# Marine Biological Survey at United States Navy Support Facility, Diego Garcia, British Indian Ocean Territory
**August 2005**

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Appendix O

# MARINE BIOLOGICAL SURVEY AT UNITED STATES NAVY SUPPORT FACILITY, DIEGO GARCIA, BRITISH INDIAN OCEAN TERRITORY, JULY/AUGUST 2004

## FINAL REPORT - AUGUST 2005


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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ° | Degree |
| °C | Degree Celsius |
| °F | Degree Fahrenheit |
| ac | Acre(s) |
| BIOT | British Indian Ocean Territory |
| CITES | Convention on International Trade in Endagered Species |
| cm | Centimeter(s) |
| DGPS | Differential Global Positioning System |
| DO | Dissolved Oxygen |
| DOD | Department of Defense |
| ENSO | El-Niño Southern Oscillation |
| ft | Feet |
| $ft^2$ | Square Feet |
| $ft^3$ | Cubed Feet |
| GMI | Geo-Marine, Inc. |
| GPS | Global Positioning System |
| in | Inch(es) |
| INRMP | Integrated Natural Resources Management Plan |
| IUCN | World Conservation Union |
| kg | Kilogram(s) |
| km | Kilometer(s) |
| $km^2$ | Square Kilometer(s) |
| $km^3$ | Cubed Kilometer(s) |
| kt | Knot(s) |
| lb | Pound(s) |
| LCM | Landing Craft, Mechanized |
| LPI | Linear Point Transects |
| m | Meter(s) |
| $m^2$ | Square Meter(s) |
| mg/l | Milligram(s) Per Liter |
| mi | Mile(s) |
| $mi^2$ | Square Mile(s) |
| min | Minute(s) |
| mm | Millimeter(s) |
| MRAG | Marine Resources Assessment Group, Ltd. |
| MSC | Military Sealift Command |
| MWR | Morale, Welfare and Recreation |
| Navy | U.S. Navy |
| NM | Nautical Mile(s) |
| NTU | Nephelometric Turbidity Unit |
| SCUBA | Self Contained Breathing Apparatus |
| SD | Standard Deviation |
| U.S. | United States of America |
| UCT 2 | Underwater Construction Team 2 |

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# 1.0 INTRODUCTION

## 1.1 REPORT FORMAT AND GENERAL BACKGROUND

This report is presented in nine chapters: 1) Introduction and Background, 2) Materials and Methods, 3) Results, 4) Discussion, 5) Conclusions, 6) Recommendations, 7) Literature Cited, 8) Bibliography and 9) List of Preparers.

Diego Garcia is an atoll in the Chagos Archipelago, located in the central Indian Ocean, and under the control of the British Indian Ocean Territory. The marine natural resources of Diego Garcia are considered to be of global significance. In 2001, Diego Garcia was made part of the Ramsar Convention List of Wetlands of International Importance (Ramsar 2005) because of the significance of its "ecology, botany, limnology or hydrology" and because it is "important for the conservation of global biological diversity and for sustaining human life through the ecological and hydrological functions [it] performs" (Ramsar 2005). Spalding et al. (2001) consider that "…the reefs of the Chagos and parts of the Andaman 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 Andaman and Nicobar Islands but spared most of the Chagos, the global significance of the Chagos Archipelago marine resources may be even greater than before.

Marine field surveys reported here were conducted between July 28 and August 18, 2004. Funding for these surveys was received from the United States (U.S.) Department of Defense (DOD) Legacy Resource Management Program.

## 1.2 OBJECTIVES AND STRATEGY

The four primary objectives of these surveys were:

1. Complete a rigorous assessment of marine natural resources for use in updating the Integrated Natural Resources Management Plan (INRMP) for Diego Garcia. This report is intended to be included as an appendix in the INRMP, with excerpted portions included within the INRMP.
2. Assess and evaluate the condition of marine natural resources relative to on-going and proposed operations and activities.
3. 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.
4. Document current conditions at one of the world's most biologically important atolls, as part of the DOD's Coral Reef Protection Implementation Plan.

The strategy employed to complete this work was to deploy two teams of divers and scientists, using open circuit compressed air self contained underwater breathing apparatus (SCUBA). One team comprised two marine ecologists employed by the Naval Facilities Engineering Command, supported by eleven active duty divers from Underwater Construction Team 2 (UCT 2). The second team consisted of three marine scientists employed by Geo-Marine, Inc (GMI). Hereafter, these teams will be referred to as the U.S. Navy (Navy) team and the GMI team.

Both teams collected qualitative and quantitative biological data. The GMI team also collected water quality data. The Navy team completed a total of 181 dives over 18 diving days to a maximum depth of 30 meters (m) (100 feet [ft]). The GMI team completed 66 dives over 10 diving days to a maximum depth of 18 m (60 ft). Six broad habitat types were investigated, including sites inside the lagoon and on the seaward side of the atoll.

## 1.3 ENVIRONMENTAL SETTING

**Geographical Setting**–Diego Garcia is an atoll located in the Chagos Archipelago, Indian Ocean (**Figure 1-1**). The atoll was formed by the accretion of reef corals on the flanks of a subsiding oceanic volcano. Diego Garcia is the largest and southernmost of the islands of the Chagos (Stoddart 1971a; Menzie 1980; Wells 1988). The Chagos are located near the equator in the southern hemisphere at the approximate geographic center of the Indian Ocean. The geographical coordinates of Diego Garcia are 7°26' S, 72°23' E (Menzie 1980; DON 1997). Politically, the Chagos are governed as part of the British Indian Ocean Territory (BIOT). The island group, however, is currently uninhabited except for the U.S. military base on Diego Garcia (Naval Shore Facility Diego Garcia) (Stoddart 1971a; Menzie 1980; Wells 1988; DON 1997; Procter and Fleming 1999; Sheppard and Seaward 1999; Wilkinson 2000; Spalding et al. 2001).

The Maldives, located 500 kilometers (km) (311 miles [mi]) to the north are the nearest islands to the Chagos Archipelago. Distances to other coral islands of the Indian Ocean are: 1,700 km (1,056 mi) to Rodrigues; 2,400 km (1,491 mi) to Reunion; 2,100 km (1,305 mi) to Mauritius; and 1,900 km (1,181 mi) to the Seychelles. The nearest continental land mass is the southern tip of India located 1,900 km (1,181 mi) to the northeast. The continental landmass of Africa is located 2,900 km (1,802 mi) to the west; Western Australia is located 4,828 km (3,000 mi) to the east (DON 1997; Sheppard and Seaward 1999; Spalding et al. 2001).

**Geological Setting**–The Chagos Archipelago is exists on the Chagos Plateau. The plateau is an oceanic feature that rises from the ocean basin floor to a plateau depth of 2,000 m (6,562 ft) (**Figure 1-2**) (Stoddart 1971a). The Chagos are the southernmost of an oceanic island system that leads to the north along the Laccadive-Chagos Ridge that also includes the Maldives and Lakshadweep off the southwestern tip of India. The island ridge system is postulated to be a remnant trail left by the continental drift of the Indian sub-continental landmass into Asia over a mid-ocean "hotspot" (the Reunion hotspot) in a similar process that formed the extended chain of the Hawaiian Islands (Stoddart 1971a; Sheppard et al. 1999; Wilkinson 2000; Spalding et al. 2001). Under this hypothesis, the Chagos would be the youngest of the island formations. The Chagos region is seismically active with many tremors recorded within the past 20 years. Several earthquake epicenters have been located near Diego Garcia: one in 1968 (magnitude not available) and in 1983 with a magnitude of 7.6 on the Richter scale (DON 1997; Proag 1999). The seismic activity is the result of continued crustal movement in the Chagos (Henstock and Minshull 2003).

**Geomorphology**–The Diego Garcia atoll is a continuous, undulating strip of land that encircles a highly enclosed and protected lagoon (**Figures 1-3** and **1-4**). The north-south extent of the island is 24 km (15 mi) and its greatest east-west extent is 16 km (10 mi). The exposed dry-land area covers 31 square kilometers ($km^2$) (11.6 square miles [$mi^2$]) (Stoddart 1971a). The surface area of the lagoon covers 124 $km^2$ (47.9 $mi^2$) (Stoddart 1971a). An insular shelf with a total area of 17 $km^2$ (6.6 $mi^2$) encircles the seaward edge of the exposed terrestrial land-rim of the atoll (Stoddart 1971a) (**Figures 1-3** and **1-4**). The continuous outer edge circumference of the terrestrial rim is 61 km (38 mi) (Menzie 1980).

The mouth to the lagoon is 7 km (4 mi) wide and is located at the northern end of the atoll. In this area of the atoll, there are three islands arranged sequentially along the continued submerged rim of the atoll. The islands vary in size from 200 to 800 m across (656 to 2,625 ft) and the passes are of varying widths and depths (widths: 700 to 3,400 m [2,297 to 11,155 ft]; depths: 0 to 20 m [0 to 66 ft]). The islands have large shallow shelves supporting reef formations. The Main Pass has been partially dredged and marked as the entry channel to the lagoon. With its single continuous stretch of exposed land rim comprising about 90% of the entire circumference of the atoll, Diego Garcia is one of the most continuous encircling atolls in the world (about 10% is submerged rim or non-continuous land/islands) (Stoddart 1971a; Menzie 1980; Wells 1988).

Compared to other atolls in the Chagos and the world, the Diego Garcia lagoon is relatively shallow with a maximum depth of 31 m (102 ft) (Stoddart 1971a). In general the lagoon can be divided into two distinct areas or basins: a northern and a southern basin. The northern basin is larger and deeper (maximum

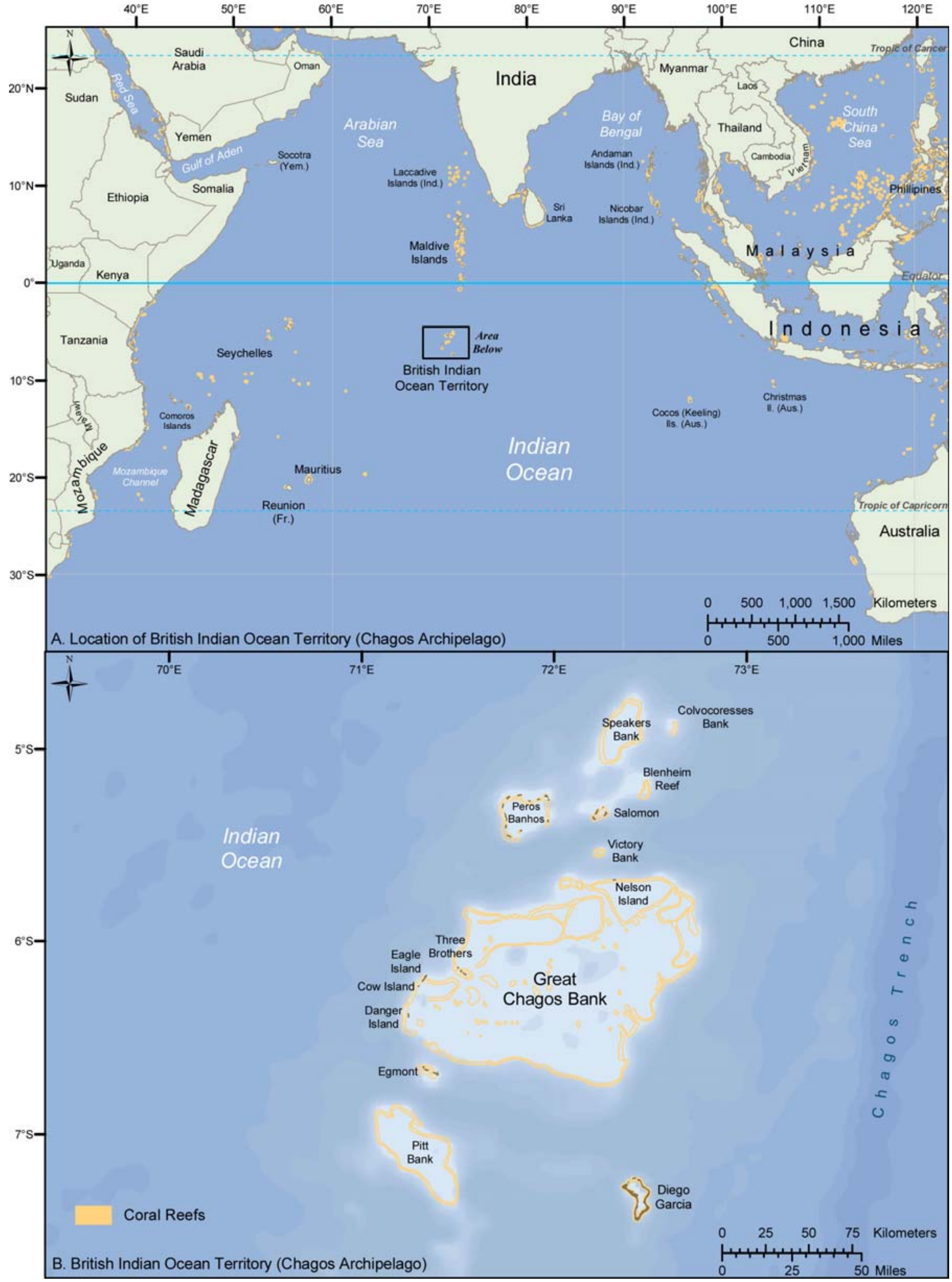


**Figure 1-1.** Location map of (A) the British Indian Ocean Territory Chagos Archipelago and (B) Diego Garcia.

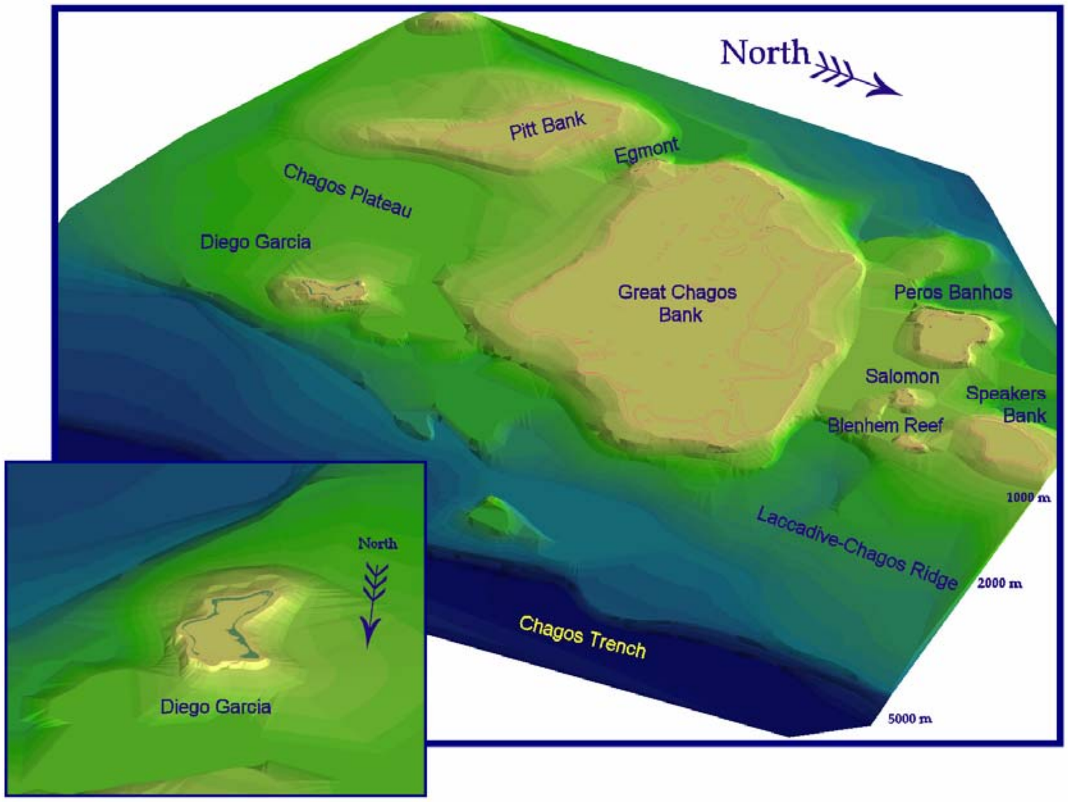


**Figure 1-2.** Generalized three-dimensional bathymetry of the Chagos Archipelago in the Indian Ocean.

**Figure 1-3.** Oblique aerial view of Diego Garcia from the north.


**Figure 1-4.** Map of Diego Garcia, British Indian Ocean Territory: military facilities, place names, and significant features.

water depth of 31 m [102 ft]) than the southern basin (maximum water depth of 5 m [16 ft]). More subtly, the southern basin can be divided further into two separate areas using submerged bathymetric features as guides: a nearly circular formation in the north and Turtle Cove in the south. A large portion (about 50%) of the northern basin has been dredged to accommodate the anchoring and turning of large ocean-going vessels and submarines (Menzie 1980; DMA 1983; DON 1997, 2004). The seaward island slope drops off sharply and, in some places, reaches depths of 457 m (1,499 ft) within 1 km (0.6 mi) of the shoreline (DON 1997) (**Figure 1-2**). The southern and eastern sides of this seamount plunge to depths of 2,000 m (7,620 ft) onto the Chagos Plateau. Further to the east the base of the Chagos Plateau is in a water depth of 5,000 m (16,405 ft) beyond which are the Chagos Trench and deep ocean basin (Stoddart 1971a). Depths to the north and west reach 1,500 m (4,922 ft) on the Chagos Plateau before rising again in the north at the southern extent of the Great Chagos Bank and rising to the west at Pitt Bank. Great Chagos Bank lies 55 km (34 mi) to the north of Diego Garcia and Pitt Bank lies about 85 km (53 mi) to the west. The nearest exposed dry land is the island of Egmont 112 km (70 mi) to the northwest (Stoddart 1971a).

**Biological Setting**–Diego Garcia, as well as most of the islands of the Chagos, supports a lush tropical terrestrial habitat (Stoddart 1971b). Below the waves, coral reefs are an integral part of Diego Garcia and all the other islands, banks, and submerged banks of the Chagos (Sheppard 1999a). Area for area, Diego Garcia and the entire Chagos Archipelago is much more biologically productive than the surrounding ocean for a great distance (Sheppard 1999a).

The Chagos and Diego Garcia are important biogeographical features of the Indian Ocean. These islands are believed to play a linking or “stepping stone” role for marine species between East and West (Sheppard 1999a). Distribution and dispersal patterns show that the Indonesia region is the epicenter of coral reef diversity (Spalding et al. 2001). The composition of coral reef species at the Chagos reflects aspects of eastern Indian Ocean reefs and western Indian Ocean reefs. The Chagos may play a key role in the ultimate distribution of coral reef species in the Indian Ocean (Sheppard 1999a; Spalding 1999; Spalding et al. 2001).

**Climatology**–The weather of Diego Garcia is affected by the two monsoon seasons of southern Asia. The Northeast Monsoon season occurs usually from December to April bringing light winds with mostly clear skies and scattered showers and isolated thunderstorms. The Southwest Monsoon season occurs from July to September causing east-southeast winds of 10 to 15 knots (kt) and light showers (NCMOD 2002).

Temperatures do not vary greatly year round. The warmest high daily maxima of 31 degrees (°) Celsius (C) (88° Fahrenheit [F]) occur in March and April. The coolest high daily maxima occur from July through September at about 29°C (84°F). Temperature variations between day and night are about 4°C (10°F) year-round. Winds from December through March (summer) are westerly at about 6 kt, becoming light and variable in April and May (fall transition). From June through September (winter) winds are east-southeasterly at 10 to 15 kt. In October and November (spring transition) light variable winds return, becoming westerly by the beginning of summer. Annual mean rainfall is 260 centimeters (cm) (102.5 inches [in]) with the minimum monthly totals of 11 cm (4.2 in) occurring in August and 35 cm (13.9 in) occurring in January. Thunderstorms occur mostly in the summer and fall transition months (December through May) during late afternoon to midnight hours. Tropical cyclonic storms (equivalent to hurricanes of the Atlantic and Eastern Pacific Oceans) are rare in the Chagos Archipelago. The proximity to the equator limits the full cyclonic force to be experienced at Diego Garcia, however the island may be affected by wind and thunderstorms generated by tropical depressions and early stages of cyclonic storms during the tropical cyclone season from December through March. In general, winter (June through September) is dryer and cooler with east-southeasterly winds. Summer is considered the rainy season with light west-northwesterly winds and warmer temperatures. Transition months between seasons are variable with mixed characteristics of summer and winter (NCMOD 2002).

**Hydrography**–Seasonal winds determine the direction of dominant wind-driven sea surface transport both in and outside the Diego Garcia atoll. During the winter (June through September) sea surface water transport is to the northwest as driven by east-southeasterly winds (McGee 1987). In the summer

(December through March) light west-northwesterly winds drive sea surface water to the east-southeast. The wind regime also defines the seasonal exposure of the coastline to wind and wave action (McGee 1987). From June to September, the exposed atoll coastline stretches from Simpson Point through South Point to Cust Point. From December through February, the western side of the island is exposed to wind and wave action.

The almost completely enclosed Diego Garcia lagoon creates a unique marine environment characterized by weak flushing of its waters (1.9 cubic kilometers [$km^3$], $67*10^9$ cubed feet [$ft^3$]) through three relatively small openings in the atoll (the cross sectional area of the passes amount to 27,000 $m^2$ [6.7 ac]) (McGee 1987; Miller 1997). Tidal currents in the passes typically measure 0.5 to 2.5 kt but can be as high as 4.5 kt. Flushing of the southern part of the lagoon is further restricted by a shallow sill (2 to 4 m; 6.6 to 13.2 ft) separating the south and north parts of the lagoon (Miller 1997).

Average tidal range for neap tides at Diego Garcia is 0.5 m (19.7 in), and is 1.5 m (4.9 ft) for spring tides (McGee 1987; Miller 1997). During ebb tide, approximately 0.1 $km^3$ ($2.7*10^9$ $ft^3$) of lagoon water flows out of the passes, and during spring tides it is approximately 2.6 times greater (Miller 1997). Most of the tidal seawater exchange between the lagoon and the open sea is restricted to the area of the northern-most part of the lagoon, 1.5 to 2 nautical miles (NM) from the lagoon mouth (Miller 1997).

As the southwesterly-moving rising tide approached Diego Garcia, it is spun into counterclockwise gyre to the northeast of the island (between Chagos Bank/Pitt Bank and Diego Garcia) (U.S. Naval Oceanography Command Detachment Diego Garcia 1986). This gyre moves to the southwest during the course of the rising tide. When the tide falls, the motion of the gyre will change from a counterclockwise to clockwise direction and remain stationary. The formation of these gyres is thought to be induced by underlying bathymetric features (U.S. Naval Oceanography Command Detachment Diego Garcia 1986).

**Human Presence**–Humans have been present on Diego Garcia since 1778 (Edis 2004) and permanently settled on the island starting in 1786 (Stoddart 1984a). Diego Garcia has been a source of coconut products (1793-late to the late 1960s), a coaling station (1882 to1900), a refueling station (1950-1970), and military base (1971 to present) (Stoddart 1984a, 1984b, 1984c; Edis 2004). Remnant structures of a copra plantation occur around the island. In 1971, the plantation activity ended when the U.S. began construction of the military base (Edis 2004). There are currently about 3,000 military and civilian/contractor inhabitants on Diego Garcia (Guzman personal communication). An airport is located on the west side of the atoll (**Figure 1-4**). Residents partake in various terrestrial and marine-related recreational activities. Distinct portions of the lagoon and seaward side waters are restricted from certain recreational activities. Recreational SCUBA diving is not permitted anywhere around the island and snorkeling and swimming are restricted to designated areas of the lagoon. The strict prohibition on coral export from Diego Garcia is enforced and highly punishable.

A large portion of the northern lagoon has been dredged and is used as an anchorage and turning basin (**Figure 1-4**). A small portion of the western lagoon shore is used for large ship docking. There is also a small vessel harbor facility and a large-vessel fueling pier.

## 1.4 NEARSHORE MARINE HABITATS

**Seaward Habitats**–A reef flat consisting of reef aggregate extends 100 m (328 ft) or more seaward of the shoreline (Stoddart 1971a). Most of the reef flat is exposed at low tide. Depressions on the reef flat function as tidal pools. Algae cover most of this reef aggregate substrate. Live corals occur along the edges of carved out (and mined) depressions and within surge channels that branch out to sea. An algal ridge delineates the seaward reef margin which drops off rapidly onto a gently-sloped reef terrace.

