that a hammerhead longer than his boat (31 feet [9.5 m]) had remained along side his vessel for several minutes. This very large shark encounter occurred off Horsburgh Point.

Figure 4.69 Napoleon wrasse (*Cheilunus undulatus*). This specimen was estimated to be 5 feet (1.5 m) long.

The number of Napoleon/humphead wrasse (*Cheilinus undulatus*) observed at several ocean side reefs was encouraging. On two separate dives, five, individual adult Napoleon wrasse were observed. During this survey, sighted individuals were estimated to be 7 feet (2.2 m) long. This is significant because of the severely depressed populations of Napoleon/humphead wrasse in most areas of the Pacific and Indian Oceans. They are favored in the live fish trade because of their large sizes (US Newswire 2004). The Chagos and Diego Garcia may represent a refuge for these fish since they are generally not caught on hook and line, and local fishers do not seek them.

Influence of Reef Habitats on Fish Communities

The habitats of the ocean side reefs were mostly similar to each other but their fish populations appeared to vary in relation to coastal exposure, reef zone, live coral cover, presence of coral rubble, and topographic complexity. At the northwest tip of Diego Garcia, anthiases were highly abundant and diverse near the seaward edge of the fore reef terrace. Large schools of fusiliers (Caesioninae) and many large unicornfishes and surgeonfishes (Ancanthuridae) were common near the edge of the fore reef terrace. Groups of Napoleon/humphead wrasse were observed with the abundant schooling anthiases and fusiliers. Groups of chubs/drummers (Kyphosidae) and breams (Lethrinidae) also frequented the terrace edge. As mentioned above, the distribution of large groupers (greater than 20 in [50 cm]) varied among ocean side study sites. Ocean side sites located near points consistently had larger individuals and larger populations of groupers. In contrast, Moorish idols (*Zanclus cornutus*), regal angelfish (*Pygoplites diacanthus*), and emperor angelfish (*Pomacanthus imperator*) tended to be more common at sites supporting lower live coral cover and more rubble.

The reef habitats of the lagoon varied greatly. Discontinuous and patchy reef formations contrasted with the fore reef terrace and slope reefs of the ocean side. Sites within the lagoon also varied greatly in depth, from 5 feet (1.5 m) in the southern lagoon basin and the lagoon shelf to 50 feet (15 m) at the base of knolls and deeper still to 93 feet (29 m) in the Anchorage Area. Yet, despite the patchy nature of lagoon reefs and the variety of the reef types (e.g., deep knoll reefs, shallow knoll reefs, shallow patch reefs, etc.), the fish assemblages within the lagoon were generally similar to each other.

The key predatory fishes of the lagoon were consistently present, however their abundance and species richness varied between sites. Groupers, snappers, and emperors were less abundant on lagoonal reefs than on ocean side reefs but large individuals were certainly present within the lagoon. Small species of groupers (e.g., strawberry grouper [*Cephalopholis spiloparaea*], tomato grouper [*C. sonnerati*], hexagon grouper [*Epinephelus hexagonatus*], and honeycomb grouper [*E. merra*]) were common while very large species (≥ 1 m [3.3 ft]; e.g., saddleback grouper [*Plectropomus laevis*] and giant grouper [*E. lanceolatus*]) were only seen near the Main Pass and Middle Pass. Medium sized Carangidae (jacks/trevallies) were commonly seen in schools within the lagoon but were usually noted outside of survey zones. At least four requiem sharks (Carcharinidae) were observed at one study site in the Replenishment Zone (L-N-RZ-1-N) located near Middle Pass. Additionally, several blacktip reef sharks were seen from shore at the Turtle Cove observation area. There were no other requiem shark sightings from within the lagoon during this study.

Patches of algal growth (turf algae) were noted at most lagoon sites. Damselfishes (Pomacentridae; whiteband damselfish [*Plectroglyphidodon leucozonus*] and jewel damselfish [*P. lacrymatus*]) were frequently associated with these algal patches. Pomacentridae were by far the most abundant and diverse of the fishes found in the lagoon. Moray eels (Muraenidae) were surprisingly under-represented in fish surveys within the lagoon. Fluctuating populations of moray eels may reflect greater ecological changes undergone within the lagoon since the warming/mass bleaching event of 1998. Manta rays were regularly seen within the lagoon (several were seen on the ocean side reefs as well).