The terrace is populated by encrusting, branching, and massive Scleractinia (stony corals), and non-Scleractinia corals including Milleporina (fire corals), Stylasterina (lace corals), Coenothecalia (blue coral), Alcyonacea (soft coral) and Gorgonacea (gorgonians) and algae. Between water depths of approximately 12 to 18 m (40 to 60 ft) the terrace slopes down rapidly giving way to the outer reef slope and the deeper fore reef communities which support well developed stony corals, gorgonian sea fans, and Antipatharia (black corals) (Stoddart 1971a).

**Lagoon Pass Habitats**–There are four ocean passes separated by three small islands in the lagoon mouth (Stoddart 1971a). These passes vary greatly from west to east. The area between Eclipse Point and West Island is less of a pass than it is a shallow spit-like reef flat that is awash at low tides. Between West Island and Middle Island, is Main Pass, 200 m (656 ft) wide and up to 13.7 m (45 ft) deep at its center (a dredged portion of the entry channel). Middle Pass, a narrow pass (depths to 13 m [45 ft]), is located between Middle Island and East Island. Barton Pass, a relatively shallow pass (depths to 6 m [20 ft]) lies between East Island and Barton Point. Middle Island is a partially submerged bank associated with a fairly large reef system. Southeast of this reef is a shallow patch reef complex consisting of reef knolls (Stoddart 1971a).

**Shallow Lagoon Habitats**–The lagoon is characterized by a shelf of varying width and two distinct basins of varying depth (Stoddart 1971a). A reef flat-like habitat existed on part of the western lagoon shelf in the past, but has been built upon in the construction of the naval base. Scleractinian corals occur along the lagoon shelf edge on fringing and patch reef formations and within the basins on patch reef and knoll-like formations.

A unique intertidal habitat consisting of tidal swamps and flats, named barachois, occurs along the inner edge of the land rim on the southern half of the atoll (Stoddart 1971a). Also, some marshes and landlocked ponds occur within the land rim mostly on the southern half of the atoll.

The south lagoon basin can be subdivided into northern and southern sub-areas. The northern sub-area is a nearly circular shallow basin bound to the east and west by the land rim and shelf, and to the north and south by submerged ridges. Patch reefs are distributed along the edge and within the northern sub-area. The southern sub-area is the shallowest region of the lagoon and contains an interconnected network of reefs.

Seagrass beds were previously described in various locations of the lagoon shelf as well as on the shallow portions of the lagoon mouth and around its islands (Stoddart 1971a). However, the current condition of these seagrass beds is unknown and is possibly greatly diminished based on opportunistic observations made during this study and by Smith (1999) and Pepi (personal communication).

**Deep Lagoon Habitats (Anchorage Area)**–Based upon observations made by Smith (1999) and during this study, the designated Anchorage Area, or deep lagoon habitats can be divided into three basic zones: 1) soft unconsolidated sediment comprised of fine sand; 2) unconsolidated sediment with sand and rubble and widely scattered boulders and coral heads, both generally less than 1 m (3.3 ft) in their maximum dimension; 3) hard bottom communities supporting modest to dense growth of stony corals. The latter zones were only found in close proximity to permanent channel marker buoys where little or no anchoring has occurred.

## 1.5 ANTHROPOGENIC INFLUENCE ON MARINE COMMUNITIES

Habitats that have been altered by human activities at Diego Garcia include:

- Seaward reef flats mined and harvested for coral rubble/aggregate
- Lagoon swamp/marsh areas drained for land construction/development
- Lagoon reef flats reclaimed/filled in for land construction/development
- Lagoon area dredged for anchorage and turning basin
- Lagoon mouth passes dredged for entry channel
- Extension of land based donkey exclusion fence into shallow water
- Construction of piers and docks
- Construction of a small boat basin harbor

- Emplacement of seaward outflow pipes
- Emplacement of navigational marker buoys and pilings

### 1.6 LOCAL ENVIRONMENTAL KNOWLEDGE

The following is a brief summary of local environmental knowledge on the lagoon and seaward reefs we gathered from Naval Support Facility Diego Garcia staff. We spoke with Nestor Guzman (Natural Resources Manager, Public Works Department, 8 year resident of Diego Garcia), Daniel Hombrebueno (OM 3, recreational fishing boat captain; 20-year resident of Diego Garcia), Oscar Opolento (Landing Craft, Mechanized [LCM] Captain; 12-year resident of Diego Garcia), and Ramon Espiritu (OM 1, recreational fishing boat captain; 24-year resident of Diego Garcia). The following is a compilation of the information we received by topic. The emphasis of our conversations was reef fishes since the individuals we spoke with were most familiar with recreational fishing. We did, however, ask questions about the marine environment in general and sought information on water quality, human disturbances, natural disturbances, and marine life.

The goal of our discussions with these long-term residents of Diego Garcia was to obtain information on extreme events, variations, and unusual patterns. While our study was to include a snap shot quantitative assessment of reef biota, the individuals we spoke with could potentially provide us with a qualitative understanding of the entire Diego Garcia atoll (lagoon and seaward areas), representing decades of observations. The information provided by our interlocutors could potentially fill gaps of our information base and identify areas needing further study.

**Recreational Fishing on Diego Garcia**–Recreational fishing on Diego Garcia has been done both from the shoreline and from boats. Hook and line bottom fishing has been the most common and frequent fishing method used at Diego Garcia, while trawling has been more seasonal. Prior to the 1980s, the recreational fleet consisted of three Boston Whalers and two sail boats. The number of recreational fishing vessels increased over the years. There are currently four Ocean Master deep-sea fishing vessels and nine Mako vessels available for fishing through the Morale, Welfare and Recreation (MWR) program. In the recent past there have been up to 14 Mako vessels. The Mako and Ocean Master vessels can each carry up to five passengers. Weather permitting, recreational fishing from these vessels can be done on a daily basis. Fishing trips each last four hours. No anchoring is allowed while fishing from the Ocean Master or Mako. Since 2000 and twice on every Sunday, recreational fishing has been done from a dedicated LCM vessel carrying up to 20 passengers per trip. The length and weight of fishes caught are recorded at the MWR marina and records are kept by the BIOT Fishery Officer.

Overall, the best fishing on Diego Garcia has been on the seaward side of the atoll, and typically takes place from February to April, April being the best month. In March and April seas are often very calm. March and April also coincide with the highest abundance of sharks, snappers, and groupers. The seaward East end of the atoll of the South Point area stood out as the best fishing locations at Diego Garcia. Bottom fishing has been the best on the southeast end of the atoll. The catch by bottom fishing has gradually decreased over the years. Fishing was better before 1998. Since the 1980s, recreational fishing grounds gradually expanded around the island from the lagoon to the north end of the atoll and then around the north end on either side of the island to South Point. This expansion occured as the catch at closer fishing grounds decreased.

Prior to the 1980s, there were plentiful fish in the MWR Marina and the area bordering the Officer's Club. Fish were also plentiful at Rambler Bay up until 2002. Mullets have always been plentiful in the nearshore area. Currently, there are four main fishing areas in the lagoon (i.e., areas more heavily fished than others), each contained in the area bound by the following latitude and longitudes: 7° 19' 53"S, 7° 21' 53"S and 72° 26'10E", 72° 27'45E". Good fishing areas in the lagoon are near Buoy #8. The fishermen remembered seeing a very large grouper in the current location of the alpha wharf.

Up until 2002, the northern end of the island (Cannon Point) used to be a good fishing spot. Prior to 2002, fish caught while wading at Cannon Point had to be held out of the water to prevent the abundant eels from eating the catch. There were plentiful barracuda and trevally, and black tip sharks (one measuring

2.4 m [8 ft]) could be seen while wading at Cannon Point. A bad day in 1987 was catching seven wahoos in four hours off Cannon Point. In fact, Cannon Point and South Point used to be good year round prior to 1998. Also prior to 1998, Barton Pass (northeast end of the atoll) was known as "wahoo alley." Ramon Espiritu remembers having caught 33 wahoo at Barton Pass in four hours. Each of these fish measured 140 to 150 cm (55 to 59 in) in length and weighed 13.6 to 15.4 kilograms (kg) (30 to 34 pounds [lb]). We were informed that the record for wahoo at Diego Garcia is 42.6 kg (94 lb) and 182.9 cm (72 in).

The best fishing areas on the seaward side of the atoll have been on the eastern end of the atoll (7° 15' 45" S, 72° 27' 35" E; Cust Point; Horsburgh Point), below Simpson Point on the west side, and the South Point area. Fishes caught in these areas included large groupers, emperors, lyretail, and Napoleon wrasse. At Cust Point it was common to catch marlin, sailfish, and big yellow (yellowfin tuna?). Horsburgh Point was a site known for hammerhead sharks. Large groupers were caught on the southeast side of the atoll between Horsburgh Point and South Point. The Simpson Point area had lots of grey sharks and nurse sharks. A whale shark was observed off Simpson Point. Tuna were caught on the west side of the atoll. South Point was the site with the greatest fish diversity. At South Point there were white tipped and black tipped sharks that weighed 91 to 136 kg (200 to 300 lb). A 25 kg (55 lb) Napoleon wrasse was caught in July 2004 off South Point. Another Napoleon wrasse (18 kg [40 lb]) was caught in the lagoon in 2004.

Large sharks (including black tip shark and oceanic whitetip shark) (≥3 m, 10 ft) have been caught on a seamount located 19 km (12 mi) northwest of Diego Garcia in a 63 m (207 ft) (no specific location was provided). Both Mr. Opolento and Mr. Espiritu have seen many sharks in the 3.7 to 4.6 m (12 to 15 ft) range. Mr. Espiritu claimed that while fishing off Horsburgh Point, a hammerhead came along side the 9.4 m (31 ft) fishing boat and was clearly longer than the boat. Crewmen aboard the military sealift command (MSC) ships anchored in the lagoon reported to Stephen Smith seeing very large hammerheads.

**Recreational Fishing Mitigation**–Our interlocutors recommended the use of monofilament over the required lead wire. This prevents the need for landing the sharks in or near the boats in order to unhook or cut the leaders. Monofiliment can be safely cut with harming the shark or fishermen.

**Water Quality**–The highest water transparency at Diego Garcia usually occurs in April and May, and the lowest water transparency is usually in February and March. There are changing water transparency conditions in July and August.

One unusual event affecting water quality was mentioned:

- In August, March or April of 1998, 2000, or 2003 (different people remembered a different year and different months of the year), the sea surface of half of the lagoon (from Camp Justice to the northern end of the atoll) was brown for two to four weeks. It was not an oil spill. No particular smell was associated with the discolored water. The discoloration had the appearance of runoff. There was no visible fish mortality associated with this event, and no apparent change in fish catches.

**Human Disturbances**–Following is a list of human disturbances our interlocutors provided:

- Trash washed up on the west shoreline of the atoll has been cleaned up twice a year. On average, these beach cleanups result in 24 truckloads (dump trucks) of trash per year consisting of pieces of plastic, plastic bottles, pieces of styrofoam, flip flops, slippers, glass bottles, and canisters.
- Dredging of the lagoon took place in 1971, 1976, and 1982.
- In 1999, hydroaccoustic data system cables were placed off the north end of the island (Simpson Point) and the south side (Donkey Gate, Ammo location).
- In May 1993, 150 gallons of oil (F-76, IFO-180, and miscellaneous lube oils) were spilt into the Anchorage Area of the lagoon when the M/V *Jeb Stewart* dischared its bilge tank. Oil washed up over approximately ¾ miles of beachfront of the northwest lagoon shore.

- In September 1996, 100 gallons of F-76 oil spilled at the Alpha Wharf when drilling operations through the concrete pier hit an underground pipeline located bellow it releasing a slick roughly 15 m by 60 m (50 ft by 200 ft) in size.
- In June 1997, 100 gallons of waste oil spilled at the Small Boat Basin when a BOS contractor was transferring the oil from an oil barge to a donut container.

**Natural Disturbances**–In December 1983, an earthquake (7.6 Richter scale) shook Diego Garcia. No tsunami was associated with the earthquake.

**General Observations of Marine Biota**–The following are some general and unusual observations regarding the marine biota at Diego Garcia:

- **Macroalgae**–In April 2004, unusually abundant macroalgae (*Sargassum*?) were observed on the eastern side of the island.
- **Corals**–In 1989, "black corals" were found on the beach.
- **Echinoderms**–The abundance of sea cucumbers is in decline and there are no sea stars.
- **Lobster**–Lobsters (blue-spot rock lobster, *Panulirus femoristriga*) occur along the shore in the breakers from Barton Point to Cust Point.
- **Marine Mammals**–Spinner dolphins occur year round at Diego Garcia. Humpback whales were observed in 2003. A round nosed black fish (pilot whale?) has been seen on rare occasions on the east side of the atoll. Mr. Opolento (who spent many years on the California coast) reported that in 1997 a large seal or sea lion (about 2 m [6.6 ft] long) was removed from an oil spill boom near the POL pier. The seal or sea lion then moved away and was seen hauled out on the beach at Eclipse Bay. The animal was seen at Diego Garcia for two to three days.

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# 2.0 METHODS

## 2.1 STUDY DESIGN

The emphasis of this study was the field evaluation of the distribution and apparent health of selected macroscopic sessile benthic organisms. The groups assessed were: algae, seagrass, fire corals (Milleporina), lace corals (Stylasterina), stony corals (Scleractinia), black corals (Antipatharia), blue coral (*Heliopora coerulea*), soft corals (Alcyonacea) and gorgonian sea fans (Gorgonacea). Selected mobile macroscopic benthic mollusks and echinoderms were also assessed along with sharks, high trophic level bony fishes, and sea turtles.

Six main habitat types were surveyed:

- Ocean/Seaward (**Figure 2-1**)
- Main Pass (**Figure 2-2**)
- Replenishment Zone (**Figure 2-3**)
- Anchorage Area (**Figure 2-4**)
- Lagoon North (**Figure 2-5**)
- Lagoon South (**Figure 2-6**)

At each site we recorded substrate categories along point intercept transects (linear point intercept transects [LPI]), selected macroscopic invertebrates along belt transects, fish abundance and size at stationary survey locations, and fish species richness along roving transects. Opportunistic observations of fish species and sizes were done in addition to the stationary and roving fish censuses.

A summary of the number of dives and number of survey transects by team is presented in **Table 2-1**.

**Table 2-1.** Total number of dives and survey transects the Navy and Geo-Marine, Inc. (GMI) field teams conducted while at Diego Garcia in July and August of 2004. The Navy team consisted of 13 individuals and the GMI team consisted of three individuals.

| Habitat Type | Navy Dives | Navy Transects | GMI Dives | GMI Transects |
|---|---|---|---|---|
| Ocean/Seaward | 63 | 28 | 24 | 16 |
| Main Pass | 10 | 0 | 0 | 0 |
| Anchorage Area | 33 | 25 | 0 | 0 |
| Replenishment Z. | 33 | 21 | 12 | 8 |
| Lagoon North | 24 | 12 | 18 | 12 |
| Lagoon South | 18 | 15 | 12 | 8 |
| Total | 181 | 101 | 66 | 44 |

## 2.2 DESCRIPTION OF STUDY SITES

For purposes of this report, survey sites were named using an alpha-numeric code to assist with data analyses and to convey the location of each study area (**Table 2-2**). The code divides the study sites using five elements:

- Area type
- General location (north, south, east, west)
- Local place name
- Local site number
- Dive team

**Figure 2-1.** Seaward terrace edge reef (Cannon Point; O-W-CnPt-2-G). [*Photo: D. Evans*]

**Figure 2-2.** Main Pass habitat (deep; P-M-1-N). [*Photo: S. Smith*]

**Figure 2-3.** Reef in Replenishment Zone (L-N-RZ-9-G). [*Photo: D. Evans*]

**Figure 2-4.** Reef in the Anchorage Area (L-N-An-4-N). [*Photo: S. Smith*]

**Figure 2-5.** Reef in northern lagoon area (Rambler Bay; L-N-RBy-3-G). [*Photo: D. Evans*]

**Figure 2-6.** Reef in southern lagoon basin (L-S-4-G). [*Photo: D. Evans*]

**Table 2-2.** Alpha-numeric coding of Diego Garcia reef survey sites (*Site surveyed by the Navy team but not by the GMI team).

| Code Element | Abbreviation | Meaning |
|---|---|---|
| ***Area Type*** | O | Ocean |
| | P | Pass* |
| | L | Lagoon |
| ***General Location*** | N | North |
| | S | South |
| | E | East |
| | W | West |
| ***Local Place Name*** | An | Anchorage |
| | Ar | Airport |
| | B | Barton* |
| | BPt | Barton Point* |
| | CnPt | Canon Point |
| | CsPt | Cust Point |
| | EcBy | Eclipse Bay |
| | Mn | Main |
| | PtMr | Point Marianne |
| | RBy | Rambler Bay |
| | RZ | Replenishment Zone |
| | SPt | Simpson Point |
| | TC | Turtle Cove* |
| ***Local Site Number*** | 1 – 10 | Local sites numbered consecutively W to E and N to S, Navy first then GMI |
| ***Survey Team*** | G | Geo-Marine, Inc. (GMI) |
| | N | Navy |

For example, L-N-RZ-9-G indicates that this study site was located in the lagoon (L), in the northern part of the lagoon (N), in the replenishment zone (RZ), at study site number 9 (9), and that the site was surveyed by the GMI team (G).

The Navy team surveyed 23 sites in the lagoon, nine sites on seaward reefs, and three sites in passes (**Table 2-3**; **Figure 2-7**). Of the 23 lagoon sites, five were located in the anchorage zone, eight were in the replenishment zone, five in the north lagoon area, and five in the south lagoon area (**Table 2-3**; **Figure 2-7**). Of the nine seaward sites, three were located on the east side of the atoll, and the remaining six on the west side. The GMI team examined seven lagoon sites (five in the north lagoon and two in the south) and four seaward sites (one on the east side and three on the west side).

### *2.2.1 Lagoon Reefs Surveyed by the Navy Team*

**L-N-An-1-N (Anchorage Zone)**–The seafloor at this site supported a moderate coverage of Acroporidae, including some tabular specimens over 1.5 m (5 ft) in diameter. The depth at this site was 23 m (75 ft). Twenty percent of the transect intercept points were stony coral, with 17 Acroporidae and 14 specimens from other coral families (Agariciidae, Mussidae and Poritidae). Of the 31 coral colonies counted only one Acroporidae showed slight signs of bleaching. Only one dead coral was encountered. Approximately 53% of the intercept points were sand or sand/rubble, the remainder included algae and sponges. The area supported a diverse fish population, including numerous small groupers. Underwater horizontal visibility was 12 m (40 ft).

**L-N-An-2-N (Anchorage Zone)**–This site consisted of a low knoll with gently sloping sides. The crest of the knoll was approximately 24 m (78 ft) deep, the surrounding seafloor was approximately 29 m (95 ft) deep. The knoll supported 100% cover by a single coral species. Based upon field observations and photos, the coral was tentatively identified as *Leptoseris mycetoseroides*. However, based upon the

**Table 2-3.** List of lagoon and seaward coral reef sites surveyed at Diego Garcia in July and August 2004 by the Navy and GMI teams.

| Survey Team | Site Code | Survey Date | Site Depth (m) | Site Depth (ft) |
|---|---|---|---|---|
| Navy | L-N-An-1-N | 5-Aug-04 | 24 | 79 |
| Navy | L-N-An-2-N | 3-Aug-04 | 25 | 82 |
| Navy | L-N-An-3-N | 7-Aug-04 | 28 | 92 |
| Navy | L-N-An-4-N | 30-Jul-04 | 24 | 80 |
| Navy | L-N-An-5-N | 30-Jul-04 | 23 | 74 |
| Navy | L-N-EcBy-1-N | 31-Jul-04, 1-Aug-04 | 11 | 35 |
| Navy | L-N-PtMr-1-N | 14-Aug-04 | 7 | 22 |
| Navy | L-N-PtMr-2-N | 14-Aug-04 | 11 | 35 |
| Navy | L-N-RBy-2-N | 13-Aug-04 | 7 | 22 |
| Navy | L-N-RBy-3-N | 13-Aug-04 | 12 | 40 |
| Navy | L-N-RZ-1-N | 5-Aug-04 | 15 | 50 |
| Navy | L-N-RZ-2-N | 9-Aug-04 | 9 | 28 |
| Navy | L-N-RZ-3-N | 5-Aug-04 | - | - |
| Navy | L-N-RZ-4-N | 4-Aug-04 | 12 | 40 |
| Navy | L-N-RZ-5-N | 31-Jul-04 | 12 | 40 |
| Navy | L-N-RZ-6-N | 31-Jul-04 | 17 | 55 |
| Navy | L-N-RZ-7-N | 31-Jul-04, 1-Aug-04 | 11 | 35 |
| Navy | L-N-RZ-8-N | 29-Jul-04 | 9 | 30 |
| Navy | L-S-1-N | 11-Aug-04 | 5 | 15 |
| Navy | L-S-2-N | 11-Aug-04 | 11 | 35 |
| Navy | L-S-3-N | 11-Aug-04 | 8 | 25 |
| Navy | L-S-TC-1-N | 15-Aug-04 | 5 | 15 |
| Navy | L-S-TC-2-N | 15-Aug-04 | 11 | 35 |
| Navy | L-S-TC-3-N | 15-Aug-04 | 2 | 7 |
| Navy | O-E-CsPt-1-N | 10-Aug-04 | 24 | 80 |
| Navy | O-N-BPt-1-N | 2-Aug-04, 4-Aug-04 | 24 | 80 |
| Navy | O-N-BPt-1-N | 2-Aug-04, 4-Aug-04 | 14 | 47 |
| Navy | O-W-Ar-1-N | 6-Aug-04 | 12 | 40 |
| Navy | O-W-Ar-2-N | 6-Aug-04 | 30 | 100 |
| Navy | O-W-Ar-3-N | 6-Aug-04 | 12 | 40 |
| Navy | O-W-CnPt-1-N | 12-Aug-04, 13-Aug-04 | 23 | 77 |
| Navy | O-W-CnPt-1-N | 12-Aug-04 | 12 | 40 |
| Navy | P-B-1-N | 29-Jul-04 | 18 | 60 |
| Navy | P-Mn-1-N | 8-Aug-04 | 23 | 75 |
| Navy | P-Mn-1-N | 29-Jul-04, 8-Aug-04 | 15 | 50 |
| GMI | L-N-EcBy-2-G | 16-Aug-04 | 7 | 24 |
| GMI | L-N-Rby-3-G | 13-Aug-04 | 4 | 13 |
| GMI | L-N-Rby-4-G | 9-Aug-04 | 12 | 40 |
| GMI | L-N-RZ-9-G | 5-Aug-04 | 15 | 49 |
| GMI | L-N-RZ-10-G | 7-Aug-04 | 5 | 15 |
| GMI | L-S-4-G | 11-Aug-04 | 4 | 14 |
| GMI | L-S-5-G | 12-Aug-04 | 3 | 10 |
| GMI | O-E-CsPt-2-G | 10-Aug-04 | 16 | 51 |
| GMI | O-W-Ar-4-G | 6-Aug-04 | 15 | 50 |
| GMI | O-W-CnPt-2-G | 14-Aug-04 | 17 | 55 |
| GMI | O-W-SmPt-1-G | 15-Aug-04 | 16 | 54 |


**Figure 2-7.** Navy and GMI reef survey locations assessed in July and August 2004 at Diego Garcia, British Indian Ocean Territory.

photos, Dr. Charles Sheppard believes these specimens are more likely to be *Echinopora lamellose* or *Podabacia crustacean.* Large numbers of soldierfishes, squirrelfishes, cardinalfishes, fusiliers, and emperors were closely associated with the reef. The seafloor surrounding the knoll supported a moderate coverage of Acroporidae, including some tabular specimens over 1.5 m (5 ft) in diameter. None of the coral specimens sighted showed any signs of bleaching or disease. No specimens of *Leptoseris mycetoseroides* were sighted off the knoll. Underwater horizontal visibility was 12 m (40 ft).

**L-N-An-3-N (Anchorage Zone)**–The depth at this site ranged from 27 to 28 m (90 to 93 ft). Stony corals were diverse and comprised 39% of the point intercepts. None of the corals showed any signs of bleaching or disease. Large tabular Acroporidae (some over 2 m [6.5 ft] 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, above, but with larger numbers of surgeonfishes and a 1 m (3.3 ft) long grouper (*Epinephelus multinotatus*).