Figure 4.70 Giant manta ray (*Manta birostris*)

The knolls and reefs of the Replenishment Zone supported more diverse and abundant fish populations compared to those of the shallow lagoon shelf reefs and those of the southern lagoon basin. The fish populations observed off Point Marianne and northern Eclipse Bay were similar to those of the Replenishment Zone. The knoll at Minni Minni patch reef in Rambler Bay (L-N-Rby-3-G) supported a large fish population also similar to the Replenishment Zone.

The Eclipse Bay (L-N-EcBy-2-G) site located along the western lagoonal shelf appeared to be under stress. High turbidity and sedimentation were observed at this site, located immediately north of the small boat basin. Due west of the site was the construction yard of a contracting company. The land to shoreward is part of the area filled as reclaimed land for harbor facilities and other operational base structures. The reef at this site had at one time been separated from land by a greater distance and by sand and reef flats (e.g., Menzie *et*. *al*. 1980). The skeletal remains of corals showed that this reef had previoulsy consisted of large massive coral heads and high topographic complexity. Even though the reef is now mostly dead, there were a few juvenile corals growing on dead coral substrate.

The survey sites located in the delineated Anchorage Area were markedly different from the remainder of the lagoon. The Anchorage Area occupies the deepest part of the entire lagoon. The lagoon floor in most portions of the Anchorage Area examined consisted of a fine sand or rubble. On several Anchorage Area survey dives, the only fish sighted were passing schools of jacks

(Carangidae). As topographic (structural) complexity increased, the abundance and diversity of fishes increased. In the vicinity of the northern Anchorage Area (L-N-An-2-N), there was a small mono-specific coral reef (*Leptoseris* tentatively *yabei*). Dense schools of bigeye emperors (*Monotaxis grandoculis*), goldlined seabreams (*Gnathodentex aureolineatus*) and a variety of squirrelfishes and soldierfishes were closely associated with this reef. The adjacent seafloor areas were comprised of boulders and low tabular Acroporidae corals. A diverse population of fishes was associated with this surrounding relief.

4.3.4 Opportunistic Observations

Marine Mammals

An observation occurred on the ocean side shelf near the southern end of the airport runway in which a pod of 20 to 30 spinner dolphins (*Stenella longirostris*) passed the dive vessel, moving to the north and out of sight while jumping and spinning. Another observation was made from the deck of the dive vessel while transiting the northern lagoon area in a heavy chop. Four or five spinner dolphins were seen and they approached the vessel with one individual riding the bow wave of the boat for several minutes.

Additional information on marine mammals was obtained via personal communication with long-time Diego Garcia residents. Nestor Guzman, a Natural Resources Specialist, cleaned and identified the skull of a Cuvier's beaked whale (*Ziphius cavirostris*). The skull had been found on Salomon Island on June 26, 2002 (Salomon Island is north of Diego Garcia within the Chagos Archipelago). Oscar Opolento has worked as a boat captain in Diego Garcia for over 15 years; prior to this, he served in the Merchant Marines on the California coast, where he regularly observed seals and sea lions. In 1997 he sighted a seal or sea lion hauled out on a buoy near the fuel pier. This is believed to be the first and only sighting of any species of pinniped (including seals and sea lions) in the Chagos Archipelago.

Seagrasses

Four minimal occurrences of seagrasses were observed. Three or four dispersed living sprigs (separate rhizomes) of *Thalassodendron ciliatum* were noted at L-S-4-G between survey transects. A second observation was made while snorkeling near shore in Rambler Bay in the lagoon (just north of study site L-N-Rby-3-G). This sighting consisted of the remant of a seagrass bed that ran parallel to shore between the beach and a silted/remnant near-shore coral reef in about 4 to 8 ft (1.2 to 2.4 m) of water. A single blade of *T. cilliatum* was witnessed at this site. Three rough strands of seagrass, tentatively *Springodium sp.* were observed in the survey area at L-S-1-N. Some seagrass fragments were noted on one benthic transect at L-N-RZ-6-N. No other evidence of detached or detrital leaves were noted at this site or anywhere visited during the survey at Diego Garcia despite several beach visits around the island. No *Halophila decipiens* was seen.