**L-N-An-4-N and L-N-An-5-N (Anchorage Zone)**–These sites were located in the southeastern portion of the designated anchorage area. At both sites the seafloor was flat with no visually detectable slope. The water depth at L-N-An-4-N was 24 m (80 ft), at L-N-An-5-N, 23 m (74 ft). Ninety-nine of the 100-point intercepts at L-N-An-4-N were fine sand. Several bushy black coral trees (*Antipathes* sp.) were sighted at each of the sites, no other corals of any type were seen. Site L-N-An-5-N had a more varied seafloor, in addition to fine sand, mud rubble and small boulders were present. Underwater horizontal visibility at these sites was less than 6 m (20 ft).

**L-N-RZ-1-N (Replenishment Zone)**–This site was located in the Replenishment Zone near the lagoon side of Middle Pass and south east of Middle Island. The area contained dramatic relief from approximately 17 m (55 ft) to less than 5 m (15 ft). Large head forming corals were dominant and 38% of the intercept points were live, healthy coral. Many large head corals contained dead areas, but most were more than 60% live and showed no signs of current bleaching, algal overgrowth or disease. Coral diversity was high and included soft corals, fire corals, lace corals and blue coral, in addition to Acroporidae, Poritidae, Agariciidae, Faviidae and other families. Virtually all the corals present were healthy. The fish population included at least four individual requiem sharks (Carcharhinidae), at least three separate groupers over one meter long (*Plectropomus laevis* and *Epinephelus multinotatus*) and an aggregation of over 50 black snapper (*Macolor niger*). These snappers were large specimens, estimated to be 45 to 55 cm (18 to 27 in) in length. Underwater horizontal visibility was 20 m (66 ft).

**L-N-RZ-2-N (Replenishment Zone)**–This site was located south of East Island. The seafloor was 8 m (25 ft) deep, with coarse sand with scattered knolls. The site investigated was a knoll rising to a depth of approximately 4 m (12 ft), oval in shape and about 25 m (82 ft) long. The knoll supported very dense coral growth, 42% of the intercept points were *Acropora* sp*.,* and 3% were other scleractinians. None of these corals showed any signs of bleaching or disease. The remaining intercept points (55%) were rubble. Most of this rubble consisted of *Acropora* sp. fragments which were less than 10% coated with macroscopic algal or invertebrate growth. The fish population here was moderately diverse and abundant. Numerous parrotfishes over 50 cm (20 in) in length were sighted. Underwater horizontal visibility was 25 m (82 ft).

**L-N-RZ-3-N (Replenishment Zone)**–This site was nearly due south of L-N-RZ-1-N and bore little resemblance to it. The seafloor was 12 m (40 ft) deep, relatively flat, and had numerous low knolls. The knolls were almost entirely composed of coral rubble. Seventy-four percent of the intercept points were sand or rubble; the rubble being composed primarily of *Acropora* sp. fragments that appeared to have been dead for five years or more. Thirteen intercept points were live, healthy *Acropora sp*. and five were other scleractinians and three were fire coral. All the coral specimens were small. Fishes were neither abundant nor diverse. Underwater horizontal visibility was 20 m (66 ft).

**L-N-RZ-4-N (Replenishment Zone)**–This area was located in the western portion of the Replenishment Zone. The seafloor was relatively flat and approximately 15 m (50 ft) deep; large knolls rose to within 5 m (15 ft) of the surface. In some cases the knolls were over 100 m (328 ft) long. The percentage of live coral cover was estimated to be more than 70%, with *Acropora* sp*.* clearly dominant. Healthy, tabular specimens over 1.5 m (5 ft) in diameter were sighted. No bleached or diseased Acroporidae were seen, but dead Acroporidae and other scleractinian specimens and fragments of dead specimens were observed. These all appeared to have been dead for several years. A variety of other stony corals were also present, as were soft corals, lace corals, fire corals and blue coral. None of the corals within these groups showed signs of bleaching or disease. The fish population at this site was very abundant and diverse. Clouds of tiny Anthiidae utilized the Acroporidae thickets and the area was estimated to be supporting thousands of damselfishes (Pomacentridae), with *Chromis viridis*, and *C. atripes* appearing to be the most abundant. Dense schools of small snappers and emperors (*Lutjanus gibbus* and *Monotaxis grandoculis*) were present, as were large numbers of moderate size groupers like the whitemargined lyretail (*Variola albimarginata*). Although this area had obviously sustained losses during the 1998-bleaching event, many large colonies survived and a dense growth of young coral colonies was present. Underwater horizontal visibility was 20 m (66 ft).

**L-N-RZ-5-N (Replenishment Zone)**–The site was located in the central, east side of the Replenishment Zone. The dive began at a depth of 15 m (50 ft) over a sand bottom with numerous crab and/or shrimp mounds. Proceeding in an easterly direction, the seafloor shoals at an angle of 5 to 10 degrees. Numerous large pits (tentatively stingray feeding pits) were observed on the slope at depths between 9 to 15 m (30 and 50 ft). At 9 m (30 ft), widely scattered corals and small rock outcrops appeared. The rocks supported both filamentous algae, encrusting calcareous algae and *Halimeda* sp. At 8 m (25 ft) a colony of *Porites australiensis* (tentative), measuring 320 cm (10.5 ft) in its greatest dimension was recorded. Except for a 5 by 10 cm (2 by 4 in) patch showing very slight bleaching, this colony appeared healthy. From this point on, coral cover increased, dominated by *Acropora* sp., and various members of the families Poritidae, Faviidae, Pocilloporidae and Hydrozoan fire corals *Millepora* sp. All these corals appeared healthy. No soft corals, blue corals or gorgonian corals were sighted. In contrast to the apparently healthy corals just described the skeletal remains of large numbers of stony corals from the family Mussidae were also present. These specimens appeared to have been dead for several years and most were probably *Blastomussa merleti* or *Lobophyllia* sp*.* Few macroscopic benthic invertebrates, including sea urchins and sea cucumbers, were sighted. This area supported a moderately diverse fish population. Underwater horizontal visibility was approximately 10 m (33 ft).

**L-N-RZ-6-N (Replenishment Zone)**–This site was located in 17 m (55 ft) of water and consisted of a nearly flat medium to fine sand bottom, dotted with numerous crab and/or shrimp mounds ranging from 5 to 10 cm (2 to 4 in) in diameter. Two dives, with three divers on each, were made at this location; not a single fish or macroscopic invertebrate was sighted, except for one small black coral tree (*Antipathes* sp*.*). Underwater visibility was 5 m (16 ft).

**L-N-RZ-7-N (Replenishment Zone)**–This site was located to the east of L-N-RZ-6-N, closer to shore and in shallower water (11 to 12 m [35 to 40 ft] deep). The area consisted of a coarse sand bottom, with small to large coral colonies and coral heads. Thirty-three percent of the line intercept points were stony coral, 18 *Acropora* sp. and 14 other stony corals primarily from the families Poritidae, Agariciidae, Mussidae and Faviidae. Only one coral specimen on the transect line showed signs of bleaching. All other living stony corals appeared healthy and disease free. No specimens of soft coral, fire coral, lace coral or gorgonian corals were sighted. Bivalve mollusks were common, including pen shells (*Atrina* sp.) and various oyster species. The abundance and diversity of fishes at this site were moderate. Underwater horizontal visibility was 8 m (26 ft).

**L-N-RZ-8-N (Replenishment Zone)**–This site was located in the northwestern portion of the Replenishment Zone. The seafloor was 9 m (30 ft) deep at this location, with large numbers of coral heads and knolls closely spaced. Soft corals, gorgonian corals, fire coral, blue coral, lace coral, and stony corals were all present. With the exception of three slightly bleached Acroporidae, all the corals appeared healthy. The fish population was large and diverse. More parrotfish were seen on this dive than any other single dive. Fishes sighted included *Cetoscarus bicolor, Scarus frenatus, S. gibbus, S. niger, S. rubroviolaceus, S. sordidus,* and *S. tricolor*. More than 25 parrotfish specimens measuring each over 60 cm (24 in) were counted during the dive. Underwater visibility was approximately 20 m (66 ft).

**L-N-EcBy-1-N (Eclipse Bay)**–This site was located in 11 m (35 ft) of water. The seafloor consisted of medium to coarse sand, with scattered coral heads. The intercept points at this location showed 72% sand, 9% rubble and 16% coral. No bleached or diseased corals were observed, and only one recently dead coral specimen was sighted. In addition to scleractinian corals, fire corals, blue corals and soft corals were also observed. Bivalve and gastropod mollusks were relatively abundant. The fish population was larger and more diverse than expected, given the relatively small amount of relief. Fishes included 1 m (3.3 ft) long groupers (*Epinephelus multinotatus*), large schools of approximately 40 cm (16 in) long surgeonfish (*Acanthurus xanthopterus*). Underwater horizontal visibility was 8 m (26 ft).

**L-N-RBy-2-N (Rambler Bay)**–This 7 m (22 ft) deep site was shoreward of L-N-RBy-3-N. More than any other site visited by the Navy team, this area appeared to have been devastated by the 1998-bleaching event. It looked like a 'bone yard', with the 'bones' being composed almost entirely of the skeletal remains (corallites) of Mussidae corals, primarily *Blastomussa merleti* and *Lobophyllia* sp*.* It appeared that the reef had been composed predominately of 30 to 100 cm (12 to 39 in) diameter heads of these species. When these heads died, they literally fell apart, leaving the large individual corallites scattered across the seafloor. Poritidae and Faviidae heads were also present; and some remained alive. However, most of the living specimens from these two families were riddled with brown boring sponges, ranging from 2 to 4 cm (0.8 to 1.6 in) in diameter. It was noted, that very little of the dead coral material had been colonized by encrusting calcareous algae. Of the currently living corals, none showed any signs of bleaching or disease, except for the infestation of boring sponges. However, it appeared that about 95% of all the scleractinian species had died within the past few years. One 95 cm (37 in) diameter tabular colony of *Acropora* sp*.* was sighted and measured. Signs of coral recruitment were very limited on this reef. This fish population at this site was very limited. The most abundant species appeared to be the striped bristletooth surgeonfish (*Ctenochaetus striatus*), followed by unidentified juvenile parrotfishes and various damselfishes. Underwater horizontal visibility at this site varied from 6 to 8 m (20 to 26 ft).

**L-N-RBy-3-N (Rambler Bay)**–This 12 m (40 ft) deep site in Rambler Bay consisted of a flat fine sand bottom. There was no visual evidence of burrowing crabs or shrimps and the fish population was neither abundant nor diverse. Sixteen percent of the intercept points were scleractinian corals, three *Acropora* sp*.* and the remainder various head forming species, particularly Faviidae and Poritidae. All the colonies sighted were small to moderate in size, none showed any signs of disease or bleaching. No fire corals, lace corals, soft corals, gorgonian corals or blue coral were sighted. The area did not show evidence of having been impacted by the 1998-bleaching event. Underwater visibility was 6 m (20 ft).

**L-N-PtMr-1, 2 and 3-N (Point Marianne)**–These three sites were all very similar, and ranged from 7 to 11 m (22 to 35 ft) in depth. No line intercept transects were performed. This area was unlike any other visited. The seafloor consisted of fine sand; there was a great deal of suspended material in the water column. Corals were sparse, however, many of the specimens present were large and healthy, for example, tabular *Acropora* sp. (160 cm [63 in]), *Porites* sp*.* (460 cm by 210 cm [15 by 7 ft]), and *Blastomussa merletti* (110 cm by 120 cm [4 ft by 4 ft]). The *Porites* sp*.* colonies that were sighted were all secreting copious quantities of mucous. The fish population at this location was not diverse, but there were large numbers of cardinalfishes (Apongonidae) and damselfishes (Pomacentridae). Underwater horizontal visibility was less than 5 m (16 ft).

**L-S-1-N (Lagoon South)**–This site in the southern portion of the lagoon was one of the shallowest investigated by the Navy team, only 5 m (15 ft) deep. Rubble made up 86% of the intercept points, sand 7% and scleractinian corals only 3%. The rubble was comprised mostly of coral fragments, but also included significant quantities of bivalve remains. Head forming Faviidae and Poritidae whose tops and centers were dead and deeply eroded, resulting in a 'micro-atoll' effect, dominated the scleractinian corals at this site, and L-S-2-N. Corallites on the sides of these colonies appeared healthy. Large numbers of dark brown volcano shaped sponges were present; most were approximately 4 cm (2 in) tall. A striking feature of this site was the presence of large numbers of dead bivalve mollusk shells. Forty-three *Tridacna* sp. valves (shell half), three dead, but intact *Tridacna gigas* (tentative) and one intact *Hyotissa hyotis* (tentative) were counted. The length of the valves ranged from 8 to 20 cm (3 to 8 in). None showed any signs of breakage or other damage. No fire, lace, blue, soft or gorgonian corals were sighted. Underwater horizontal visibility was 8 m (26 ft).

**L-S-2-N (Lagoon South)**–This site was located at a depth of 11 m (35 ft), in the southern portion of the lagoon. The seafloor was flat and composed predominately of sand (67% of intercept points) and unidentifiable coral rubble (27% of intercept points). Only 5% of the intercept points were scleractinian corals and no fire, lace, blue, soft or gorgonian corals were sighted during the dives. Although corals were sparse, all of those present appeared healthy, no bleaching or disease was observed. Numerous depressions (70 to 120 cm [2 to 4 ft] in diameter) in the sand were seen; they were believed to be stingray-feeding pits. The fish population was unremarkable. Underwater horizontal visibility was 6 m (20 ft).

**L-S-3-N (Lagoon South)**–This site was located at a depth of 8 m (25 ft). The seafloor was flat with a mix of coarse sand, rubble and shell hash. This was the only site visited which contained a classic shell hash substrate (45% of the intercept points). No *Tridacna* sp*.* was seen at this site, but thousands of bivalve shell fragments were seen. Based upon the condition of the shell, many appeared to have come from animals that may have died within the last two to 10 years. Although no fire, lace, blue, soft or gorgonian corals were sighted, and scleractinian comprised only 8% of the intercept points, the scleractinians present created substantial relief and showed no evidence of bleaching or disease. Most were head forming specimens more than 50 cm (19 in) in size. Coral heads, comprised primarily of various Poritidae and Faviidae, dotted this study site. These multi-species heads generally ranged from 1.5 to 3 m (5 to 10 ft) in height and diameter. This site had more relief and supported substantially more fish species and total numbers of fish than L-S-1 or 2. The most abundant fishes were anthids (Anthiidae), cardinalfishes (Apogonidae) and snappers (Lutjanidae). There were two hawksbill sea turtle sightings (*Eretmochelys imbricata*) during this dive. Underwater horizontal visibility was 8 m (26 ft).

**L-S-TC-1-N (Turtle Cove)**–This site was in only 5 m (15 ft) of water. Visibility was only 2 m (6.6 ft) and no transects were performed. The seafloor was flat and consisted of coarse to medium grained sand and rubble. One colony of *Porites* sp. measuring 1 m (3.3 ft), and several small specimens of *Acropora* sp. were sighted. One *Acropora* sp*.* was slightly bleached and one was recently dead. No other corals, from any coral groups were sighted. A live *Tridacna* sp. measuring 20 cm (8 in) was seen and brown upright ball shaped sponges, measuring up to 15 by 15 cm (6 by 6 in) were common. Very few fishes were sighted, and those seen were common at other lagoon dive sites. Large depressions, apparently stingray feeding pits, were seen.

**L-S-TC-2-N (Turtle Cove)**–This site was located at a depth of 11 m (35 ft), in the southern extremes of the lagoon and near Turtle Cove. Large boulders and moderate sized coral heads were present on an otherwise flat sand and rubble seafloor. The boulders appeared to be the remains of head forming corals that were long dead and deeply eroded. The size of most boulders and of the live coral heads was generally 75 to 200 cm (2 to 7 ft). Scleractinian corals were recorded for 20%, sand for 51% and boulders for 22% of the intercept points. Some *Acropora* sp*.* were partially bleached, and some were recently dead. All other scleractinians appeared to be healthy. No fire, lace, blue, soft or gorgonian corals were sighted. Both upright and encrusting sponges were common. Underwater horizontal visibility was 5 m (13 ft).

**L-S-TC-3-N (Turtle Cove)**–A dive was made in the Turtle Cove inlet to the barachois, in the hope of photographing the sea turtles and stingrays sighted from the observation platform on shore. Visibility underwater was only 2 m (6.6 ft) and the current was too strong to swim against. No turtles or rays were seen underwater. No corals of any type were seen. The seafloor was a mix of coarse rubble, sand and small boulders.

### *2.2.2 Lagoon Reefs Surveyed by the GMI Team*

**L-N-RZ-9-G (Replenishment Zone)**–This site was located in the northern portion of the Replenishment Zone, in the north lagoon area. The Replenishment Zone is an off-limits (no activity) area set aside as a marine preserve. L-N-RZ-9-G is a knoll type of patch reef situated south of the shallow reef complex known as Spur Reef and approximately 1 km (0.6 mi) east of Main Pass. Main Pass has been partially dredged for safe vessel passage in and out of the lagoon. A number of additional reef knolls occurred to the south of this study site. Middle Island and East Island as well as Middle Pass are located to the north of the study site and separated from the study site by a reef complex. The reef knoll studied here rose from a seafloor depth of about 12 m (40 ft) to within 3 m (10 ft) of the sea surface. We examined the north slope of the knoll. Sediments bordered the base of the knoll. Visibility was somewhat poor at the study site ranging from 12 m (39 ft) to nearly 25 m (82 ft). There were abundant stringy mucous substances suspended in the water column. Acroporidae were the dominant corals at this site. There were recently bleached corals at this site as well as dead corals and reef rubble. Low cropped macroalgae and turf algae were common on the edges of and away from the study site.

**L-N-RZ-10-G (Replenishment Zone)**–This site was located in the northeast sector of the Replenishment Zone in Orient Bay. This site was a fringing patch reef located near a narrow stretch of the atoll rim. This patch reef was part of a fringing reef system that ran parallel to the beach. The depth range at this site was 1.5 m (5 ft) to 4 m (13 ft). Visibility was generally poor. This site had a moderate reef topographic complexity and the reef substrate was primarily made of Acroporidae and Mussidae corals. There were extensive "bone yard" patches consisting of dead *Lobophyllia hemprichii* (Mussidae) corallites. There were overturned and upended Acroporidae formations as well as numerous juvenile Acroporidae and Mussidae corals. Low cropped macroalgae and turf algae overgrew patches of coral rubble.

**L-N-EcBy-1-G (Eclipse Bay)**–This site was located on the west side of the lagoon in the area known as Eclipse Bay found near the entrance to the small boat basin. This site was close to one of the engineering contractor's construction yards. L-N-EcBy-1-G is on a portion of a patch reef that was at the edge of the lagoon shelf and part of a fringing reef that ran parallel to shore. The study site was located on a deep portion of the fringing reef (depth range: 2.7 to 5 m [9 to 17 ft]). This reef was located north of an area of the lagoon shelf that had been filled in. Sediments bordered the deeper side of the reef. Visibility was extremely limited. The site was characterized by dead large massive Poritidae and dead corallites of Mussidae (*L. hemprichii*). There were abundant juvenile corals growing on the dead massive coral substrate. There was abundant coral rubble and algal cover.

**L-N-RBy-3-G (Rambler Bay)**–This site was similar to L-N-RZ-10-G in that it was a nearshore reef located adjacent to a thin stretch of the atoll rim. The site was located in Rambler Bay, north of Cust Point, near one of the narrowest parts of the exposed land, and east of the Anchorage Area. L-N-RBy-3-G was a patch reef found in slightly deeper water than the thin fringing reef that runs parallel to the beach. It is surrounded by sediment that contains scattered solitary coral formations. Some large coral formations are present as well as an extensive "bone yard" patch of dead *L. hemprichii* corallites. There was moderate coral topographic complexity. The reef was shallow and we surveyed it within the 2.4 to 2.7 m (8 to 9 ft) depth range. Visibility was generally poor. Algal growth was evident on patches of coral rubble. The remnants of a nearby *Thalassodendron ciliatum* seagrass bed (root systems with no live shoots) were seen beachward of a dead longshore fringing reef.

**L-N-RBy-4-G (Rambler Bay)**–This site was in a deep and more southern part of Rambler Bay. L-N-RBy-4-G is a reef knoll named on navigational charts as the "Mini-Mini Patch Reef" (Defense Mapping Agency 1983). The site was surveyed within the 6 to 7 m (19 to 23 ft) depth range. The water depth surrounding the study site reached 18 m (60 ft). The top of the reef was within 3.6 m (12 ft) of the sea surface. This site was further from shore than the Replenishment Zone and Rambler Bay sites and is in close proximity to the southeastern extent of the Anchorage area. Visibility was generally poor. The reef had a moderate topographic complexity with some large boulder coral formations. Patches of algal growth covered many of the dead massive corals as well as smaller coral heads and abundant coral rubble. Fewer Acroporidae were noted compared to the other Rambler Bay site and the two Replenishment Zone sites. Nevertheless, some large coral formations were present.

**L-S-4-G (South Lagoon)**–This site was located in the southern lagoon basin within a circular caldera-like area of the atoll. This south lagoon site was part of a twin patch reef surrounded by carbonate sediments. The site was the westernmost of the two reef patches. The depth of the study transects ranged here from 2 to 3 m (6 to 11 ft). The edges of this patch reef dropped off gradually to a 12 to 17 m (40 to 56 ft) depth range. The reef substrate was relatively flat and the topographic complexity moderate. There were scattered massive corals (Poritidae; ≤40 cm [16 in] across), several of them on their side and detached from the seafloor. The majority of the live corals were relatively small and either curlicue-shaped or donut-shaped (Acroporidae, *Astreopora* sp.). None of these colonies was attached to the seafloor and appeared to have been tumbled by wave action. These colonies had large areas of partial mortality covered by sediments and turf algae. Most of the outer edges of the colonies were alive. Corals were interspersed with carbonate sediments. We observed Poritidae shedding sediment-covered mucus films. We observed little algal growth on the reef substrate. There were two small roots with several shoots of seagrass (*Thalassodendron ciliatum*) within this study site.

**L-S-5-G (South Lagoon)**–This site was located in the southern lagoon area on the southern edge of the caldera-like formation. L-S-5-G was an isolated patch reef surrounded by carbonate sediments. Small individual coral formations were scattered nearby. To the south and east of this patch reef was a wide portion of the atoll land rim, as well as some of the smaller barachois of the eastern rim. The study transects were all situated in about 1.5 m (5 ft) of water. Visibility was poor due to suspended sediment. Coral formations produced a moderate level of topographic complexity. Poritidae corals were covered with mucus films much like what was observed at site L-S-4-G. There were medium and large sized coral formations including Acroporidae and Poritidae with few coral rubble areas. Algal growth areas were interspersed among the boulder coral formations.

### *2.2.3 Seaward Reefs Surveyed by the Navy Team*

**O-N-BPt-1-N (Barton Point)**–This area is characterized by a narrow fore reef terrace that slopes from less than 5 m (15 ft) to between 11 and 15 m (35 and 50 ft), at which point there is a near vertical drop off. Transects and fish counts were performed at the edge of the drop off, in the 12 to 14 m (40 to 45 ft) zone, and down the drop off at a depth of 24 m (80 ft). There were marked differences between the two zones, with the deeper sites appearing to have sustained less damage from the 1998 bleaching event. In the deep zone, 2% of the intercept points were rubble, in the medium zone 31% were rubble. Live scleractinian corals comprised 49% and 41% of the intercept points in the deep and medium zones respectively. No bleached, diseased or dead scleractinians were encountered at any intercept points, although a few were observed adjacent to the transect line. Fire corals, lace corals, blue coral, soft corals and gorgonian corals were seen at both depths; however, fire corals, blue corals and soft corals were much better represented at the shallower site. Gorgonians were a prominent feature of the deeper zone and comprised 10% of the point intercepts, but 0% on the shallower ones. Most of these gorgonians were over 2 m (6.6 ft) across. There was an abundant and diverse population of fishes, but a complete absence of sharks. Underwater horizontal visibility ranged from 20 to 30 m (66 to 98 ft).

**O-E-CsPt-1-N (Cust Point)**–The general topography at this Cust Point site was very similar to that described for Barton Point, although the drop off began slightly deeper. As with the surveys at Barton Point, deep transects were conducted along the drop off, at 24 m (80 ft), and shallower transects were conducted at the edge of the drop off 14 to 15 m (45 to 50 ft). Six percent of the medium depth intercept points were rubble, with approximately 50% of the rubble being identifiable as *Acropora* sp*.* fragments coated with encrusting calcareous algae. The algae were serving to cement these fragments together. None of the deeper intercept points fell on rubble. Scleractinian percentages were 38% at 24 m (80 ft) and 31% at 14 m (45 ft). Five percent of the intercept points at 24 m (80 ft) were gorgonians, half of which were dead. No gorgonians were present at the shallower transect. Fire corals, lace corals and blue corals were present at both depths. Soft corals comprised 17% of the intercept points on the shallower transect, 9% on the deeper transect. The overwhelming majority of all coral types seen were healthy and showed no signs of bleaching or disease. However, the subjective impression was that this area had suffered more than Barton Point from the 1998 bleaching event. Fishes were abundant and diverse, although fewer large specimens were seen than at Barton Point.