Anthropogenic/Hazardous Materials

The majority of anthropogenic (human origin) materials found on the surveyed reefs were fishing related but boating/shipping-related objects were noted as well. The most common item observed was fishing line. It was recorded in at least six study sights both inside and outside the lagoon. Fishing line was observed coiled around reef formations, affecting several formations and species of coral. A dark phase *Epinephalus multinotatus* (whiteblotched grouper) was seen at O-W-CnPt-2-G with about a 60 cm (2 ft) length of fishing line extruding from its mouth. Fishing tackle (lead sinkers and hooks) were occasionally seen. A complete fishing rod, without the fishing line, was found at the Minni Minni patch reef (L-N-Rby-4-G). Boat lines (ropes) of various dimensions were observed among coral formations as well (in the same manner as fishing line); in at least three study sites. No fish traps or nets were sighted during any of the dives

Four derelict anchors were observed and one occurrence of possible small anchor scarring was noted. Two of the derelict anchors were small boat-type and the other two were large ship anchors. One of the large ship's anchors was a modern Navy-type anchor, approximately 8 feet (2.5 m) long; it was located in 72 feet (23 m) of water in the Main Pass and was heavily encrusted with coral (*Tubastraea micrantha*). A second, much older looking admiralty-type anchor was seen nearby and was approximately 10 feet (3 m) long and was heavily encrusted with *Tubastraea micrantha.*

Two sightings of miscellaneous metallic debris were made. Several sections of wire cable approximately 2 inches (4 cm) in diameter were seen in the Main Pass and a hand-sized piece of crosshatch metal grating was observed at L-N-EcBy-2-G just north of the small boat basin entrance. Miscellaneous trash, such as aluminum cans and plastic bottles, was very rarely sighted. At most dive locations no such items were seen.

Two observations of potentially hazardous material occurred. Both sightings were within a few meters of the mooring blocks for Channel Marker Buoy No. 2 in the Main Pass. One appeared to be an automobile-type battery, the second was a much larger battery measuring approximately 3 x 2.5 x 2.5 feet (1 x 0.75 x 0.75 m).

No other observations of potentially hazardous or toxic materials were made during any of the dives. A sunken, but intact, channel marker buoy was observed a short distance from the mooring blocks for Channel Marker Buoy No. 2.

Water Quality

Water quality readings of temperature, salinity, dissolved oxygen (DO), and pH were consistent among the study sites and were associated with low variance (See Appendix O). Turbidity readings, however, showed the greatest variation among sites and ranged from 0.16 to 4.79 NTU. Measured turbidity was lowest at seaward sites at Cannon Point and Simpson Point. Lagoon sites, except for those at Rambler Bay, had the highest turbidity levels. The seaward site at Cust Point also had somewhat elevated turbidity levels compared with the other sites. Visibility was moderate to poor at most sites. The lowest visibility occurred at L-N-EcBy-2-G. O-W-SmPt-1-G located near the high-energy ocean interface of Simpson Point had reduced visibility near the channels of the reef platform and visibility in general appeared to be affected by the changing tide. Seawater temperature was lowest on the ocean side reefs (mean water temperature was 26 °C, 78.8 °F), the west side being slightly higher than the east, and warmest in the southern lagoon area (26.9 °C, 80.4 °F). Dissolved oxygen (DO) levels were also greater outside the lagoon: the mean DO concentration was 6.2 mg/l on seaward reefs and 5.9 mg/l on lagoon reefs.

4.3.5 Description of Anchorage Area

During the present survey, study sites within the Anchorage Area were primarily restricted to the periphery (of the Anchorage Area). One of this report's contributors (Smith) conducted moderately extensive surveys in the central portions of the Anchorage Area in 1999, including surveys under vessels at anchor. The point intercept method was used to assess the benthic community. Results for the 1999 survey within the Anchorage Area included: sand (42%), rubble (26%), bare rock (3%), algae (11%) and scleractinian coral (17%).

Five separate areas within the designated Anchorage Area were investigated during the 2004 survey. The following briefly describes each of the five sites.

L-N-An-1-Nv: The depth at this site was 75 feet (23 m) and the sea floor was generally flat. Approximately 68% of the transect data points were sand or sand/rubble. The rubble at this site was predominately bare, with less than 10% visible algal cover on the individual rubble pieces. Twenty percent of the intercept points were stony coral, with 17 Acroporidae and 14 specimens from other groups (Agariciidae, Mussidae and Poritidae). Of the 31 coral colonies counted only 1 Acroporidae showed slight signs of bleaching. Only one dead coral was encountered. Most of the coral specimens sighted were of moderate to large size (6 to 30 in [15 to 75 cm] in their greatest dimension). The remaining intercept points included algae and sponges. The area supported a diverse fish population, including numerous small groupers. Underwater visibility was 39 feet (12 m).

L-N-An-2-Nv: This site consisted of a low knoll with gently sloping sides. The crest of the knoll was approximately 78 feet (24 m) deep, the surrounding sea floor was approximately 95 feet (29 m) deep. The knoll supported 100% cover by a monospecific reef of the Agariciidae, *Leptoseris* tentatively *yabei.* Large numbers of soldierfishes, squirrelfishes, cardinalfishes, fusiliers, and emperors were closely associated with the reef. The sea floor surrounding the knoll supported a moderate coverage of Acroporidae, including some tabular specimens over 4.9 feet (1.5) m in diameter. None of the coral specimens sighted showed any signs of bleaching or disease. No specimens of *Leptoseris* tentatively *yabei* were sighted off the knoll. Underwater visibility was 39 feet (12 m).

L-N-An-3-Nv: The depth at this site ranged from 90 to 93 feet (27.7 to 28.6 m). Stony corals were diverse and comprised 39% of the transect data points. None of the corals showed any signs of bleaching or disease. Large tabular Acroporidae (some over 6.6 feet (2.0 m) in diameter) were present. Moderate amounts of the Agariciidae cactus coral (*Pavona cactus*) were also sighted. Unconsolidated sediment (silt, fine sand and rubble) and algal turf were recorded at 36% and 19% of the intercept points, respectively. The fish population was very similar to that described for L-N-An-1 and 2, but with larger numbers of surgeonfishes and a 3 foot (1 m) long grouper (*Epinephelus multinotatus*).

L-N-An-4-Nv and L-N-An-5-Nv: These sites were located in the southeastern portion of the designated anchorage area. At both sites the sea floor was flat with no visually detectable slope. The depth at site 1 was 80 feet (25 m), at site 2, 74 feet (23 m). Ninety-nine of the 100-transect data points for site 1 were fine sand. Several bushy black coral trees (*Antipathes* sp.) were sighted at each site, no other corals of any type were seen. The second site had a more varied sea floor, in addition to fine sand, mud rubble and small boulders were present. Underwater visibility at these sites less than 19.7 feet (6 m).

4.4 Threatened and Endangered Species List

Table 4.4 Threatened or Endangered species that may/are found on or around Diego Garcia.

Common Name	Latin Name	Status	Presence: Known (K) or Possible/Probable (P)
Reptiles			
hawksbill turtle	*Eretmocheyls imbricata*	E	K
leatherback turtle	*Dermochelys coriacea*	E	P
green turtle	*Chelonia mydas*	T	K
olive ridley	*Lepidochelys oliveacea* E.	E	P
Mammals			
sperm whale	*Physeter macrocephalus*	E	P
sei whale	*Balaeonoptera borealis*	E	P
finback whale	*Balaeonoptera physalus*	E	P
Brydes whale	*Balaeonoptera edeni*	E	P
blue whale	*Balaeonoptera musculus*	E	P
humpback whale	*Megaptera novaeangliae*	E	P

4.5 December 26, 2004, Tsunami

Commander Davies, British Representative, led a small team to survey the eastern side of the atoll immediately following the tsunami. He observed that beach gradients were steeper, but little overall damage was noted (C. Davies, pers comm.). The area that bore the brunt of the damage was on the low-lying ¼ mile (0.4 km) stretch of road and beach leading to East Point Plantation, approximately 3 - 4 miles (4 – 6 km) north of GEODDS (north of Horsburgh Point). As well, limited wash-over occurred north of Minni Minni. The tidal wave surge near Horsburgh Point appeared to have ranged from 8 – 15 feet (2 – 5 m) in height and went inland an estimated 100 – 250 yards (91 – 229 m). The road was impassable in this area due to uprooted/fallen trees and 2 – 10 inches (5 – 25 cm) of sand/aggregate deposited on to the road. The road had to be cleaned and graded (N. Guzman 2005). NAVFAC PAC biologists visited the area on January 26, 2005. The road had already been graded, but the damage was still visible (Figures 4.71 – 4.73). Dr. Sheppard whom also visited Diego Garcia a few months after the tsunami noted (The tsunami, shore erosion and corals in the Chagos Islands 2005) that erosion on Diego Garcia is more evident and that the tsunami may very well have accelerated coastal erosion by 1 – 2 years.

Figure 4.71 Tsunami damage on Diego Garcia (Jan. 26, 2005).

Figure 4.72 Graded area (Jan. 26, 2005).

Figure 4.73 Height of the damage is at least 10 feet (3 meters) high (Jan. 26, 2005).