**O-W-CnPt-1-N (Cannon Point)**–Five dives were conducted at Cannon Point, one to 27 m (90 ft), two at 21 m (70 ft) and two at 12 m (40 ft). Transects were completed at 11 and 21 m (35 and 70 ft). The general topography is similar to Barton Point and Cust Point, with a gently sloping fore reef terrace from the shore to approximately 9 m (30 ft), at which point there is a near vertical drop off. The drop off begins shallower here, than at Barton Point or Cust Point, and the terrace is wider. There were a number of notable differences between these three sites. Along the 11 to 12 m (35 to 40 ft) contour transects, 35% of the intercept points were fossilized reef platform, with virtually no macroscopic algae visible. At this depth, 14% of the intercept points were sand or uncolonized fragments of *Acropora* sp*.* Most of the encrusting calcareous algae at this location was growing on what appeared to have been large head forming scleractinians; at Barton Point and Cust Point, most of the encrusting calcareous algae were found on fragments of Acroporidae. Fire corals, lace corals, black corals, soft corals and gorgonian corals were present along both the transect depths. Forty percent and 48% of the intercept points at 21 and 11 m (70 and 35 ft) respectively, were healthy scleractinian corals. Some partially bleached and recently dead scleractinians were present, but the vast majority of corals appeared very healthy, and many tabular *Acropora* sp*.* and head forming colonies over 1.5 m (5 ft) in diameter were present. Extraordinarily large gorgonian sea fans were present at 21 m (70 ft) and below, many were over 3 m by 3 m (10 by 10 ft) in size. Although most of the gorgonian sea fans appeared healthy, several specimens appeared to be diseased, and some were dead. Fishes were abundant and diverse at this location. Napoleon wrasse were sighted on every dive, with up to five individuals being sighted at once. Large groupers, snappers and emperors were abundant. Long-jawed squirrelfish (*Sargocentron spiniferum*) were also abundant and many appeared to be in excess of 40 cm (16 in) long. There were four Carcharhinidae shark sightings, two specimens in the 1 to 2 m (3.3 to 6.6 ft) range and two specimens over 2 m (6.6 ft) in length. Underwater horizontal visibility at this site ranged from 20 to 30 m (66 to 98 ft).

**O-W-Ar-1-N and O-W-Ar-3-N (Airport)**–The depth at these two sites was 12 m (40 ft), and they were located shoreward of the deep airport study site. The seafloor was basically flat rock, but with numerous spurs and groves (50 cm [20 in] high and deep) and widely scattered coral heads to about 100 cm (39 in) high. Sediment was sparse and coarse. The area appeared to be subject to strong surge on a regular basis, and a strong wave surge was present during the dives. Algal turf was recorded at 31% of all intercept points for both dives. Calcareous algae were present at 9% and 13%, and scleractinian corals were recorded at 24% and 26% of the intercept points. No bleached or diseased scleractinians were sighted. Soft corals represented 17% of the intercept points at site 3 and none at site 1. However, the subjective distribution of soft corals appeared to be comparable between the two sites. A greater diversity of snappers (Lutjanidae) was sighted, than at any other location. An approximately 2.5 m (8 ft) wide manta ray was sighted from the boat. Overall, the fish population was only modestly diverse and abundant. Underwater horizontal visibility was 20 m (66 ft).

**O-W-Ar-2-N (Airport)**–This site was unlike any of the others observed. A well-developed reef sloped at an approximately 30-degree angle from 12 to 30 m (40 to 100 ft). Dive time was focused between 23 and 30 m (75 and 100 ft). At 30 m (100 ft) a coarse sand plain stretched seaward. No transects were performed at this site. However, soft corals (*Sinularia* sp. and *Sarcophyton* sp*.*) and calcareous algae (*Halimeda* sp*.*) were estimated to each comprise approximately 20% of the seafloor cover. Acroporidae and other scleractinians were also present, as were blue coral and lace corals. None of the corals observed showed any signs of bleaching or disease. Giant sea anemones (*Stichodactyla* sp*.*) and giant clams (*Tridacna* sp*.*) appeared to be more abundant here than at any other site visited. Fishes were abundant and diverse, with unicornfishes and small emperors being particularly well represented. Underwater visibility was 40 m (131 ft).

**P-Mn-1-N (Main Pass)**–Three dives were competed in the Main Pass; dive depths were 28, 18, and 15 m (93, 60, and 50 ft). As expected, the Main Pass was dramatically different than any of the other sites visited. Currents in the Main Pass typically range from 0.5 to 2.5 kt, but have been recorded up to 5 kt (McGee 1987; Miller 1997). No transects were attempted in this area. The seafloor in this area is typical of reef passes subject to strong currents and scouring, very little unconsolidated sediment was present. The sediment that was observed consisted of very coarse sand and rubble. Turf algae coated most of the seafloor to the edge of the drop off. Small amounts of leafy algae, *Halimeda* sp. and encrusting calcareous algae were also present. Large brown encrusting sponges, approximately 5 cm (2 in) high and up to 200 cm (6.6 ft) across were also sighted. The limited relief in the 14 m (45 ft) zone consisted of widely scattered boulders and coral heads of *Porites* sp*.* Several small specimens of *Acropora* sp. and lace corals were sighted, in addition to other small head forming members of the Poritidae and Faviidae. At 14 to 15 m (45 to 50 ft), a vertical drop off was present. Below the lip of the drop off, from about 21 m (70 ft) to the limit of visibility the wall contained many undercut ledges and grottos. Along the top edge of the drop off to a depth of approximately 23 m (75 ft) the beautiful greenish-black Dendrophylliidae *Tubastraea micrantha* made up approximately 95% of all coral cover. This species has not previously been reported from Diego Garcia or the Chagos Archipelago. Many of the specimens were over 1 m (3.3 ft) high and 1.5 m (5 ft) wide. Dozens to hundreds of anthids (Anthiidae) were present around each of the *Tubastraea micrantha* colonies. Black corals and gorgonian corals became increasingly abundant below 18 m (60 ft), with many large specimens being sighted. Small specimens of Nephtheidae soft corals were also present. None of the corals sighted at any location within the Main Pass showed any signs of bleaching or disease. The fish population in this area was striking, with many very large specimens sighted, including two giant grouper (*Epinephelus lanceolatus*) over 1.5 m (5 ft) long, five saddleback grouper *(Plectropomus laevis*) over 1 m (3.3 ft), and more than 20 smaller specimens of this species, three Napoleon wrasse (*Cheilinus undulatus*) up to 1.5 m (5 ft) long. Schools of large yellowfin surgeonfish (*Acanthurus xanthopterus*) were sighted on all of the dives in this area, and over 50 individual palette surgeonfish (*Paracanthurus hepatus*) were sighted in the shallow portions of the Main Pass. The palette surgeonfish had never been collected and very rarely sighted in the Chagos Archipelago. Underwater horizontal visibility on these dives ranged from 15 to 25 m (49 to 82 ft).

#### *2.2.4 Seaward Reefs Surveyed by the GMI Team*

**O-E-CsPt-2-G (Cust Point)**–We examined the shallow fore reef at Cust Point on the northeast side of the atoll rim. Survey transects were located on the terrace within the 4.5 to 16 m (15 to 52 ft) depth range. Horizontal visibility was much improved here compared to the lagoon sites. Coral formations of small to medium to large sizes are spread out over the study area and shallow terrace. The reef front drops off precipitously beyond the 18 m (60 ft) isobath. Dead coral substrate (mostly rubble) was scattered between the live hard and soft corals.

**O-W-Ar-4-G (Airport)**–This site was located on the west side of the atoll, west of the southern end of the runway. The studied area was contained within the 12 to 14 m (40 to 46 ft) depth range between the surge channels of the reef flat and the edge of the terrace. This reef had low topographic complexity and widespread areas of coral rubble. There were, however, a few large massive coral heads. Most of the live corals were juveniles. Rubble and dead coral substrate were, in some areas, encrusted by calcareous algae and in others by turf algae. There was abundant soft coral cover at this site. Large, low growing soft corals were common.

**O-W-SmPt-1-G (Simpson Point)**–This site was located on the west side of the atoll, north of Simpson Point. The land immediately adjacent to the study site is mostly undeveloped and covered by jungle. The study area was contained between the surge channels of the reef flat and the edge of the fore reef terrace. There was a sharp drop off at the edge of the terrace (approximately 17 m [55 ft]). On the day of the survey, the north shore of Simpson Point was sheltered from the southeast wind and wave action. The depth of the studied area ranged from 9 to 15 m (30 to 50 ft). There were abundant juvenile and medium-sized colonies of Acroporidae. There were few large coral colonies (Poritidae). Many soft corals were scattered about the site. Turf algae and encrusting calcareous algae were found on dead coral substrate, reef rock, and coral rubble. We observed small patches of fine grained carbonate sediments. Several large seafans as well as antipatharians occurred on the fore reef slope beyond the study site.

**O-W-CnPt-2-G (Cannon Point)**–This site was located on the northwest end of the atoll, east of Simpson Point. We examined the fore reef terrace contained between the reef flat surge channels and the edge of the terrace in water depths ranging from 5 to 18 m (16 to 58 ft). Land bordering this survey site was a mixture of jungle, base living and support facilities, and sewage lagoons and outflow pipes. The terrace here supported large patches of small colonies of Acroporidae. Topographic complexity overall was low to moderate. There were few soft corals at this site. We observed patches of fine grained carbonate sediments interspersed with dead coral substrate, reef rock, and coral rubble encrusted by calcareous algae. Turf algae were seen growing on hard substrate. Large seafans as well as antipatharians were seen on the edge of the terrace and below.

### 2.3 FIELD LOGISTICS

The sampling techniques used in this study were selected mainly for their efficiency and effectiveness, i.e., the methods were rapid while still acquiring accurate and representative samples.

**Timing of the Survey**–The survey was to coincide with the onsite presence of the UCT 2 team to benefit from the availability of their recompression chamber in case of a dive-related accident. The Navy team surveyed 35 sites from 29 July through 15 August 2004 (18 days of fieldwork), and the GMI team surveyed 11 sites from 5 August to 16 August 2004 (11 days of fieldwork). The survey took place during the Diego Garcia winter season. Air temperature at Diego Garcia during the survey averaged 26.7°C (80°F). The air was dryer and cooler than what would be encountered during the summer. Winds were consistently out of the southeast and stronger than those reported in summer.

**Dive Vessels**–While the Navy and GMI teams operated off separate dive vessels, the survey sites were located in the same general areas of the lagoon and the seaward reefs. All study sites were reached by boat. The Navy team used a Landing Craft Unit and the GMI team sued an Ocean Master deep-sea fishing boat.

**Selection of Study Sites**–Study site areas were selected by the project manager and Navy Technical Representative, Stephen H. Smith (Naval Facilities Engineering Command Pacific, Pearl Harbor, Hawai'i). Each survey team chose the specific survey locations (except at L-N-RZ-9-G and O-W-CnPt-2-G) and determined the orientation of survey transects.

**Recording Study Site Locations**–The GMI team survey site coordinates were recorded using a Trimble® ProXRS differential global positioning system (DGPS) unit (Trimble Navigation Ltd., Sunnyvale, CA) running Assess Surveyor 4.0. The OmniSTAR real-time DGPS correction service was used to attempt to gain high geographical positioning accuracy (OmniSTAR, Inc. 2003). A laser rangefinder gun was used to "shoot" the offset of the survey site buoy marker from the deck of the survey vessel. The remoteness of Diego Garcia reduced the accuracy of the survey grade global positioning system (GPS) unit slightly. The swing, bob, and drift of the survey vessel at anchor while recording the survey site position also introduced some additional inaccuracy to the data recorded by the GPS unit. The DGPS positioning data were downloaded using Pathfinder Office 2.70 and exported into ESRI ArcGIS 8.2 Geodatabase data layers.

**Reconnaissance Level/Roving Diver Swims**–At selected locations the Navy team performed random zig zag swims to obtain a qualitative/semi-quantitative overview of a large area. The starting point for each of these dives was recorded as the dive location. During these dives, presence/absence data were recorded for sessile benthos categories, and for the fish families. Selected fishes, such as Napoleon wrasse, were recorded individually. For all areas assessed in this manner, except the deep reef off the Airport and the Main Pass, subjectively comparable sites were subsequently assessed with transects.

**Survey Transects**–The Navy and GMI teams established four survey transects at each of their study sites along which both benthic organisms and fishes were surveyed. Each transect radiated from a central point (recorded geographical location of the study site). The heading of each transect was randomly chosen using tables of random numbers (Rohlf and Sokal 1969).

At Navy study sites along the terrace edge drop offs, transects followed pre-determined depth contours. The transects ran in opposite directions and were separated by a 5 m (16 ft) interval. For example, at Barton Point, transects 1 and 2 ran in an easterly direction from 0 to 25 m (0 to 82 ft) and 30 to 55 m (98 to 180 ft) along the 23 to 25 m (75 to 80 ft) depth contour, and transects 3 and 4 followed the same pattern and contour in a westerly direction.

Each transect was 25 m (82 ft) in length as measured and marked by a survey measuring tape. The transects generally began 2 to 3 m (7 to 10 ft) from the center of the survey site. Benthic surveys (LPI and 2 m [6 ft] wide belt transects) were conducted along these transects. Roving diver fish surveys were conducted along each of these transects using the survey tape as a guideline. Stationary fish counts and size estimates were conducted near the distal end of each survey tape. The fish census was limited only by the horizontal visibility of the water column. Additional visual observations, as well as digital image and video captures, were made among and between the survey transects in an area measuring approximately 2,290 $m^2$ (24,640 square feet [$ft^2$]) per site. The Navy fish census was based upon the roving diver method.

**Water Quality Assessments**–Water quality parameters (temperature, salinity, dissolved oxygen [DO], pH, and turbidity) were recorded at each survey site using a Hydrolab Datasonde 4a survey unit placed on the reef during the period of the survey.

## 2.4 BENTHIC SURVEYS

The percent cover of scleractinians and non-scleractinians as well as the cover of other sessile organisms (including turf algae, crustose coralline algae, macroalgae, sponges, zoanthids, mollusks, echinoids, star fishes, sea cucumbers) were determined using the LPI transect method (Liddell and Ohlhorst 1987; Ohlhorst et al. 1988; Aronson and Precht 1995; Rogers et al. 1994).

**Sessile Benthos and Seafloor Composition**–The Navy and GMI teams examined sessile benthos and the seafloor composition along four replicate transects per site using an adaptation of the LPI transect method (Liddell and Ohlhorst 1987; Ohlhorst et al. 1988; Aronson and Precht 1995; Rogers et al. 1994). An LPI transect here consisted of a 25 m (82 ft) long surveyor's fiberglass measuring tape (marked at 1 cm [0.39 in] intervals) loosely draped over the top surface of the reef. Each end of the tape was weighted down using a 0.5 kg (1 lb) lead ball. Each transect radiated from a central point (recorded geographical location of the study site). The heading of each transect was randomly chosen using tables of random numbers (Rohlf and Sokal 1969). The transects generally began 2 to 3 m (7 to 10 ft) from the center of the survey site.

A single observer recorded the identity of the benthic organism/substrate under equally spaced points (1 m [3.3 ft] apart) along a line transect (measuring tape) for a total of 25 observations per transect. The observer photographed each of the point intercepts. Each photograph was taken such that the camera was held vertically 1.5 m above the reef. A bubble level attached to the upper face of the underwater housing allowed the diver to position the camera in a vertical position above the reef. The Navy team substituted this method with use of continuous video footage.

Benthic organisms/substrate noted included scleractinian corals (identified to the family level), non-scleractinian corals, gorgonians, sponges, turf algae (mostly filamentous algae, less than 10 millimeters [mm] [0.4 in] in height; Steneck 1988), encrusting calcareous algae, macroalgae, mollusks, incidence of bleaching, and substrate type (silt/mud, sand, sand and rubble, boulder, fossilized reef pavement).

The percent cover of a given organism/substrate ($PC_i$) in a transect was equal to the ratio of the sum of observations for that particular organism/substrate ($OB_i$) and the total number of observations per transect (25).

$$PC_i = \frac{OB_i}{25}$$

**Macroscopic Invertebrate Survey**–Once the LPI survey was complete, the observer conducted a belt transect survey for each transect by swimming twice above the transect tape and recording all macroscopic invertebrates found within 1 m (3.3 ft) on either side of and at the end of the LPI transect (i.e., 62.6 $m^2$ area per transect). Macroscopic invertebrates were to include barrel sponges, giant sea anemones, sea cucumbers, sea urchins, sea stars, crown of thorns starfish, giant *Tridacna* clams, pen shells, cowries, the horned helmet, and the triton trumpet.

## 2.5 REEF FISH CENSUSES

Variations of roving diver surveys (Schmitt et al. 1998) and stationary surveys (Bohnsack and Bannerot 1986) were used to census fish populations at Diego Garcia. A number of Indian Ocean and Pacific Ocean reef fish guides were used to assist in fish identification. The two primarily used were Allen et al. (2003) and Lieske and Myers (1994). Four repetitions of both survey types were conducted at every survey site, one for each transect.

**Roving Diver Fish Census**–Both teams used the roving survey method which consisted of a diver swimming in a non-linear fashion using a 25 m (82 ft) survey tape-transect as a guideline while censusing fishes. Fishes were identified to family and species, if possible, and abundance was recorded.

The Navy team recorded the actual number of specimens, when possible. When that was not feasible, the number of sightings was recorded in the following categories: 0-5, 5-10, 10-20, 20-50, 50-100, 100-200 and >200. It is important to note, that particularly in murky water, multiple sightings during an observation period may represent the same individual fish or fishes sighted repeatedly. The Navy team's standard observation period was 20 minutes (min).

The GMI team used a logarithmic scale after the fashion of the Reef Environmental Education Foundation (REEF) organization's roving diver surveys (Schmitt et al. 1998). Abundance categories were: single (one fish), few (2-10 fishes), many (11-100 fishes), and abundant (>100 fishes). The zone of inclusion was limited only by the visibility at the time of the roving survey, each one lasting 20 to 30 min from beginning to end of each transect. We also recorded the presence/absence of fishes between transects.

**Stationary Fish Census**–The Navy team did not perform stationary fish counts. GMI stationary fish identifications, and abundance and size estimates were conducted in the vicinity of the end of each survey transect. The diver conducting the census would remain in a single hovering location above the reef to count and measure fishes all around and above him. The dimensions of the imaginary cylinder within which the census was conducted were limited only by the water transparency and insolation. Each stationary survey lasted 20 to 30 min. The diver first recorded the presence of fish families in a 360° sweep. Then the diver recorded the abundance and size of the identified fishes during a second 360° sweep. The diver added more fish identifications (and respective abundance and size) during the second sweep if missed on the first sweep. The stationary survey diver had experience estimating both abundance and sizes of reef fishes. Fish identifications were limited to a pre-determined list of families. Whenever possible, we recorded fish species and additional families when thought to be noteworthy (e.g., Aulostomidae – trumpetfishes). Where possible fish sizes were recorded in three categories: minimum, maximum, and average.

## 2.6 OPPORTUNISTIC OBSERVATIONS

Additional data of opportunistic nature were recorded at survey sites as well. All encounters with sea turtles and marine mammals at the surface or while diving on a survey site were noted. Where possible, marine mammals and sea turtles were identified to species, counted, and their sizes estimated.

While most of the study sites were specifically located on coral reefs, evidence of seagrasses and seagrass beds were sought and readily noted. Observations were mostly restricted to the designated survey areas. A particular effort was made to look for and record any suspected hazardous material, hazardous waste, pollutants, debris/trash or fishing gear. Anomalies or abnormalities on marine life, such as lesions on fishes, were also recorded.

## 2.7 WATER QUALITY

Water quality parameters were measured using a Hydrolab Datasonde 4a Multiprobe equipped with the Surveyor 4a waterproof display and Hydrolab Profiler software. The multiprobe was calibrated using required calibration standards and techniques. The Hydrolab unit was placed directly on the reef at the center of the survey site. We recorded selected water quality parameters (temperature, specific conductivity, salinity, dissolved oxygen, pH, depth, and turbidity) every 10 min during the roughly two hours spent at each study site. Each evening, data were downloaded from the Hydrolab handheld data logger to a laptop computer.

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# 3.0 RESULTS

## 3.1 MACROSCOPIC BENTHOS AND SEAFLOOR COMPOSITION

The results of the LPI and belt transects were used to determine the mean percent cover of live benthic organisms and type of seafloor substrate, the composition of coral families, and the presence/absence of selected macrobenthic organisms on Diego Garcia seaward and lagoon reefs. Data from the two survey teams are presented separately to distinguish sampling areas and depths.

### *3.1.1 Seaward Reefs*

Seaward reefs were examined in three general areas: the northwestern tip of the atoll (Cannon Point and Simpson Point), the eastern side off the airport, the northeastern tip at Barton Point, and the western side at Cust Point (**Figure 2-7**). The Navy team surveyed the shallow fore reef terrace communities at 12 m (40 ft) and upper slope communities at 23 to 30 m (77 to 100 ft). The GMI team surveyed the terrace edge communities between 15 and 17 m (50 to 54 ft).

**Cannon Point**–At Cannon Point, benthos/substrate categories associated with the largest amount of percent cover were hard corals (Scleractinia), turf algae, crustose algae, and coral rubble (**Tables 3-1** and **3-2**; **Figures 3-1** and **3-2**). Hard coral (Scleractinia) cover ranged from 46.6 to 39%, with the shallow terrace bearing the greatest amount of coral cover. While many of the coral colonies accounted for on the LPI transects were relatively large (>30 cm [12 in], longest dimension), there were also many juvenile corals measuring 10 cm (4 in) or less. Individual coral colonies were not extensive (not several meters across). There were four families of corals found on the LPI transects at the terrace edge: Acroporidae (51.3% occurrence), Poritidae (35.9%), Faviidae (7.7%), and Pocilloporidae (5.2%) (**Table 3-3**).

Alcyonacea (soft corals) were accounted for only on the upper slope (2.9%). No Gorgonacea (including sea fans) were found on the LPI transects. The crustose algae cover ranged from 12.6 to 17.5% and was greatest on the terrace edge and the upper slope. The turf algae cover was just as high as the coral cover on the terrace edge (35%) and covered for the most part vast areas of dead coral substrate. Interestingly, macroalgae cover was less than 4%. Coral rubble represented 20% of the cover in the shallow part of the terrace and on the upper slope (**Tables 3-1** and **3-2**; **Figures 3-1** and **3-2**).

The belt transects conducted at Cannon Point provided a broader yet qualitative assessment of macrobenthic organisms and substrate present within the surveyed areas. We found that coral rubble seemed to accumulate at the edge of the terrace. Within 1 m (3.3. ft) on either side of survey transects (LPI measuring tapes) there were sponges, giant sea anemones, fire and lace corals, Antipatharia corals, blue corals, sea fans, cowries, giant clams (*Tridacna* sp.), pen shells, oysters, sea urchins, sea stars, and sea cucumbers (**Tables 3-4** and **3-5**; **Figure 3-3**). Dead coral colonies were seen both on the shallow terrace and terrace edge. We found few coral colonies that were entirely bleached within our LPI and belt transects on the terrace edge. The most common occurrence of bleaching was that of massive and branching coral colonies (Poritidae and Acroporidae, respectively) bleached at their edges and in few small areas (spot bleaching). Some of the massive and branching corals were partially dead. There were, however, abundant fish bite scars on hard corals at the edge of the terrace. Within the terrace edge transects, we found fishing line entangled on the reef.

**Simpson Point**–At Simpson Point, we surveyed the terrace edge. There we found 57% turf algae cover which was the highest amount of turf algae accounted for in all of the seaward sites (**Tables 3-1** and **3-2**; **Figures 3-1** and **3-2**). Hard coral cover was 26%. Most of the Scleractinia accounted for as point intercepts were juveniles measuring 2 to 15 cm (0.8 to 6 in) across (longest dimension). The juvenile corals had settled on the very abundant dead coral substrate (dead Acroporidae and Poritidae) including in some places what had been fairly large massive coral heads (Poritidae). In one of our belt transects, we also came across a large and healthy Poritidae (2.4 by 2.4 m; 8 by 8 ft). Some of the live hard corals had fish predation scrapes. Coral bleaching was observed as colony-edge and spot bleaching on massive

**Table 3-1.** Mean percent cover of live benthic taxa and seafloor substrate found on the Navy linear point intercept transects on seaward reefs of Diego Garcia in July and August 2004. Water depths ranged from 12 to 30 m (40 to 100 ft).

| Taxa/Substrate | O-W-CnPt-1-N (Deep) | O-W-CnPt-1-N (Med) | O-W-Ar-1-N (Med) | O-W-Ar-3-N (Med) | O-N-BPt-1-N (Deep) | O-N-BPt-1-N (Med) | O-E-CsPt-1-N (Deep) | O-E-CsPt-1-N (Med) |
|---|---|---|---|---|---|---|---|---|
| **Turf Algae** | 1.0 | 0.0 | 43.8 | 31.1 | 0.0 | 2.0 | 1.9 | 1.0 |
| **Macroalgae** | 3.9 | 0.0 | 2.7 | 10.7 | 0.0 | 0.0 | 11.7 | 9.7 |
| **Crustose Algae** | 17.5 | 12.6 | 9.6 | 3.9 | 2.0 | 15.7 | 9.7 | 21.4 |
| **Seagrass** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Spongia** | 1.9 | 1.0 | 0.0 | 1.9 | 6.1 | 3.9 | 7.8 | 0.0 |
| **Scleractinia** | 44.7 | 46.6 | 34.2 | 26.2 | 51.0 | 41.2 | 38.8 | 32.0 |
| **Milleporina** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Helioporacea** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.0 | 1.0 |
| **Alcyonacea** | 2.9 | 0.0 | 0.0 | 17.5 | 6.1 | 3.9 | 8.7 | 16.5 |
| **Gorgonacea** | 0.0 | 0.0 | 1.4 | 0.0 | 10.2 | 0.0 | 1.9 | 0.0 |
| **Antipatharia** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Mollusca** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| **Silt/Mud** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Sand** | 7.8 | 1.9 | 8.2 | 8.7 | 22.4 | 0.0 | 14.6 | 7.8 |
| **Rubble** | 20.4 | 19.4 | 0.0 | 0.0 | 2.0 | 31.4 | 3.9 | 8.7 |
| **Shell Hash** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Reef Rock** | 0.0 | 18.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |

**Table 3-2.** Mean percent cover of live benthic taxa and seafloor substrate found on the GMI linear point intercept transects on seaward reefs of Diego Garcia in July and August 2004. Water depths ranged from 15 to 17 m (50 to 55 ft).

| Taxon/Substrate | O-W-CnPt-2-G | O-W-SmPt-1-G | O-W-Ar-4-G | O-E-CsPt-2-G |
|---|---|---|---|---|
| **Turf Algae** | 35.0 | 57.0 | 45.0 | 31.0 |
| **Macroalgae** | 0.0 | 1.0 | 4.0 | 0.0 |
| **Crustose Algae** | 17.0 | 7.0 | 9 | 31.0 |
| **Spongia** | 3.0 | 2.0 | 0.0 | 3.0 |
| **Scleractinia** | 39.0 | 26.0 | 7.0 | 27.0 |
| **Milleporina** | 1.0 | 1.0 | 0.0 | 3.0 |
| **Alcyonacea** | 0 | 0.0 | 23.0 | 1.0 |
| **Zoanthidea** | 0.0 | 1.0 | 1 | 2.0 |
| **Gravel** | 1.0 | 0.0 | 0.0 | 1.0 |
| **Sand** | 4.0 | 5.0 | 11.0 | 1.0 |

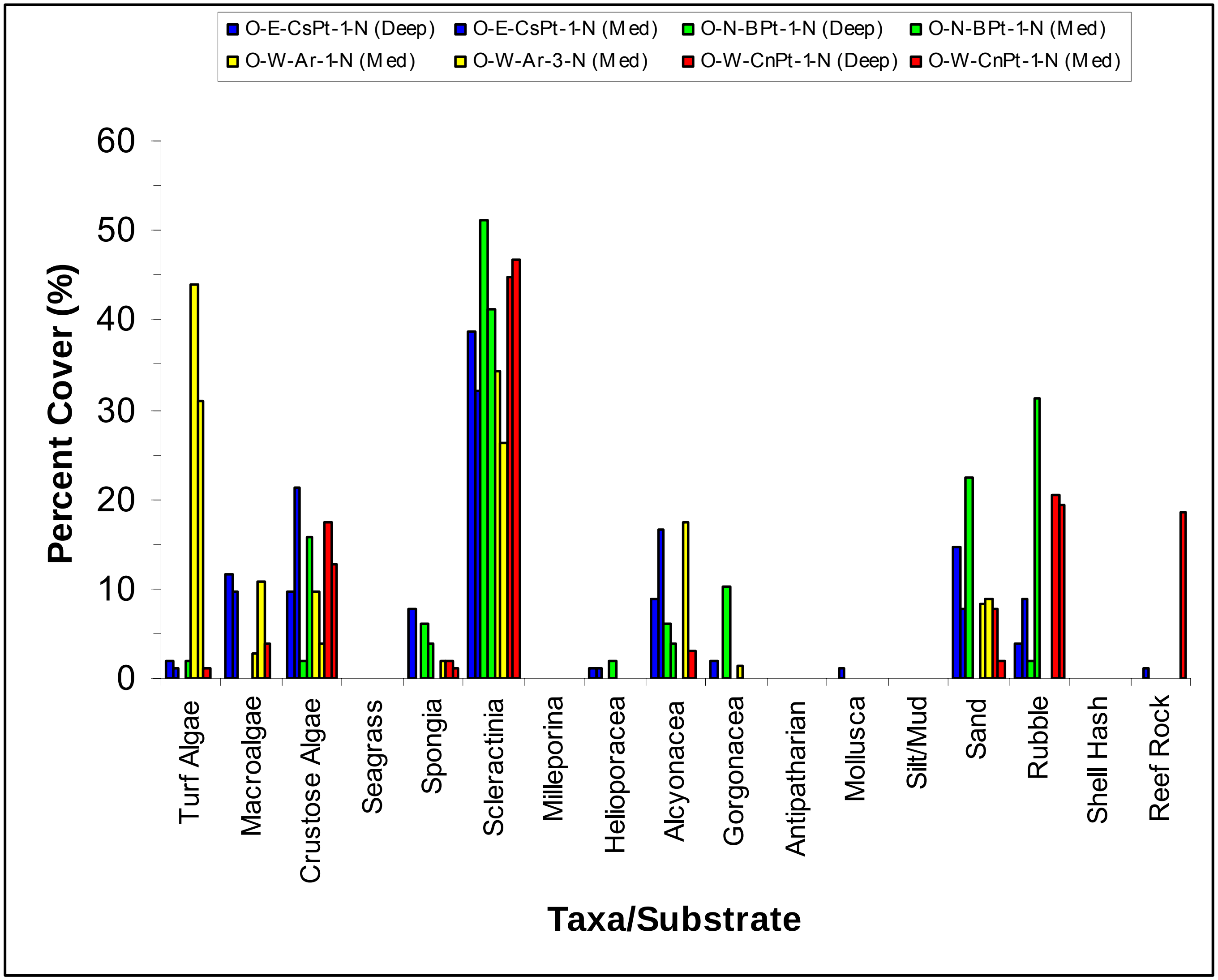


**Figure 3-1.** Mean percent cover of live benthic taxa and seafloor substrate found on the Navy linear point intercept transects on seaward reefs of Diego Garcia in July and August 2004. Water depths ranged from 12 to 30 m (40 to 100 ft).

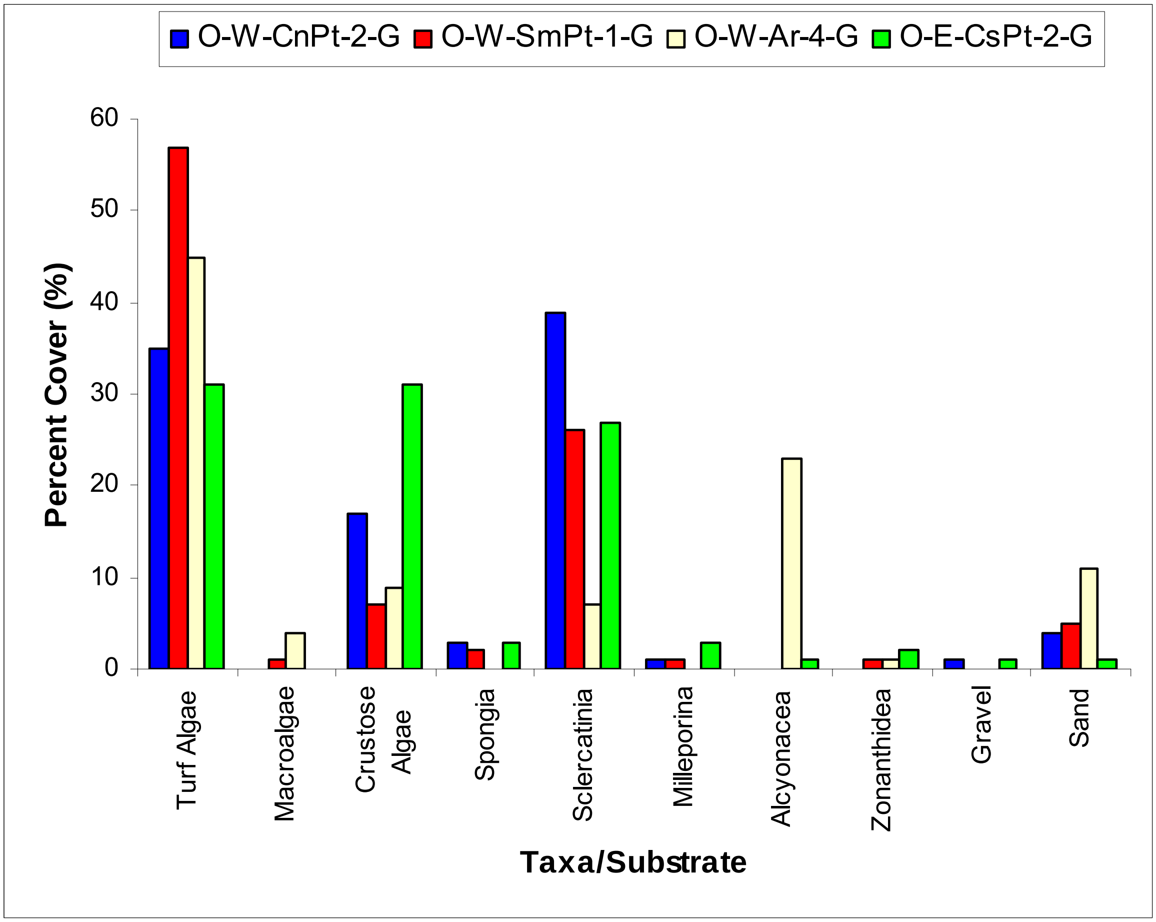


**Figure 3-2.** Mean percent cover of live benthic taxa and seafloor substrate found on the GMI linear point intercept transects on seaward reefs of Diego Garcia in July and August 2004. Water depths ranges from 15 to 17 m (50 to 55 ft).

**Table 3-3.** Mean percent occurrence of scleractinian families (coral composition) on the GMI linear point intercept transects on seaward reefs at Diego Garcia in July and August 2004. Water depths ranged from 15 to 17 m (50 to 55 ft).

| Coral Family | O-W-CnPt-2-G | O-W-SmPt-1-G | O-E-CsPt-2-G |
|---|---|---|---|
| **Acroporidae** | 51.3 | 46.2 | 25.9 |
| **Pocilloporidae** | 5.2 | 3.8 | 3.7 |
| **Agaricidae** | 0.0 | 0.0 | 7.4 |
| **Faviidae** | 7.7 | 7.7 | 11.1 |
| **Poritidae** | 35.9 | 42.3 | 51.9 |

**Table 3-4.** Occurrence (presence/absence) of macroscopic invertebrates within belt transects at Diego Garcia seaward and pass reef sites in July and August 2004. Water depths ranged from 12 to 30 m (40 to 100 ft). [Presence = 1; Absence = 0]

| Taxa | O-E-CsPt-1-N (Deep) | O-E-CsPt-1-N (Med) | O-N-BPt-1-N (Deep) | O-N-BPt-1-N (Med) | O-W-Ar-2-N (Deep) | O-W-Ar-1-N (Med) | O-W-Ar-3-N (Med) | O-W-CnPt-1-N (Deep) | O-W-CnPt-1-N (Med) | P-B-1-N | P-Mn-1-N (Deep) | P-Mn-1-N (Med) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Encrusting Sponges** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| **Non-Encrusting Sponges** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| **Giant Sea Anemones (>25 cm diam.)** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Milleporina** | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Stylasterina** | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| ***Acropora* sp.** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| ***Acropora* sp. (Partial Bleaching)** | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Acropora* sp. (Dead Colony)** | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| **Scleractinia** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Scleractinia (Partial Mortality)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Scleractinia (Dead Colony)** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| **Antipatharia** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| ***Heliopora coerulea (*Blue Coral)** | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| ***H. coerulea* (Dead Colony)** | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Alcyonacea** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| **Gorgonacea (Sea Fans)** | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| **Gorgonacea (Sea Fans, Partial Mortality)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Gorgonacea (Sea Fans, Disease)** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Gorgonacea (Sea Fans, Dead Colony)** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Cowries (*Cypraea* sp.)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| **Giant Clams (*Tridacna* sp.)** | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Pen Shells (*Atrina* sp.)** | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Oyster Species** | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| **Sea Urchins** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Sea Stars (other than *Acanthaster planci*)** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Sea Cucumbers** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |

**Table 3-5.** Mean percent cover of live benthic taxa and seafloor substrate found on the Navy linear point intercept transects in the Diego Garcia lagoon in July and August 2004. Water depths ranged from 2 to 28 m (7-92 ft).

| Taxa/Substrate | L-N-An-1-N | L-N-An-2-N | L-N-An-3-N | L-N-An-4-N | L-N-An-5-N | L-N-EcBy-1-N | L-N-Rby-2-N | L-N-Rby-3-N | L-N-RZ-1-N | L-N-RZ-2-N | L-N-RZ-3-N | L-N-RZ-6-N | L-N-RZ-7-N | L-S-1-N | L-S-2-N | L-S-3-N | L-S-TC-2-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Turf Algae** | 0.7 | 0.0 | 18.8 | 0.0 | 0.0 | 1.0 | 35.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| **Macroalgae** | 4.0 | 0.0 | 1.1 | 0.0 | 2.0 | 0.0 | 3.9 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Crustose Algae** | 4.0 | 5.0 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Seagrass** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.9 | 0.0 | 0.0 |
| **Spongia** | 0.7 | 1.0 | 0.6 | 0.0 | 3.0 | 1.0 | 1.9 | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Scleractinia** | 20.7 | 35.6 | 39.2 | 0.0 | 8.0 | 15.7 | 7.8 | 9.9 | 34.4 | 32.0 | 18.0 | 0.0 | 32.4 | 3.1 | 5.8 | 7.9 | 21.1 |
| **Milleporina** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Helioporacea** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Alcyonacea** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Antipatharia** | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Mollusca** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 |
| **Silt/Mud** | 0.7 | 0.0 | 8.0 | 0.0 | 16.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Sand** | 6.0 | 0.0 | 16.5 | 99.0 | 41.0 | 70.6 | 25.2 | 83.2 | 24.8 | 29.0 | 8.0 | 100 | 49.0 | 7.1 | 65.0 | 33.7 | 51.3 |
| **Rubble** | 63.3 | 54.5 | 11.4 | 0.0 | 23.0 | 8.8 | 26.2 | 1.0 | 19.2 | 39.0 | 66.0 | 0.0 | 17.6 | 87.8 | 26.2 | 12.9 | 5.3 |
| **Shell Hash** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.6 | 0.0 |
| **Reef Rock** | 0.0 | 4.0 | 0.0 | 0.0 | 7.0 | 2.0 | 0.0 | 0.0 | 9.6 | 0.0 | 4.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 22.4 |

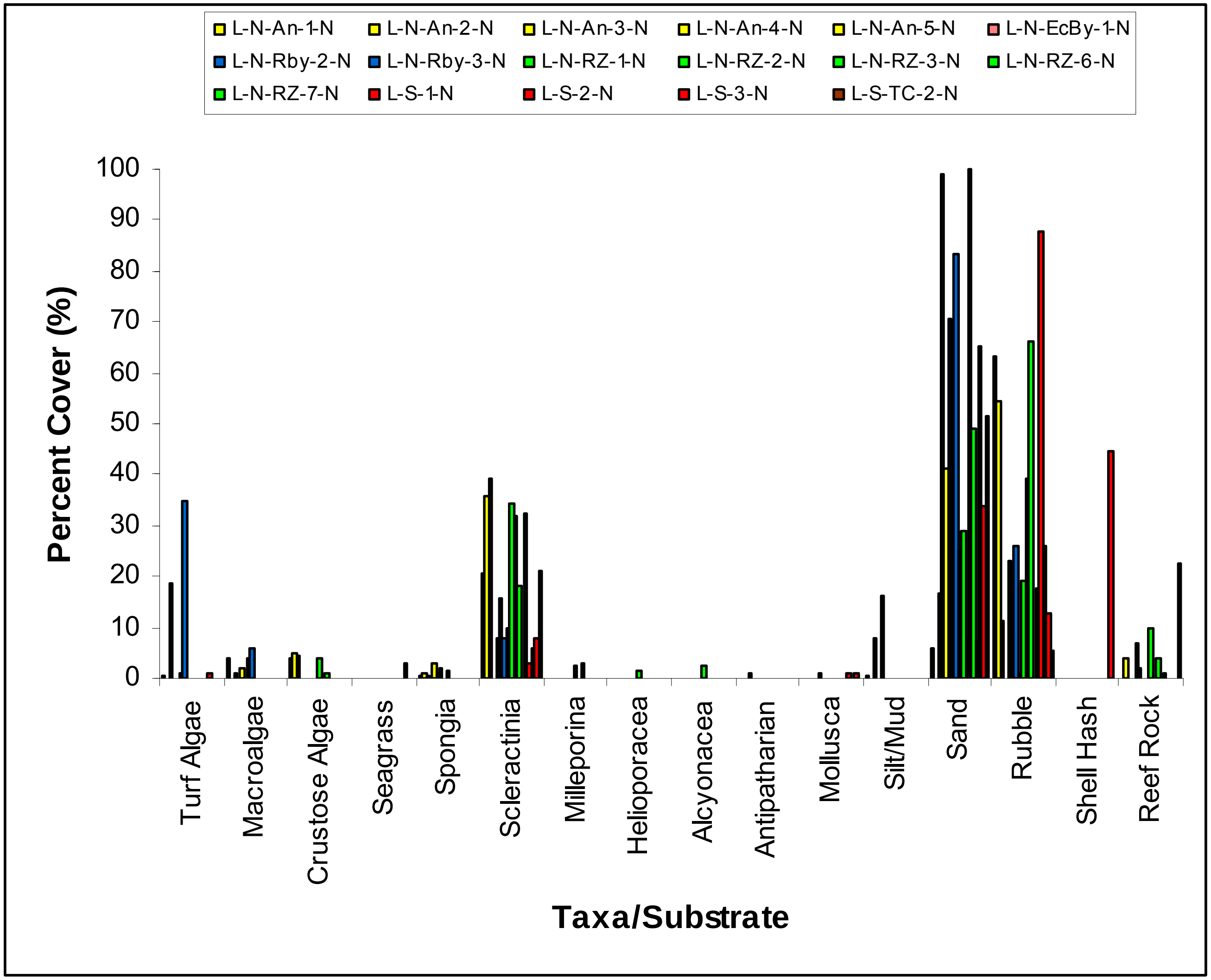


**Figure 3-3.** Mean percent cover of live benthic taxa and seafloor substrate found on the Navy linear point intercept transects in the Diego Garcia lagoon in July and August 2004. Water depths ranged from 2 to 28 m (7 to 92 ft).

colonies (mostly Poritidae). Some of the massive coral colonies (Poritidae) were partially dead. Zoanthidea cover was quite noticeable at this site despite the fact that the LPI only contained 1% Zoanthidea cover (**Tables 3-1**, **3-2**, **3-4**, and **3-5**). Coral cover on the terrace edge at Simpson Point consisted of Acroporidae (46.2% occurrence), Poritidae (42.3%), Faviidae (7.7%), and Pocilloporidae (3.8%) (**Table 3-3**).

**Airport**–The area off the airport was surveyed on the shallow terrace, terrace edge, and upper slope (**Tables 3-1** and **3-2**; **Figures 3-1** and **3-2**). LPI transects were conducted only on the terrace and not on the upper slope. Belt transects were, however, done both on the terrace and the upper slope. The most noticeable characteristics of the terrace were the relatively high cover of turf algae (31 to 45%), macroalgae (3 to 11%), and Alcyonacea (as much as 23%). Furthermore, hard coral cover on the terrace edge was only 7% compared to the 26 to 47% cover range for all other seaward sites. Of the 7% coral cover, only two percent of the cover could be identified and consisted of Faviidae (1% cover) and Poritidae (1% cover). The remaining 5% was not identified while in situ and relied on photographic records which unfortunately failed.

On the terrace edge off the airport, Alcyonacea occupied an unusually large amount of area compared to other taxa. Also, *Halimeda* sp. Accounted for a large portion of the macroalgae at this site. Some of the corals observed on the terrace edge were bleached and others (massive Poritidae) had fairly large fish bite scars. We frequently observed among our belt transects the presence of long pieces of fishing line. We saw what appeared to be small anchor damage on corals (broken corals). On the upper slope, belt transects included soft corals (Alcyonacea) but no sea fans (Gorgonacea) or Antipatharia. Sea cucumbers were also seen in the upper slope belt transects. The only other deep seaward site where sea cucumbers were seen was Cannon Point. Belt transects also included sponges, giant sea anemones (upper slope), corals, Alcyonacea, giant clams, pen shells, oysters, sea urchins, and sea stars (**Tables 3-1**, **3-2**, **3-4**, and **3-5**).

**Barton Point**–On the northeastern end of the island, at Barton Point, the Navy team conducted LPI and belt transects on the shallow fore reef terrace (14 m, 47 ft) and the upper slope (24 m, 80 ft). Turf algae cover (0 to 2%) was low compared to other seaward sites (**Table 3-1**). On the shallow terrace, there was an unusually high cover of coral rubble (31%). Even though the Helioporacea (blue coral) cover was only 2%, it was higher here than at any other site. The sponge cover was also relatively high (4%) (**Table 3-1**). Belt transects on the shallow terrace included sponges, corals, Alcyonacea, healthy Gorgonacea (none were dead, partially dead, or diseased), giant clams, pen shells, oysters, sea urchins, sea stars, but no sea cucumbers (**Table 3-4**).

On the upper slope, the sponge cover was 6.1% which was relatively high compared to the other upper slope and terrace sites. The cover consisting of Gorgonacea (10.2%) was the highest seen in any seaward site. While the rubble cover was only 2%, the sand cover was 22.4% which was higher than at any other seaward site (**Table 3-4**).

**Cust Point**–On the western side of the atoll at Cust Point, the Navy and GMI teams surveyed the shallow terrace, the terrace edge, and the upper slope. The LPI surveys revealed that the turf algae cover was higher (31%) on the terrace edge than it was on the shallow terrace (1%) and the upper slope (1.9%) (**Tables 3-1** and **3-2**). Interestingly, there were no macroalgae accounted for on the terrace edge yet there was 9.7% and 11.7% macroalgae cover on the shallow terrace and upper slope, respectively. Crustose algae were unusually abundant (31%) on the terrace edge compared to all other seaward sites. Coral cover ranged from 27 to 38.8%, the upper slope having the greatest amount. Many of the corals (33%) observed under the LPI transects on the terrace edge were juveniles and measured 15 cm (6 in) or less along their greatest dimension. Twenty-two percent of the corals accounted for on the terrace edge LPI transects were either entirely bleached, had bleached edges, or had spot bleaching. Hard coral cover on the terrace edge LPI transects consisted of Poritidae (51.9% occurrence), Acroporidae (25.9%), Faviidae (11.1%), Agaricidae (7.4%), and Pocilloporidae (3.7%) (**Table 3-3**).

Milleporina (fire coral) was more abundant (3% cover) here than at any other site. The cover of Alcyonacea was relatively high on the shallow terrace (16.5%) and upper slope (8.7%) compared to the terrace edge (1%). The cover of Zoanthidea on the terrace edge (2%) was the highest compared to all other seaward sites (**Tables 3-1** and **3-2**). The belt transects revealed that, like other seaward sites observed during this study, there was abundant dead coral substrate on the terrace edge area (**Tables 3-4** and **3-5**). Much of this dead coral substrate consisted of rubble. There was evidence of fish predation both on the dead and live hard coral substrate. Few areas of Halimeda cover were seen along the belt transects on the terrace edge. Giant clams (*Tridacna* sp.) were seen both on the terrace edge and the upper slope. Belt transects on the upper slope contained lace coral, Gorgonacea and Antipatharia that were not seen in the shallower areas of the Cust Point reef. Other macroscopic benthic organisms seen in belt transects both on the terrace and upper slope included sponges, fire corals, blue corals, Alcyonacea, pen shells, oysters, sea urchins, and sea stars. No sea cucumbers were seen in the areas surveyed at Cust Point (**Tables 3-4** and **3-5**).

### *3.1.2 Pass Reefs*

**Barton Pass and Main Pass**–The one Barton Pass (18m, 60 ft) and two Main Pass sites (15 m [50 ft] and 23 m [75 ft]) were surveyed using belt transects (**Figure 2-7**). At Barton Pass, the live and healthy macrobenthos included sponges, giant anemones, fire coral, lace coral, Acroporidae and other Scleractinia, Antipatharia, blue corals, Alcyonacea, Gorgonacea (sea fans), giant clams (*Tridacna* sp.), pen shells, sea urchins, and sea stars (**Table 3-4**). Both the Scleractinia and sea fans included colonies that were dead, partially dead, or diseased. The Main Pass at a 15 m (50 ft) water depth was very different compared to the Barton Pass site. There were encrusting sponges but no non-encrusting (upright) sponges. There were no giant sea anemones, fire corals, Antipaharia, blue corals, Alcyonacea, sea fans, giant clams, or pen shells. There were, however, lace corals, Scleractinia, cowries, oysters, sea urchins, sea stars, and sea cucumbers. The deep site in Main Pass (23 m [75 ft]) did have upright sponges, Antipatharia, Alcyonacea, and sea fans in addition to lace corals, Acroporiade, Scleractinia, oysters, sea urchins, and sea stars (**Table 3-4**).

### *3.1.3 Anchorage Area*

The Navy team surveyed five replicate deep sites in the Anchorage Area in the lagoon using LPI and belt transects (**Tables 3-5** and **3-6**; **Figures 2-7** and **3-3**). Data collected during these surveys were site specific and not representative of the entire Anchorage Area. The sites were investigated within the 23 to 28 m (74 to 92 ft) depth range. All sites except for the one surveyed at 28 m (92 ft) contained virtually no turf algae cover. At the 28 m (92 ft) site, however, there was over 18% turf algae cover. Macroalgae cover ranged from 1.1 to 4%. Crustose algae cover was less than 5% at all sites and sponge cover less than 3%. In three of the sites (L-N-An-1-N, L-N-An-2-N, L-N-An-3-N) coral cover was high (20.7 to 39.2%) compared to seaward reef sites. The two other sites had much less coral cover: 0 and 8%. The sites with little coral cover mostly consisted of sand. Coral rubble cover was high (>54%) in sites L-N-An-1-N and L-N-An-2-N.

Belt transects at the sites consisting mainly of sand, contained no other macroscopic benthic organisms than Antipatharia. All other sites contained Acroporidae and other Scleractinia. Bleached, partially dead, and dead Acroporidae as well as dead and partially dead Scleractinia were recorded at site L-N-An-1-N. This site did, however, contain giant clams, oysters, sea urchins, sea stars, and sea cucumbers. Sites L-N-An-2-N and L-N-An-3-N contained upright sponges, pen shells and oysters. There were also sea urchins and sea cucumbers at site L-N-An-3-N.

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

**Table 3-6.** Occurrence (presence/absence) of macroscopic invertebrates within Navy belt transects at Diego Garcia lagoon sites in July and August 2004. Water depths ranged from 2 to 28 m (7-92 ft). [Presence = 1; Absence = 0]

| Taxa | L-N-An-1-N | L-N-An-2-N | L-N-An-3-N | L-N-An-4-N | L-N-An-5-N | L-N-EcBy-1-N | L-N-PtMr-1-N | L-N-PtMr-2-N | L-N-Rby-2-N | L-N-Rby-3-N | L-N-RZ-1-N | L-N-RZ-2-N | L-N-RZ-3-N | L-N-RZ-4-N | L-N-RZ-5-N | L-N-RZ-6-N | L-N-RZ-7-N | L-N-RZ-8-N | L-S-1-N | L-S-2-N | L-S-3-N | L-S-TC-1-N | L-S-TC-2-N | L-S-TC-3-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Encrusting Sponges** | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| **Non-Encrusting Sponges** | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Giant Sea Anemones (> 25 cm diam.)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Milleporina** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stylasterina** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Acropora* sp.** | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| ***Acropora* sp. (Partial Bleaching)** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| ***Acropora* sp. (Partial Mortality)** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Acropora* sp. (Dead Colony)** | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| **Scleractinia** | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| **Scleractinia (Partial Bleaching)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Scleractinia (Partial Mortality)** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Scleractinia (Dead Colony)** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| **Antipatharia** | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Cowries (*Cypraea* sp.)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Triton's Trumpet (*Charonia tritonis*)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Horned Helmet (*Cassis cornuta*)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Giant Clams (*Tridacna* sp.)** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| **Pen Shells (*Atrina* sp.)** | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| **Oyster Species** | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Octopus* sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Sea Urchins** | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| **Sea Stars (other than *Acanthaster planci*)** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| **Sea Cucumbers** | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |

### 3.1.4 Replenishment Zone

Ten sites were examined within the Replenishment Zone. This general study area was contained within the northern end of the lagoon, above the Anchorage Area (**Figure 2-7**). Water depths at these sites ranged from 5 to 17 m (15 to 55 ft). The surveys were done at three main depths: 5 m (15 ft), 9 to 12 m (28 to 40 ft), and 15 to 17 m (50 to 55 ft) (**Table 3-7**). The Navy team examined eight of the ten sites. Belt transects were conducted in each of their sites and LPI transects in five of the sites. The GMI team conducted belt and LPI transects at two sites (**Table 3-7**).

**Table 3-7.** Depth distribution of study sites and sampling methods completed within the Replenishment Zone.

| Depth | Site | LPI | Belt |
|---|---|---|---|
| 5 m (15 ft) | L-N-RZ-10-G | ✓ | ✓ |
| 9 m (28 ft) | L-N-RZ-2-N | ✓ | ✓ |
| 9 m (28 ft) | L-N-RZ-8-N | - | ✓ |
| 11 m (35 ft) | L-N-RZ-7-N | ✓ | ✓ |
| 12 m (40 ft) | L-N-RZ-4-N | - | ✓ |
| 12 m (40 ft) | L-N-RZ-5-N | - | ✓ |
| 15 m (50 ft) | L-N-RZ-1-N | ✓ | ✓ |
| 15 m (50 ft) | L-N-RZ-9-G | ✓ | ✓ |
| 17 m (55 ft) | L-N-RZ-6-N | ✓ | ✓ |
| N/A | L-N-RZ-3-N | ✓ | ✓ |

Overall, the main taxa/substrate categories accounted for in the Replenishment Zone by the LPI transects were Scleractinia, sand, and rubble (**Tables 3-5**, **3-6**, **3-8**, and **3-9**; **Figures 3-3** and **3-4**). Two distinct differences in LPI transect records between the Navy and GMI teams were the “turf algae” and “rubble” data. Where the Navy recorded rubble, GMI recorded turf algae growing on underlying rubble. The GMI recorded rubble in LPI transects when rubble was bare. At a depth of 5 m (15 ft), the LPI recorded a simplified reef substrate consisting of Scleractinia (30% cover), turf algae (29%), Mollusca (1%), and sand (40%) (**Table 3-8**). The “simplified” live Scleractinia cover at 5 m (15 ft) consisted of five families: Acroporidae (42.1% occurrence), Mussidae (21.1%), Poritidae (15.8%), Fungidae (10.5%), and Faviidae (10.5%) (**Table 3-9**). Within the available photographic records of LPI transects, all Acroporidae were branching. Half of the Acroporidae colonies measured 14 to 17 cm (5.5 to 6.7 in) along the longest dimension and the other half measured more than 30 cm (12 in). Some of the Acroporidae colonies were partially bleached. Mussidae colonies measured 11 to 15 cm (4 to 6 in) across, and more than 30 cm (12 in) across. Some of the Mussidae were partially bleached. The Poritidae colonies were massive and measured 14 cm (5.5 in) to more than 30 cm (12 in) across. Some of the Poritidae colonies had fish bite scars on them. Faviidae colonies were massive as well and measured 6 to 7 cm (2.4 to 2.8 in) across. Belt transects at 5 m (15 ft) contained abundant dead coral substrate consisting of Mussidae corallites. The dead coral substrate was in the process of being recolonized by abundant and diverse Scleractinia. The area that was surveyed was a patch reef surrounded by carbonate sand. Fungidae corals were seen on the sand substrate. There were also massive head-forming Poritidae.

Within the 9 to 12 m (28 to 40 ft) depth range, the Navy team conducted LPI transects at two sites. Here again, LPI data were limited to few categories: Scleractinia (32.2% mean cover), sand (39%), rubble (28.3%), and reef rock (0.5%) (**Table 3-5**). The belt transects conducted at the five Replenishment Zone sites in the 9 to 12 m (28 to 40 ft) depth range all contained encrusting and upright sponges, healthy Acroporidae and other Scleractinia, and sea urchins (**Table 3-6**). There were dead Acropiradae at all sites and other dead Sclercatinia at all sites except L-N-RZ-7-N. There were partially bleached Scleractinia in two of the sites (L-N-RZ-5-N and L-N-RZ-7-N). One site (L-N-RZ-2-N) contained partially dead

**Table 3-8.** Mean percent cover of live benthic taxa and seafloor substrate found on the GMI linear point intercept transects in the Diego Garcia lagoon in July and August 2004. Water depths ranged from 3 to 15 m (10 to 49 ft).

| Taxon/Substrate | L-N-RZ-9-G | L-N-RZ-10-G | L-N-RBy-3-G | L-N-RBy-4-G | L-N-ECBy-2-G | L-S-4-G | L-S-5-G |
|---|---|---|---|---|---|---|---|
| **Turf Algae** | 41.0 | 29.0 | 46.0 | 31.0 | 49.0 | 27.0 | 20.0 |
| **Macroalgae** | 1.0 | 0.0 | 0.0 | 15.0 | 0.0 | 0.0 | 0.0 |
| **Crustose Algae** | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Spongia** | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| **Sclercatinia** | 22.0 | 30.0 | 22.0 | 25.0 | 41.0 | 22.0 | 35.0 |
| **Alcyonacea** | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| **Mollusca** | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| **Rock** | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Rubble** | 4.0 | 0.0 | 1.0 | 0.0 | 0.0 | 3.0 | 5.0 |
| **Gravel** | 8.0 | 0.0 | 2.0 | 0.0 | 0.0 | 2.0 | 0.0 |
| **Sand** | 17.0 | 40.0 | 28.0 | 28.0 | 9.0 | 46.0 | 39.0 |

**Table 3-9.** Mean percent occurrence of scleractinian families (coral composition) on the GMI linear point intercept transects in the Diego Garcia lagoon in July and August 2004. Water depths ranged from 3 to 15 m (10 to 49 ft).

| Coral Family | L-N-RZ-9-G | L-N-RZ-10-G | L-N-RBy-3-G | L-N-RBy-4-G | L-N-ECBy-2-G | L-S-4-G | L-S-5-G |
|---|---|---|---|---|---|---|---|
| **Acroporidae** | 92.3 | 42.1 | 9.1 | 56.0 | 26.8 | 81.8 | 20.0 |
| **Fungidae** | 0.0 | 10.5 | 4.5 | 12.0 | 2.4 | 0.0 | 0.0 |
| **Mussidae** | 0.0 | 21.1 | 0.0 | 0.0 | 53.7 | 0.0 | 0.0 |
| **Faviidae** | 7.7 | 10.5 | 0.0 | 16.0 | 12.2 | 0.0 | 2.9 |
| **Poritidae** | 0.0 | 15.8 | 86.4 | 16.0 | 4.9 | 18.2 | 77.1 |

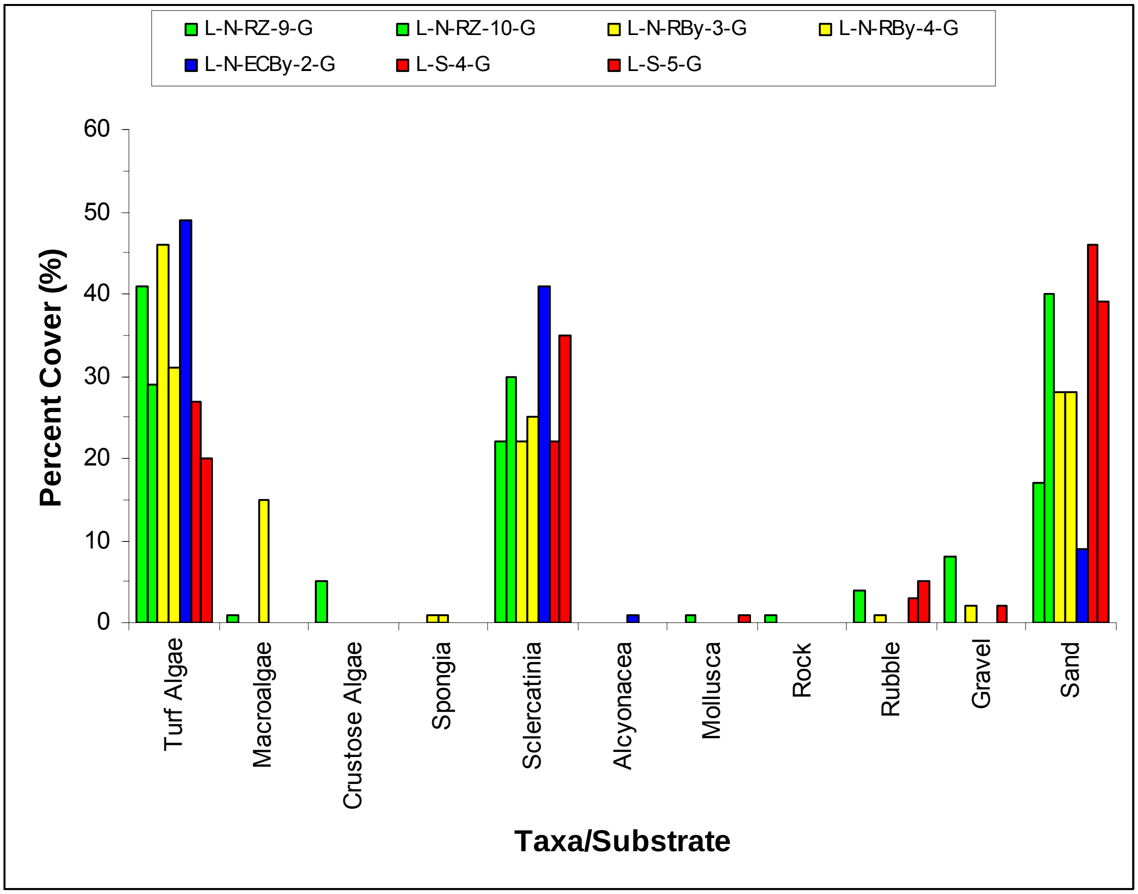


**Figure 3-4.** Mean percent cover of live benthic taxa and seafloor substrate found on the GMI linear point intercept transects on lagoon reefs of Diego Garcia in July and August 2004. Water depths ranged from 3 to 15 m (10 to 49 ft).

Scleractinia. Giant sea anemone were found at L-N-RZ-8-N. There were Milleporina at three of the five sites, and Stylasterina at two of the sites. Cowries were seen at L-N-RZ-8-N. Giant clams were present at all sites except for L-N-RZ-7-N. Pen shells were present at three of the sites and oysters at four of the five sites. Sea stars were present in four of the five sites and sea cucumbers in two of the sites (**Table 3-6**).

Three sites were surveyed within the 15 to 17 m (50 to 55 ft) depth range within the Replenishment Zone. The LPI survey at site L-N-RZ-6-N revealed nothing but sand (100%) cover (**Table 3-5**). Only Antipatharia were seen in belt transects at this site (**Table 3-8**). There was 22 and 34.4% Scleractinia cover in sites L-N-RZ-1-N and L-N-RZ-9-G at 15 m (50 ft) (**Tables 3-5** and **3-8**). Two coral families accounted for the LPI Scleractinia cover at site L-N-RZ-9-G: Acroporidae (92.3% occurrence) and Faviidae (7.7%) (**Table 3-9**). Crustose algae represented 4 and 5 % cover, respectfively. The turf algae cover of 41% at site L-N-RZ-9-G potentially indicated abundant dead coral substrate/rubble (which was verified by the belt transect surveys). Other live cover consisted of crustose algae (4 and 5%), macroalgae (1%), Spongia (1.6%), Milleporina (2.4%), blue corals (1.6%), and Alcyonacea (2.4%). Sand, gravel, rubble and reef rock accounted together for 30 and 54% of the cover in sites L-N-RZ-1-N and L-N-RZ-9-G, respectively (**Tables 3-5** and **3-8**). The belt transects at site L-N-RZ1-N contained sponges (both encrusting and upright), fire corals, lace corals, Acroporidae and other reef building corals, and the greatest variety of mollusks among all lagoon sites (cowries, Triton’s trumpet, giant clams, horned helmet, pen shells, oysters, and octopus). There were also sea urchins, sea stars, and sea cucumbers (**Table 3-6**).

### *3.1.5 Lagoon North*

In the northern part of the lagoon, we surveyed two sites located in Eclipse Bay, four sites in Rambler Bay, and two sites near Point Marianne (**Figure 2-7**). LPI and belt transects were done at both Eclipse Bay sites (**Tables 3-5**, **3-6**, and **3-8**; **Figures 3-3** and **3-4**). LPI transects were conducted at four of the Rambler Bay sites and belt transects were done at all Rambler Bay sites (**Tables 3-5**, **3-6**, and **3-8**; **Figures 3-3** and **3-4**). Only belt transects were conducted at the Point Marianne sites (**Table 3-6**).

**Eclipse Bay**–Eclipse Bay sites L-N-EcBy-2-G and L-N-EcBy-1-N were surveyed at 7 m (24 ft) and 11 m (35 ft), respectively. The latter site was located at the northern end of the bay off the military living quarters and administrative offices (**Figure 2-7**). Site L-N-EcBy-2-G was located near the harbor area. We observed high turbidity (horizontal visibility was approximately 3 m [10 ft]) and sedimentation at this site. Turbidity measured 4.79 nephelometric turbidity units (NTU) (±1.55) at this site and was the overall highest turbidity among all sites. Live cover at L-N-EcBy-2-G consisted of turf algae (49%), Scleractinia (41%), and Alcyonacea (1%) (**Table 3-8**). The remainder of the cover was made of sand (9%). The site at the north end of the bay contained mostly sand (70.6%) (**Table 3-5**). Live cover was made of turf algae (1%), sponges (1%), Scleractinia (15.7%), and mollusks (1%). Assuming that the rubble (8.8% cover) at this site was covered with turf algae, the total turf algae cover was possibly close to 10%.

Despite the fact that there was relatively high Scleractinia cover at site L-N-EcBy-2-G compared to other lagoon and seaward sites, there was potentially 49% dead coral substrate (abundant dead coral substrate was observed in the belt transects). The live Scleractinia cover at site L-N-EcBy-2-G was composed of Mussidae (53.7% occurrence), Acroporidae (26.8%), Faviidae (12.2%), Poritidae (4.9%), and Fungidae (2.4%) (**Table 3-9**). Most of the dead coral substrate consisted of Mussidae corallites (tentatively *Lobophyllia* sp.). On the LPI transects there were both large (>30 cm [12 in] across) and juvenile (7 to 17 cm [3 to 7 in] across) colonies of Acroporidae. Mussidae colonies were for the most part large (>30 cm [12 in]). Faviidae colonies were massive and measured 8 to 15 cm (3 to 6 in) across. Many of the Faviidae colonies were partially dead. There were both massive and branching colonies of Poritidae. Massive Poritidae colonies measured 10 to 15 cm (4 to 6 in) across. The branching Poritidae colonies were large (>30 cm [12 in]). A Fungidae colony was 20 cm (8 in) across.

Belt transects at the north end of Eclipse Bay contained sponges (encrusting and upright), fire corals, live Acroporidae and other Scleractinia, mollusks (giant clams, pen shells, oysters), and echinoderms (sea urchins, sea stars, and sea cucumbers) (**Table 3-6**). We noted abundant live and dead Faviidae and Mussidae (tentatively *Lobophyllia* sp.) within the belt transects at the site near the harbor. Dead Mussidae (*Lobophyllia* sp.) and table Acroporidae were very abundant at this site. Several of the live Mussidae (*Lobophyllia* sp.) colonies were fairly large measuring up to 3 by 3 m (10 by 10 ft). The skeleton of a dead massive Poritidae was 1.8 m (6 ft) high and was colonized by several juvenile Scleractinia.

**Point Marianne**–At Point Marianne, live macrobenthic organisms observed at 7 and 11 m (22 and 35 ft) water depth were limited to Acroporidae and other Scleractinia (**Table 3-6**). We also observed dead Acroporidae and other Scleractinia at this site.

**Rambler Bay**–The Rambler Bay sites were surveyed in water depths of 4, 7, and 12 m (13, 22, and 40 ft). Scleractinia cover ranged from 7.8 to 25% (**Tables 3-5** and **3-8**). The site with the least amount of cover was in 7 m (23 ft) of water depth (L-N-RbBy-2-N) and located close to shore. The shallowest site (L-N-RbBy-3-G) in 4 m (13 ft) of water was also located close to shore but Scleractinia cover was 22%. Maximum Scleractinia cover (25%) was recorded in 12 m (40 ft) of water at site L-N-RBy-4-G. Site L-N-RbBy-3-N, also located in 12 m (40 ft) of water, contained 9.9% Scleractinia cover. This patch reef was surrounded and interspersed with abundant sand substrate (83.2% sand cover). The only other live cover at this site was that of macroalgae (5.9%). The other site in 12 m (39 ft) of water, L-N-RBy-4-G, contained relatively abundant sand cover (28%). There, in addition to Scleractinia, live cover consisted of turf algae (31% cover), macroalgae (15%), and sponges (1%). Sclercatinia consisted of Acroporidae (56% occurrence), Faviidae (16%), Poritidae (16%), and Fungidae (12%) (**Table 3-9**). There were both branching, massive, and table Acroporidae on the LPI transects at this site. The massive Acroporiadae were tentatively of the genus Astreopora. Branching Acroporiadae were for the most part relatively large and measured in excess of 30 cm (11 in) along the longest dimension. Many of the massive Acroporidae were either partially dead or were partially bleached. Most of the massive Acroporidae were relatively small and measured 7 to 12 cm (2.7 to 4.7 in) across. The Faviidae colonies were massive and measured 6 to 15 cm (2.3 to 5.9 in) across. Poritidae colonies measured 8 to more than 30 cm (3 to more than 12 in) across and exhibited partial mortality and spot bleaching. Fungidae measured (8 to 22 cm 3 to 8 in) across.

Most of the live cover at site L-N-RBy-2-N located in 7m (22 ft) of water was made of turf algae (35%) (**Table 3-8**). Aside from turf algae and Scleractinia, live cover also consisted of macroalgae (3.9%), and sponges (1.9%). Most of the cover at this site was abiotic: 25.2% sand and 26.2% rubble. Here again, assuming that the rubble was covered with turf algae, total turf algae cover was possibly close to 61%. LPI transects at site L-N-RBy-3-G in 4 m (13 ft) of water showed that there was 46% turf algae cover, and 1% sponge cover (**Table 3-9**). Sand, gravel and rubble together accounted for 31% cover. Scleractinia found on the LPI transects were for the most part Poritidae (86.4% occurrence) (**Table 3-9**). There were also Acroporidae (9.1%) and Fungidae (4.5%). Most of the Poritidae were branching and some formed relatively large patches (>30 cm [12 in]). The massive Poritidae colonies were also fairly large, had few fish scrapes, some spot bleaching, and many boring bivalves embedded in their skeleton. A branching Acroporidae that was 10 cm (4 in) across was seen under an LPI transect, as well as a large massive Acroporidae. A Fungidae recorded along an LPI transect measured 8 cm (3 in) along its longest dimension.

Belt transects at the shallow, nearshore Rambler Bay sites (L-N-RbBy-3-G and L-N-RbBy-2-N) showed obvious signs of extensive Scleractinia mortality. There were large patches of dead Mussidae (*Lobophyllia* sp.). At L-N-RbBy-3-G, we found that a branching form of a Poritidae was the dominant reef building coral. There were numerous damselfish territories among the branching Poritidae colonies. Large patches of the branching Poritidae were dead. We observed *Tridacna* sp. (25 cm [10 in] length) and abundant boring bivalves embedded in massive Poritidae colonies. Some of these colonies were fairly large (e.g., 1.8 m [6 ft] high and 3.7 m [12 ft] wide). One massive Poritidae outside of the belt transects was 2.7 m (9 ft) tall and 6 m (20 ft) wide, 50% of which was alive. Most of the massive Poritidae were shedding sheets of mucus that were covered with fine sediments. We saw fish scrapes on the massive Poritidae. Belt transects also contained numerous Fungidae and Mussidae colonies. Most of the Acroporidae were of the table-like forms. A large oyster was attached to the coral substrate. Two pin cushion stars (*Culcita* sp.) were found on the sandy substrate. Scattered on the sandy substrate of this large patch reef were abundant coral and shell rubble and *Tridacna* shells.

At site L-N-RbBy-2-N, there were encrusting and upright sponges, Acroporidae and other Scleractinia, *Tridacna* sp. and pen shells (**Table 3-6**). Some of the Scleractinia were partially dead. Dead coral substrate included dead Acroporidae. Belt transects at the two sites at 12 m (40 ft) water depth (L-N-RBy-3-N and L-N-RBy-4-G) produced very different results. At L-N-RBy-3-N there were only Acroporidae and other Scleractinia. At L-N-RBy-4-G, we found that the abundant dead coral substrate was colonized by a variety of Scleractinia. There were healthy table-like Acroporidae; Fungidae scattered on the sandy substrate; sea fans; and mollusks including oysters (*Pinctada* sp.; diameters: 13 cm [5 in], 15 cm [6 in]), a cowry (*Cypraea tigris*), five *Tridacna* sp. (25 cm [ 10 in] across, 30 cm [11.8 in], 46 cm [18 in], 30 cm [11.8 in], and 7 cm [2.8 in]), two *Lambis truncata* (each approximately 15 cm [6 in] wide and 30 cm [11.8 in] long), and a thorny oyster (*Spondylus* sp., 12 cm [4.7 in] diameter).

### *3.1.6 Lagoon South*

We surveyed five sites in the south lagoon and three more in Turtle Cove (**Figure 2-7**). The Navy team surveyed the Turtle Cove sites in 2 to 11 m (6.6 and 36 ft) water depth. The depth range of the south lagoon sites was 3 to 11 m (10 to 36 ft). LPI transects were conducted at each of the south lagoon sites and one of the Turtle Cove sites.

**South Lagoon**–Sites L-S-1-N, L-S-2-N, and L-S-3-N were located in the same general area and close to a sill that separates the southern circular basin from the extreme southern portion of the (**Figure 2-7**). Scleractinia cover at these sites ranged from 3.1 to 7.9% and ranked amongst the sites with the least hard coral cover for this study (**Table 3-5**). Seagrass was observed under the LPI transects at sites L-S-1-N and L-S-2-N (2% and 2.9% cover, respectively) and nowhere else at Diego Garcia. Rubble accounted for 87.8% of the cover at site L-S-1-N. A large amount of that rubble could have possibly been covered with turf algae and thus added to the 1% reported (**Table 3-5**). Likewise, a large portion of the rubble cover at site L-S-2-N (26.2%) could have possibly been attributed to turf algae cover. The dominant seafloor cover at L-S-2-N was sand (65%). One remarkable finding at site L-S-3-N was an unusual 44.6% cover of shell hash (**Table 3-5**). No other site contained such characteristic. Belt transects at these three sites contained upright sponges and Scleractinia (**Table 3-6**). Site L-S-1-N also contained dead Scleractinia, and live giant clams, pen shells, sea urchins, sea stars, and sea cucumbers. At site L-S-2-N, there were Acroporidae and sea urchins. At site L-S-3-N, there were dead Scleractinia, and live giant clams and pen shells (**Table 3-6**).

Site L-S-4-G and L-S-5-G were each located on isolated patch reefs. L-S-4-G was peculiar in that it consisted of a multitude of donut and curlicue-shaped *Astreopora* sp. (*myriopthalma*?) colonies, none of which were attached to the underlying seafloor which was heavily bioeroded. Several Poritidae colonies were tilted on their side. Only fire coral colonies seemed to be firmly attached to the seafloor. The general appearance of this patch reef was that of coral colonies being tumbled about. None of the *Astreopora* colonies exceeded 40 cm (16 in) along the longest dimension. Each of the *Astreopora* colonies was partially dead: sides of the colonies were live and the upper surface was covered with fine sediments and turf algae.

In contrast, site L-S-5-G was characterized by large massive Poritidae and branching Poritidae firmly attached to the seafloor. Sediment interspersed between the Scelarctinia consisted of sand, shell and coral rubble. There was heavy sedimentation at this site. Turbidity was high (3 m [10 ft] horizontal visibility). Within the belt transects, massive, head-forming colonies were 1 to 1.6 m (3.3 to 5.2 ft) high and several meters wide. One colony in particular was 1.5 m (4.9 ft) high, 8 m (26 ft) long and 4 m (13 ft) wide. There were numerous boring bivalves embedded in the massive Poritidae. The massive Poritidae were shedding sediment-laden sheets of mucus. Damselfish were aggressively watching over their individual territories on dead branching Poritidae. In the belt transect we also noted numerous serulpid worms, five *Tridacna* sp. (20 cm, 30 cm, 30+ cm, 30 cm, 15 cm) embedded in the reef, one large octopus living within a large massive *Porites* head, and five sea cucumbers.

Scleractinia cover at site L-S-4-G was 22% and 35% at site L-S-5-G (**Table 3-8**). Dominant Scleractinia families at sites L-S-4-G and L-S-5-G were very distinct. Because of the dominant Astreopora at site L-S-4-G, Acroporidae were the dominant family (81.8% occurrence) (**Table 3-9**). The other corals found under the LPI transect were Poritidae (18.2% occurrence). At site L-S-5-G, the dominance was reversed: Poritidae accounted for 77.1% of the corals recorded under the LPI transects and Acroporidae accounted for 20%. There were also Faviidae at site L-S-5-G (2.9% occurrence) (**Table 3-9**). Turf algae and mollusks (at site L-S-5-G) were the only other live cover categories captured by the LPI transects. Turf algae cover was 27 and 20% at sites L-S-4-G and L-S-5-G, respectively (**Table 3-8**). Sand, gravel and rubble amounted to 44 to 51% cover.

**Turtle Cove**–LPI transects were conducted at the deepest of the Turtle Cove sites, L-S-TC-2-N (11 m [35 ft]). There the Navy team found 21.1% Scleractinia cover and mostly sand (51.3%) (**Table 3-5**). Belt transects at this site included sponges (encrusting and upright), Acroporidae and other Scleractinia, pen shells, sea urchins, sea stars, and sea cucumbers (**Table 3-6**). There were also partially bleached and dead Acroporidae. At the shallowest and southernmost site, L-S-TC-3-N, there were only upright sponges seen in the belt transects. Site L-S-TC-1-N was more similar to site L-S-TC-2-N as it contained encrusting and upright sponges, Acroporidae and other Scleractinia, giant clams, pen shells, sea urchins, and sea stars (**Table 3-6**).

## 3.2 REEF FISH CENSUSES

### *3.2.1 Fish Populations of Diego Garcia*

GMI stationary fish counts focused on identifying fishes at the family level and selected families from a pre-determined list. Species lists, family representation, and abundance values for stationary fish counts and for roving diver counts therefore do not reflect an absolute or complete picture of reef fish communities at Diego Garcia but rather are dependent on the families that survey divers were focusing on. For instance, gobies and blennies and other small cryptic families were not included in the survey effort. However, certain species identified but beyond the scope of the pre-selected families were included in the species list. It should also be noted that since our surveys were conducted during the southern winter season, a seasonal aspect might play a role in the composition of reef fish communities we observed. Survey methods are also understood to affect the make-up of species censused. Our methods were employed to obtain the best view of species within the pre-selected families.

Three distinct survey methods were used to survey fish populations at Diego Garcia. As described in the methods section, GMI conducted stationary surveys (similar to Bohnsack and Bannerot 1986) and roving diver surveys (Schmitt et al. 1998), while Navy used a mixed stationary/roving method. Results are presented here according to the method by which the data were collected. Also, because surveys were not restricted to consistent distances or areas, direct references regarding densities (abundance per given area) are avoided. Abundance values and estimates are associated with survey effort. Stationary survey data here provide a rough estimate of density within individual areas of 800 $m^2$ (8,608 $ft^2$ ) (using an effective and allowable average distance from diver of about 16 m [53 ft]). Bohnsack and Bannerot (1986) describe the use of a 176 $m^2$ (1,571 $ft^2$) effective survey area (7.5 m [25 ft] maximum distance from diver).

The GMI stationary surveys counted a grand total of 14,318 fish in 29 pre-selected family/groups (some subfamilies were considered as a separate group such as the Caesioninae and Anthiinae). The average number of fishes counted per survey site was just over 1,300. A total of 151 species were recorded via the roving diver surveys. Winterbottom and Anderson (1999) identified 784 species of epipelagic and shore fishes (i.e., open ocean and reef fishes respectively) in 100 families at the Chagos Archipelago. Navy fish surveys were based on a more qualitative method (i.e., estimating abundance ranges of fish families). Like GMI, these surveys also restricted observations to species in 29 pre-selected family/groups. The mean abundance range of fishes recorded at navy study sites was 500 to 1,000 individuals, with most sites (mode) also in the 500 to 1,000 range. Navy study sites were generally deeper than GMI study sites.

The average number of individual fishes counted per family by GMI stationary surveys is shown in **Table 3-10**. Also shown is the percentage of study sites at which each family was observed. Where Anthiinae (anthiases) were recorded, they were very abundant. Pomacentridae (damselfishes, chromis, demoiselles), Acanthuridae (surgeonfishes and unicornfishes), Labridae (wrasses), Scaridae (parrotfishes), Chaetodontidae (butterflyfishes), and Serranidae (groupers/seabasses) were fairly ubiquitous (91 to 100%) among the study sites at Diego Garcia. Mullidae (goatfishes), Lutjanidae (snappers), and Carangidae (jacks) were relatively common as well (55 to 73% of survey sites). Four families out of the 29 pre-selected families were not encountered during any of the GMI stationary surveys: Dasyatidae (stingrays), Scorpaenidae (scorpionfishes), Siganidae (rabbitfishes), and Scombridae (tunas and mackerels). In their place, we recorded Kyphosidae (chubs and drummers), Chanidae (milkfish), Fistularidae (cornetfishes), and Ostraciidae (boxfishes). These were all rare encounters during stationary surveys and they were mostly found in low numbers, except for the Kyphosidae, which were abundant at Cannon Point and Simpson Point (O-W-CnPt-2-G and O-W-SmPt-1-G).

**Table 3-11** summarizes family/group abundance ranges recorded by Navy fish surveys at Diego Garcia reefs. Pomacentridae are shown to be the most common and abundant of the 29 pre-selected families/groups at Diego Garcia, occurring at 31 of 33 sites (94%). Pomacentridae were not encountered

**Table 3-10.** Observed fishes per family per study site and the percentage of occurrence per study site (recorded via the GMI stationary survey method) at Diego Garcia in August 2004. (Values were rounded to the nearest whole number. 0 values indicate mean abundances of less than 0.5.)

| Family | Mean Abundance | No. of Sites | Occurrence Percentage |
|---|---|---|---|
| Anthiinae | 1,500 | 2 | 18% |
| Pomacentridae | 952 | 11 | 100% |
| Caesioninae | 230 | 4 | 36% |
| Acanthuridae | 199 | 11 | 100% |
| Labridae | 181 | 11 | 100% |
| Apogonidae | 60 | 1 | 9% |
| Balistidae | 58 | 5 | 45% |
| Carangidae | 51 | 7 | 64% |
| Scaridae | 43 | 11 | 100% |
| Chaetodontidae | 34 | 11 | 100% |
| Lethrinidae | 29 | 6 | 55% |
| Serranidae | 28 | 10 | 91% |
| Lutjanidae | 20 | 8 | 73% |
| Kyphosidae | 17 | 1 | 9% |
| Mullidae | 11 | 8 | 73% |
| Nemipteridae | 7 | 1 | 9% |
| Holocentridae | 7 | 6 | 55% |
| Pomacanthidae | 5 | 6 | 55% |
| Haemulidae | 2 | 3 | 27% |
| Zanclidae | 1 | 2 | 18% |
| Muraenidae | 1 | 3 | 27% |
| Chanidae | 1 | 1 | 9% |
| Synodontidae | 1 | 1 | 9% |
| Mobulinae | 0 | 2 | 18% |
| Myliobatidae | 0 | 1 | 9% |
| Sphyraenidae | 0 | 1 | 9% |
| Carcharhinidae | 0 | 1 | 9% |
| Fistulariidae | 0 | 1 | 9% |
| Ostraciidae | 0 | 1 | 9% |

**Table 3-11.** Family abundance ranges per study site at Diego Garcia in July/August 2004 recorded via Navy fish surveys.

| index number | | estimated abundance |
|---|---|---|
| 0 | = | 0 |
| 1 | = | 1 - 5 |
| 2 | = | 6 - 10 |
| 3 | = | 11 - 20 |
| 4 | = | 21 - 50 |
| 5 | = | 51-100 |
| 6 | = | 101 - 200 |
| 7 | = | 201 - 500 |
| 8 | = | 501 - 1000 |

| | Lagoon | | | | | | | | | | | | | | | | | | | | | | Ocean | | | | | | | | Passes | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Anchorage Area | | | | | Other North Lagoon | | | | | Replenishment Zone (North Lagoon) | | | | | | | South Lagoon | | | Turtle Cv. | | North & East | | | West | | | | | | | | | | | |
| | L-N-An-1-N | L-N-An-2-N | L-N-An-3-N | L-N-An-4-N | L-N-An-5-N | L-N-EcBy-1-N | L-N-PtMr-1-N | L-N-PtMr-2-N | L-N-RBy-2-N | L-N-RBy-3-N | L-N-RZ-1-N | L-N-RZ-2-N | L-N-RZ-3-N | L-N-RZ-4-N | L-N-RZ-5-N | L-N-RZ-7-N | L-N-RZ-8-N | L-S-1-N | L-S-2-N | L-S-3-N | L-S-TC-1-N | L-S-TC-3-N | O-E-CsPt-1-N (deep) | O-E-CsPt-1-N (med) | O-N-BPt-1-N (deep) | O-W-Ar-1-N | O-W-Ar-2-N | O-W-Ar-3-N | O-W-CnPt-1-N (deep) | O-W-CnPt-1-N (med) | P-B-1-N | P-Mn-1-N (deep) | P-Mn-1-N (med) | Total (per family) | Mean | Site Count (33 Total) | Frequency (%) |
| Depth (m) | 24 | 25 | 28 | 24 | 23 | 11 | 7 | 11 | 7 | 12 | 15 | 9 | NA | 12 | 12 | 11 | 9 | 5 | 11 | 8 | 5 | 2 | 24 | NA | 24 | 12 | 30 | 12 | 23 | 12 | 18 | 23 | 15 | | | | |
| Depth (ft) | 79 | 82 | 92 | 80 | 74 | 35 | 22 | 35 | 22 | 40 | 50 | 28 | NA | 40 | 40 | 35 | 30 | 15 | 35 | 25 | 15 | 7 | 80 | NA | 80 | 40 | 100 | 40 | 77 | 40 | 60 | 75 | 50 | | | | |
| CARCHARHINIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 6% |
| DASYATIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 3% |
| MYLIOBATIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3% |
| MOBULIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 9% |
| MURAENIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 6% |
| SYNODONTIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 6% |
| HOLOCENTRIDAE | 5 | 6 | 3 | 0 | 0 | 4 | 3 | 3 | 0 | 2 | 4 | 2 | 0 | 4 | 0 | 2 | 6 | 0 | 0 | 2 | 0 | 0 | 4 | 4 | 5 | 3 | 4 | 3 | 6 | 5 | 4 | 5 | 3 | 8 | 4 | 24 | 73% |
| SCORPAENIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 0 | 0 | 0 | 6 | 1 | 4 | 12% |
| SERRANIDAE (only anthiases) | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 2 | 2 | 6 | 6 | 5 | 7 | 3 | 4 | 0 | 0 | 0 | 5 | 0 | 0 | 5 | 5 | 7 | 2 | 5 | 2 | 6 | 4 | 6 | 7 | 5 | 8 | 5 | 22 | 67% |
| SERRANIDAE (only groupers) | 4 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 1 | 0 | 5 | 2 | 1 | 3 | 1 | 2 | 4 | 0 | 0 | 2 | 0 | 0 | 4 | 4 | 5 | 3 | 4 | 2 | 4 | 4 | 4 | 5 | 4 | 8 | 3 | 24 | 73% |
| APOGONIDAE | 0 | 6 | 0 | 0 | 0 | 7 | 8 | 8 | 0 | 0 | 6 | 4 | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 5 | 0 | 0 | 5 | 5 | 7 | 3 | 6 | 0 | 6 | 6 | 6 | 0 | 0 | 8 | 6 | 17 | 52% |
| CARANGIDAE | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 2 | 3 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 6 | 0 | 4 | 1 | 4 | 4 | 4 | 3 | 3 | 8 | 3 | 15 | 45% |
| CAESIONIDAE | 6 | 6 | 5 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 | 0 | 6 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 7 | 7 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 8 | 5 | 19 | 58% |
| LUTJANIDAE | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 3 | 2 | 3 | 5 | 2 | 2 | 7 | 2 | 0 | 4 | 0 | 0 | 5 | 2 | 3 | 4 | 5 | 4 | 5 | 5 | 5 | 6 | 6 | 3 | 3 | 3 | 8 | 4 | 25 | 76% |
| HAEMULIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 1 | 4 | 12% |
| LETHRINIDAE | 7 | 7 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 6 | 2 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 7 | 4 | 7 | 0 | 7 | 4 | 5 | 4 | 4 | 0 | 0 | 8 | 5 | 17 | 52% |
| NEMIPTERIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 3% |
| MULLIDAE | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 3 | 2 | 2 | 4 | 2 | 2 | 4 | 4 | 0 | 4 | 2 | 4 | 2 | 0 | 0 | 3 | 5 | 6 | 4 | 4 | 4 | 3 | 5 | 3 | 0 | 3 | 8 | 4 | 24 | 73% |
| CHAETODONTIDAE | 3 | 3 | 0 | 0 | 0 | 0 | 4 | 4 | 3 | 2 | 4 | 3 | 2 | 5 | 3 | 3 | 4 | 0 | 2 | 3 | 0 | 0 | 5 | 5 | 5 | 3 | 3 | 3 | 3 | 3 | 5 | 4 | 5 | 8 | 4 | 26 | 79% |
| POMACANTHIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | 0 | 4 | 1 | 0 | 0 | 2 | 0 | 0 | 4 | 3 | 4 | 1 | 2 | 1 | 1 | 2 | 3 | 0 | 0 | 6 | 1 | 15 | 45% |
| POMACENTRIDAE | 5 | 4 | 6 | 3 | 3 | 6 | 8 | 8 | 5 | 5 | 6 | 6 | 6 | 7 | 5 | 6 | 7 | 3 | 3 | 4 | 0 | 0 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 6 | 8 | 6 | 31 | 94% |
| LABRIDAE | 3 | 0 | 3 | 0 | 0 | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 5 | 3 | 3 | 5 | 2 | 2 | 3 | 0 | 0 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 5 | 4 | 4 | 8 | 4 | 28 | 85% |
| SCARIDAE | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 5 | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 6 | 3 | 4 | 3 | 0 | 0 | 4 | 4 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 3 | 8 | 4 | 25 | 76% |
| SIGANIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3% |
| ZANCLIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 3 | 0 | 4 | 0 | 3 | 0 | 3 | 3 | 3 | 6 | 1 | 11 | 33% |
| ACANTHURIDAE | 0 | 0 | 2 | 0 | 0 | 5 | 5 | 4 | 6 | 0 | 5 | 4 | 4 | 6 | 4 | 5 | 6 | 3 | 3 | 3 | 1 | 0 | 6 | 4 | 6 | 4 | 7 | 4 | 6 | 5 | 5 | 6 | 6 | 8 | 5 | 27 | 82% |
| SPHYRAENIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 1 | 3 | 9% |
| SCOMBRIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 5 | 0 | 6 | 1 | 4 | 12% |
| BALISTIDAE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 3 | 2 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 4 | 2 | 0 | 2 | 1 | 0 | 3 | 6 | 3 | 7 | 3 | 16 | 48% |
| Total (per site) | 8 | 8 | 7 | 4 | 3 | 8 | 8 | 8 | 7 | 6 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 5 | 6 | 7 | 3 | 4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 33 | 100% |
| Family Richness (out of 29 total) | 7 | 6 | 5 | 2 | 1 | 11 | 11 | 11 | 10 | 9 | 21 | 13 | 12 | 15 | 13 | 12 | 15 | 5 | 6 | 14 | 2 | 2 | 18 | 16 | 22 | 15 | 18 | 16 | 23 | 17 | 17 | 15 | 14 | | | | |
| Family Representation % | 24% | 21% | 17% | 7% | 3% | 38% | 38% | 38% | 34% | 31% | 72% | 45% | 41% | 52% | 45% | 41% | 52% | 17% | 21% | 48% | 7% | 7% | 62% | 55% | 76% | 52% | 62% | 55% | 79% | 59% | 59% | 52% | 48% | | | | |

at the Turtle Cove area sites. Acanthuridae were common and usually abundant, present at 27 sites (82%) with a mean abundance range of 51 to 100 individuals per site. Serranidae and Lutjanidae were common and moderately abundant (mean abundance range of 11 to 20 individuals per site) in the Navy fish surveys.

Navy and GMI fish surveys in general produced a number of basic observations about populations at Diego Garcia. Pomacentridae were very common, appearing at almost all survey sites, and well represented in the number of species observed. Numerous schools of 50 or more Pomacentridae were often associated each with single Acroporidae formations. Schooling fishes such as the Caesioninae (fusiliers), Anthiinae, and Carangidae were recorded in high numbers. Acanthuridae were recorded in high numbers. These fishes are part of the high herbivore contingent at the atoll, both within and outside the lagoon. Although only present in moderate numbers, Scaridae were recorded at many sites and are, along with sureonfishes part of a key functional group on the reefs. Many of the Acanthuridae and Scaridae were of relatively large sizes. Chaetodontidae were very common and well represented by many species. Labridae may have been undercounted here due to the reduced emphasis on many smaller species of wrasse; however, observations do show wrasses to be ubiquitous at Diego Garcia and generally abundant. Particular effort was given toward documenting the occurrence of Napoleon/humphead wrasse (*Cheilinus undulates*).

Collectively, predators such as the Lutjanidae, Lethrinidae (emperors), and Serranidae were relatively common and well represented. Many individuals of these predatory groups were generally large in size, reflecting high overall biomass of the reefs. Healthy predator populations represent another key part of a reef community. Only a few large Sphyraenidae (barracuda) were observed. A large group of small barracuda was recorded near Barton Point. Sharks were encountered far less than expected. Only one Charcharhinidae (requiem shark) was recorded on the ocean side reefs; four were recorded in the Replenishment Zone of the north lagoon (1 to 2 m [3.3 to 6.6 ft] long). One 1.3 m (4.3 ft) shark was observed from the surface near Cust Point. A few tawny nurse sharks (Ginglymostomatidae: *Nebrius ferrugineus*) were seen at sites inside and outside the lagoon. No other sharks were observed except those noted from the shore at the Turtle Cove observation area. Two or three small *Carcharhinus melanopterus* (blacktip reef sharks) were observed swimming in the shallow channel leading into the tidal barachois area. Several *Pastinachus sephen* (cowtail stingray) were noted at survey sites as well as at the Turtle Cove nature area observed from shore.

Additional observations involve various families: *Aetobatus narinari* (spotted eagle ray) were observed several times on ocean side reefs; *Manta birostris* (manta ray) were commonly observed both in the lagoon and on ocean reefs; and Muraenidae (moray eels) were experienced at ocean and lagoon reefs in low numbers, far less than expected and previously reported.

A species list of all fishes identified via the three survey methods (GMI's stationary and roving; and Navy's stationary/roving surveys) is presented in **Table 3-12**. This list also includes species noted as present between surveys as well as those identified through digital photographs taken during and between surveys. Eight new occurrence identifications for the Chagos were made (**Table 3-13**; Also indicated in bold type in **Table 3-12**). These identifications are based on field observations of species with distinct features and markings, some being very distinctive such as the coral rabbitfish. No specimens were collected. *Paracanthurus hepatus* (palette surgeonfish), which has never been collected in the Chagos, but noted once previously at Isle Anglaise, was common at two locations in Diego Garcia (digital image captured).

Winterbottom and Anderson (1999) list 784 fish species identified for the Chagos Archipelago and report the five most speciose families at the Chagos as: Gobidae (gobies; 98 species), Labridae (63), Serranidae (51), Muraenidae (41), and Pomacentridae (38). The six most speciose families GMI recorded at Diego Garcia were Serranidae, Labridae, Pomacentridae, Acanthuridae, Chaetodontidae, and Lutjanidae, in that order (**Table 3-14**). Twenty-two grouper species were recorded (Subfamily Epinephelinae).

**Table 3-12.** Species list of all fishes observed at Diego Garcia in August 2004 (206 species) (*Valid synonym as per Fishbase.org [2005]; **Common names primarily after Allen et al. [2003] and Fishbase.org [2005]; ^New record for Chagos in bold type)

| Family | Scientific Name | Common name** |
|---|---|---|
| Ginglymostomatidae (Nurse Sharks) | *Nebrius ferrugineus* | Tawny nurse shark |
| Carcharhinidae (Requiem Sharks) | *Carcharhinus albimarginatus* | Silvertip reef shark |
| Dasyatidae (Rays) | *Pastinachus sephen* | Cowtail stingray |
| | *Pteroplatytrygon violacea* | Pelagic stingray |
| | *Taeniura meyeni* | Blotched fantail ray |
| Myliobatidae | | |
| Subfamily Myliobatinae (Eagle Rays) | *Aetobatus narinari* | Spotted eagle ray |
| Subfamily Mobulinae (Manta Rays) | *Manta birostris* | Manta ray |
| Muraenidae (Moray Eels) | *Gymnomuraena zebra* | Zebra moray |
| | *Gymnothorax javanicus* | Giant moray |
| Chanidae (Milkfish) | *Chanos chanos* | Milkfish |
| Synodontidae (Lizardfish) | *Saurida gracilis* | Graceful lizardfish |
| Holocentridae (Squirrelfishes & Soldierfishes) | *Myripristis botche** | Splendid soldierfish |
| | *Myripristis violacea* | Violet soldierfish |
| | *Neoniphon argenteus* | Clearfin squirrelfish |
| | *Sargocentron diadema* | Crown squirrelfish |
| | *Sargocentron spiniferum* | Sabre squirrelfish |
| Fistulariidae (Cornetfish) | *Fistularia commersonii* | Cornetfish |
| Syngnathidae (Pipefish) | *Syngnathidae sp.* | Unidentified pipefish species |
| Scorpaenidae (Scorpionfish) | *Pterois miles* | Devil firefish |
| | *Sebastapistes cyanostigma* | Yellow spotted scorpionfish |
| Serrandiae | | |
| Subfamily Epinephelinae | | |
| Tribe Epinephelinie (Groupers) | *Anyperodon leucogrammicus* | Slender grouper |
| | *Cephalopholis argus* | Peacock grouper |
| | *Cephalopholis leopardus* | Leopard hind |
| | *Cephalopholis miniata* | Coral grouper |
| | *Cephalopholis sonnerati* | Tomato grouper |
| | *Cephalopholis spiloparaea* | Strawberry grouper |
| | *Cephalopholis urodeta* | Flagtail grouper |
| | *Epinephelus spilotoceps* | Four saddle grouper |
| | *Epinephelus caeruleopunctatus* | Whitespotted grouper |
| | *Epinephelus fasciatus* | Blacktip grouper |
| | *Epinephelus hexagonatus** | Hexagon grouper |
| | *Epinephelus lanceolatus* | Giant grouper |
| | *Epinephelus longispinis* | Longspined grouper |
| | *Epinephelus malabaricus** | Malabar grouper |
| | *Epinephelus merra* | Honeycomb grouper |
| | *Epinephelus miliaris* | Netfin grouper |
| | *Epinephelus multinotatus* | Whiteblotched grouper |
| | ***Epinephelus ongus^*** | Whitestreaked grouper |
| | ***Gracilia albomarginata*** | Masked grouper |

**Table 3-12.** Continued.

| Family | Scientific Name | Common name** |
|---|---|---|
| Tribe Epinephelinie (Groupers) (continued) | *Plectropomus areolatus* | Squaretail grouper |
| | *Plectropomus laevis* | Blacksaddled coralgrouper/saddleback grouper |
| | *Variola albimarginata* | White-edged lyretail |
| | *Variola louti* | Yellow-edged lyretail |
| Subfamily Anthiinae (anthiases) | *Pseudanthias squamipinnis* | Goldie, lyretail anthias |
| Priacanthidae (Bigeyes) | *Priacanthurs hamrur* | Crescent tail bigeye |
| Apogonidae (Cardinalfishes) | *Apogon exostigma* | Narrowstripe cardinalfish |
| | *Cheilodipterus quinquelineatus* | Five-lined cardinalfish |
| Carangidae (Jacks) | *Carangoides fulvoguttatus* | Gold spotted trevally |
| | *Caranx ignobilis* | Giant trevally |
| | *Caranx melampygus* | Bluefin trevally |
| | *Caranx sexfasciatus* | Bigeye trevally |
| | *Elegatis bipinnulata* | Rainbow runner |
| | *Gnathanodon speciosus* | Golden trevally |
| | *Scomberoides lysan* | Double spot queenfish |
| Lutjanidae | | |
| Subfamily Caesioninae (Fusiliers) | *Caesio teres* | Yellowback fusilier |
| | *Caesio xanthonota* | Yellowtop fusilier |
| | *Paracaesio xanthura* | Yellowtail false fusilier |
| | *Pterocaesio chrysozona* | Goldband fusilier |
| | ***Pterocaesio digramma^*** | Two-lined fusilier |
| | *Pterocaesio tile* | Bluestreak fusilier |
| Subfamily Lutjaninae (Snappers) | *Aphareus furca* | Smalltooth jobfish |
| | *Aprion virescens* | Green jobfish |
| | *Lutjanus bohar* | Red snapper |
| | *Lutjanus fulvus* | Flametail snapper |
| | *Lutjanus gibbus* | Humpback snapper |
| | *Lutjanus kasmira* | Bluestripe snapper |
| | *Lutjanus monostigma* | Onespot snapper |
| | *Macolor niger* | Black snapper |
| Haemulidae (Sweetlips and Grunts) | ***Plectorhinchus goldmanni^*** | Goldman's sweetlips |
| | ***Plectorhinchus obscurus^*** | Giant sweetlips |
| | *Plectorhinchus vittatus* | Oriental sweetlips |
| Lethrinidae (Emprerors) | *Gnathodentex aureolineatus* | Striped large-eye bream |
| | *Lethrinus nebulosus* | Spangled emperor |
| | *Lethrinus olivaceus* | Longface emperor |
| | *Monotaxis grandoculis* | Humpnose bigeye bream |
| Nemipteridae (Breams and Spinecheeks) | *Scolopsis bilineata* | Two-lined monocle bream |
| | *Scolopsis frenatus* | Bridled monocle bream |
| Mullidae (Goatfishes) | *Mulloides flavolineatus* | Yellowstripe goatfish |
| | *Mulloidichthys vanicolensis* | Yellowfin goatfish |
| | *Parupeneus bifasciatus* | Doublebar goatfish |
| | *Parupeneus ciliatus* | Cardinal goatfish |

**Table 3-12.** Continued.

| Family | Scientific Name | Common name** |
|---|---|---|
| Mullidae (Goatfishes) (continued) | *Parupeneus macronema* | Longbarbel goatfish |
| | *Parupeneus pleurostigma* | Sidespot goatfish |
| Chaetodontidae (Butterflyfishes) | *Chaetodon auriga* | Threadfin butterflyfish |
| | *Chaetodon benneti* | Eclipse butterflyfish |
| | *Chaetodon falcula* | Saddleback butterflyfish |
| | *Chaetodon guttatissimus* | Spotted butterflyfish |
| | *Chaetodon lineolatus* | Lined butterflyfish |
| | *Chaetodon lunula* | Raccoon butterflyfish |
| | *Chaetodon meyeri* | Meyer's butterflyfish |
| | *Chaetodon trifascialis* | Chevroned butterflyfish |
| | *Chaetodon trifasciatus* | Redfin butterflyfish |
| | *Chaetodon unimaculatus* | Teardrop butterflyfish |
| | *Chaetodon xanthocephalus* | Yellowhead butterflyfish |
| | *Chaetodon zanzibarensis* | Zanzibar butterflyfish |
| | *Forcipiger flasvissimus* | Long nose butterflyfish |
| | *Hemitaurichthys zoster* | Black pyramid butterflyfish |
| | *Heniochus acuminatus* | Longfin bannerfish |
| | *Heniochus monoceros* | Masked bannerfish |
| Pomacanthidae (Angelfishes) | *Apolemichthys trimaculatus* | Threespot angelfish |
| | *Centropyge multispinis* | Brown pygmy angelfish |
| | *Pomacanthus imperator* | Emperor angelfish |
| | *Pygoplites diacanthus* | Regal angelfish |
| Kyphosidae (Drummers/Chubs/Rudderfishes) | *Kyphosus cinerascens* | Topsail drummer |
| | *Kyphosus vaigiensis* | Lowfin drummer |
| Cirrhitidae (Hawkfishes) | *Cirrhitichthys oxycephalus* | Pixy hawkfish |
| | *Paracirrhites arcatus* | Arceye hawkfish |
| | *Paracirrhites forsteri* | Freckled hawkfish |
| Pomacentridae (Damselfishes) | *Abudefduf sexfasciatus* | Scissortail sergeant |
| | *Amphiprion bicinctus* | Twoband anemonefish |
| | *Amphiprion chagosensis* | Chagos anemonefish |
| | *Chromis dimidiata* | Twotone chromis |
| | *Chromis nigrura* | Blacktail chromis |
| | *Chromis viridis* | Blue green chromis |
| | *Chromis weberi* | Weber's chromis |
| | *Chrysiptera biocellata* | Twospot demoiselle |
| | *Chrysiptera brownriggii* | Surge demoiselle |
| | *Dascyllus aruanus* | Humbug dascyllus |
| | *Dascyllus carneus* | Indian dascyllus |
| | *Dascyllus trimaculatus* | Three spot dascyllus |
| | *Plectoglyphidon dicki* | Dick's damselfish |
| | *Plectoglyphidon imparipennis* | Brighteye damselfish |
| | *Plectoglyphidon johnstoniamus* | Johnston's damselfish |
| | *Plectoglyphidon lacrymatus* | Jewel damselfish |
| | *Plectoglyphidon leucozonus* | Whiteband damselfish |
| | *Pomacentrus caeruleus* | Caerulean damselfish |

**Table 3-12.** Continued.

| Family | Scientific Name | Common name** |
|---|---|---|
| Pomacentridae (Damselfishes) (continued) | *Pomacentrus indicus* | Indian damselfish |
| | ***Pomacentrus similis^*** | Similar damselfish |
| Labridae (Wrasses) | *Anampses meleagrides* | Yellowtail wrasse |
| | *Aspidontus taeniatus* | Cleaner mimic |
| | *Bodianus axillaris* | Axilspot hogfish |
| | *Bodianus bilunulatus* | Saddleback hogfish |
| | *Bodianus diana* | Diana's hogfish |
| | *Cheilinus trilobatus* | Tripletail wrasse |
| | *Cheilinus undulatus* | Humphead/napoleon wrasse |
| | *Gomphosus coeruleus* | Bird wrasse |
| | *Halichoeres hortulanus* | Checkerboard wrasse |
| | *Halichoeres marginatus* | Dusky wrasse |
| | *Hemigymnus fasciatus* | Barred thicklip wrasse |
| | *Labrichthys unilineatus* | Tubelip wrasse |
| | *Labroides dimidiatus* | Bluestreak cleaner wrasse |
| | *Pseudocheilinus hexataenia* | Sixline wrasse |
| | *Pseudocheilinus octotaenia* | Eightline wrasse |
| | *Stethojulis albovittata* | Blueline wrasse |
| | *Stethojulis strigiventer* | Three ribbons wrasse |
| | *Thalassoma amblycephalum* | Two-tone wrasse |
| | *Thalassoma hardwicke* | Sixbar wrasse |
| | *Thalassoma hebraicum* | Goldbar wrasse |
| | *Thalassoma purpureum* | Surge wrasse |
| | *Thalassoma trilobatum* | Christmass wrasse |
| Scaridae (Parrotfishes) | *Cetoscarus bicolor* | Bicolor parrotfish |
| | *Chlorurus sordidus** | Bullethead parrotfish |
| | *Chlorurus strongylocephalus* | Steephead parrotfish |
| | *Scarus frenatus* | Dusky parrotfish |
| | *Scarus ghobban* | Bluebarred parrotfish |
| | *Scarus niger* | Ember parrotfish |
| | *Scarus rubroviolaceus* | Redlip parrotfish |
| | *Scarus tricolor* | Tricolor parrotfish |
| Pinguipedidae (Sandperches) | *Parapercis millepunctata* | Blackdotted sandperch |
| Blenniidae (Blennies) | *Ecsenius nalolo* | Nalolo blenny |
| | *Meiacanthus smithi* | Smith's fangblenny |
| | *Plagiotremus rhinorhynchos* | Bluestriped fangblenny |
| | *Plagiotremus tapeinosoma* | Scale eating fangblenny |
| Gobiidae (Gobies) | ***Amblygobius phalaena^*** | Banded goby |
| | *Amblygobius semicinctus* | Half banded goby |
| | *Cryptocentrus cryptocentrus* | Ninebar prawn goby |
| | *Istigobius decoratus* | Decorated goby |
| | *Valencienna sexguttatus* | Six spot goby |
| | *Valencienna strigata* | Blue streak goby |
| Microdesmidae (Wormfishes and Dartfishes) | *Nemateleotris magnifica* | Fire dartfish |
| | *Ptereleiotris zebra* | Zebra dartfish |

**Table 3-12.** Continued.

| Family | Scientific Name | Common name** |
|---|---|---|
| Microdesmidae (Wormfishes and Dartfishes) (continued) | *Ptereleotris evides* | Twotone dartfish |
| | *Ptereleotris microlepis* | Pearly dartfish |
| Siganidae* (Rabbitfishes) | ***Siganus corallinus^*** | Coral rabbitfish |
| Zanclidae (Moorish Idol) | *Zanclus cornutus* | Moorish idol |
| Acanthuridae (Surgeonfishes) | ***Acanthurus auranticavus^*** | Orange socket surgeonfish |
| | *Acanthurus leucosternon* | Powderblue surgeonfish |
| | *Acanthurus lineatus* | Striped surgeonfish |
| | *Acanthurus nigricauda* | Blackstreak surgeonfish |
| | *Acanthurus nigrofuscus* | Dusky surgeonfish |
| | *Acanthurus tenneti* | Lieutenant surgeonfish |
| | *Acanthurus thompsoni* | Thompson's surgeonfish |
| | *Acanthurus triostegus* | Convict surgeonfish |
| | *Acanthurus xanthopterus* | Yellowfin surgeonfish |
| | *Ctenochaetus binotatus* | Twospot bristletooth |
| | *Ctenochaetus striatus* | Striped bristletooth |
| | *Ctenochaetus strigosus* | Goldring bristletooth |
| | *Naso brachycentron* | Humpback unicornfish |
| | *Naso hexacanthus* | Sleek unicornfish |
| | *Naso lituratus* | Lipstick tang |
| | *Naso vlamingii* | Bignose unicornfish |
| | *Paracanthurus hepatus* | Palette surgeonfish |
| | *Zebrasoma desjardini* | Indian sailfin tang |
| | *Zebrasoma scopis* | Brushtail tang |
| Sphyraenidae (Barracudas) | *Sphyraena barracuda* | Great barracuda |
| Scombridae (Tunas and Mackerels) | *Gymnosarda unicolor* | Dogtooth tuna |
| Balistidae | | |
| Subfamily Balistinae (Triggerfishes) | *Balistapus undulatus* | Orange striped triggerfish |
| | *Balistoides conspicillum* | Clown triggerfish |
| | *Balistoides viridescens* | Titan triggerfish |
| | *Melichthys niger* | Black triggerfish |
| | *Odonus niger* | Redtoothed triggerfish |
| | *Pseudobalistes fuscus* | Blue triggerfish |
| | *Sufflamen bursa* | Scythe triggerfish |
| | *Sufflamen chrysopterus* | Halfmoon triggerfish |
| Ostraciidae (Boxfishes) | *Ostracion meleagris* | Spotted trunkfish |
| Tetraodontidae (Pufferfishes) | *Arothron meleagris* | Guineafowl puffer |
| | *Canthigaster valentini* | Black-saddled toby |

**Table 3-13.** 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).

| Species | ID by | Locations Sighted | Depths of Observations |
|---|---|---|---|
| *Epinephelus ongus*<br>Whitestreaked grouper | *PL* | L-N-RBby-3-G<br>L-S-4-G<br>L-S-5-G | 4 m (13 ft)<br>4 m (14 ft)<br>3 m (10 ft) |
| *Pterocaesio digramma*<br>Two-lined fusilier | *PL* | L-N-RBy-4-G | 12 m (40 ft) |
| *Plectorhinchus goldmani*<br>Goldman's sweetlips | *SS* | *Barton Point*<br>*Cust Point* | 22 m (70 ft)<br>22 m (70 ft) |
| *Plectorhinchus obscurus*<br>Giant sweetlips | *SS* | *Barton Pointt* | 31 m (100 ft) |
| *Pomacentrus similes*<br>Similar damselfish | *PL* | L-N-RBby-4-G<br>L-S-4-G<br>L-S-5-G | 12 m (40 ft)<br>4 m (14 ft)<br>3 m (10 ft) |
| *Amblyogobius phalaena*<br>Banded goby | *PL* | L-N-RZ-10-G<br>L-N-RBby-3-G<br>L-N-EcBy-2-G<br>L-S-4-G | 5 m (15 ft)<br>4 m (13 ft)<br>7 m (24 ft)<br>4 m (14 ft) |
| *Siganus corallinus*<br>Coral rabbitfish | *SS* | *Barton Point* | 17 m (55 ft) |
| *Acanthurus auranticavus*<br>Orange socket surgeonfish | *PL* | O-W-Ar-4-G<br>O-W-CnPt-2-G<br>O-W-SmPt-1-G<br>O-E-CsPt-2-G<br>L-N-RZ-9-G<br>L-N-RZ-10-G<br>L-N-RBy-3-G<br>L-N-RBy-4-G<br>L-S-4-G<br>L-S-5-G | 15 m (50 ft)<br>17 m (55 ft)<br>16 m (54 ft)<br>16 m (51 ft)<br>15 m (49 ft)<br>5 m (15 ft)<br>4 m (13 ft)<br>12 m (40 ft)<br>4 m (14 ft)<br>3 m (10 ft) |

**Table 3-14.** Numbers of species per family encountered via the GMI roving diver survey at Diego Garcia in August 2005 contrasted with the number of species in the Winterbottom and Anderson (1999) Chagos fish check list (*In Winterbottom and Anderson [1999]: Checklist of pelagic and shore fishes of Chagos; ** As a percentage of the number of species listed in Winterbottom and Anderson [1999]).

| Family | Species Survey Total | Species Chagos Total* | Percent Encountered** |
|---|---|---|---|
| Subfamily Epinephelinae (Groupers) | 22 | 38 | 58% |
| Labridae (Wrasses) | 21 | 63 | 33% |
| Pomacentridae (Damselfishes) | 19 | 38 | 50% |
| Acanthuridae (Surgeonfishes) | 19 | 29 | 66% |
| Chaetodontidae (Butterflyfishes) | 16 | 25 | 64% |
| Subfamily Lutjaninae (Snappers) | 9 | 21 | 43% |
| Subfamily Balistinae (Triggerfishes) | 7 | 17 | 41% |
| Gobiidae (Gobies) | 6 | 98 | 6% |
| Holocentridae (Squirrelfishes & Soldierfishes) | 5 | 22 | 23% |
| Mullidae (Goatfishes) | 5 | 11 | 45% |
| Blenniidae (Blennies) | 5 | 25 | 20% |
| Subfamily Caesioninae (Fusiliers) | 4 | 9 | 44% |
| Pomacanthidae (Angelfishes) | 4 | 6 | 67% |
| Microdesmidae (Wormfishes & Dartfishes) | 4 | 8 | 50% |
| Carangidae (Jacks) | 3 | 15 | 20% |
| Lethrinidae (Emprerors) | 3 | 18 | 17% |
| Cirrhitidae (Hawkfish) | 3 | 6 | 50% |
| Scaridae (Parrotfishes) | 3 | 22 | 14% |
| Synodontidae (Lizardfishes) | 2 | 6 | 33% |
| Subfamily Anthiinae (Anthiases) | 2 | 7 | 29% |
| Apogon (Cardinalfishes) | 2 | 33 | 6% |
| Nemipteridae (Breams and Spinecheeks) | 2 | 2 | 100% |
| Ginglymostomatidae (Nurse Sharks) | 1 | 1 | 100% |
| Carcharhinidae (Requiem Sharks) | 1 | 7 | 14% |
| Dasyatidae (Rays) | 1 | 5 | 20% |
| Myliobatidae (Eagle Rays) | 1 | 1 | 100% |
| Mobulinae (Manta Rays) | 1 | 2 | 50% |
| Muraenidae (Moray Eels) | 1 | 41 | 2% |
| Chanidae (Milkfish) | 1 | 1 | 100% |
| Priacanthidae (Bigeyes) | 1 | 2 | 50% |
| Fistulariidae (Cornetfishes) | 1 | 2 | 50% |
| Synngnathidae (Pipefishes) | 1 | 9 | 11% |
| Scorpaenidae (Scorpionfishes) | 1 | 21 | 5% |
| Haemulidae (Sweetlips) | 1 | 1 | 100% |
| Kyphosidae (Drummers/Chubs) | 1 | 2 | 50% |
| Sphyraenidae (Barracudas) | 1 | 3 | 33% |
| Pinguipedidae (Sandperchs) | 1 | 3 | 33% |
| Zanclidae (Moorish Idol) | 1 | 1 | 100% |
| Ostraciidae (Boxfishes) | 1 | 2 | 50% |
| Tetraodontidae (Pufferfishes) | 1 | 9 | 11% |

The five species encountered most consistently among roving diver surveys (**Table 3-15**) were *Chaetodon auriga* (threadfin butterflyfish), *Chromis viridis* (bluegreen chromis), *Dascyllus aruanus* (humbug dascyllus), *Chlorurus sordidus* (bullethead parrotfish), and *C. trifasciatus* (redfin butterflyfish). **Table 3-16** presents the mean abundance index value (base 10 logarithmic scale ranging from 1 to 4) of the top 25 most abundant species averaged for reefs surveyed by the GMI roving diver surveys. Pomacentridae species occupy four of the top five most abundant species. *Chlorurus sordidus* (bullethead parrotfish), ranks number three. The butterflyfishes, *Chaetodon auriga* (threadfin butterflyfish) and *C. trifasciatus* (chevroned butterflyfish), were common (ranked six and tenth respectively). The wrasses *Labroides dimidiatus* (bluestreak cleaner wrasse) and *Gomphosus coeruleus* (bird wrasse) were ranked seventh and ninth. The Cirrhitidae (hawfishes) *Paracirrhites arcatus* (arceye hawkfish) was also among the most common fishes at Diego Garcia (ranked eighth). **Table 3-17** shows abundance ranges of species recorded by Navy fish surveys.

### *3.2.2 Fish Populations by Geographic Area*

There are three distinct geographic areas: the seaward shelf reefs, the lagoon reefs, and the reefs of the lagoon passes. The study sites on the seaward shelf are subdivided into west and east sub-areas. The study sites of the lagoon are subdivided by basin: northern basin, southern basin-deep and southern basin-shallow. The deep southern basin is defined by the circular caldera-like topographic feature. The shallow basin occurs to the south and is crisscrossed with a network of shallow reefs and ridges. The depths of GMI's seaward shelf study sites are all comparable to each other, from 15 to 17 m (50 to 55 ft). The study sites located within the lagoon vary, with shallow ones situated on the lagoonal shelf and deeper ones in the north basin. The study sites in the southern basin were comparatively shallow. Another distinction, not discussed here in further detail, occurs between lagoonal shelf reefs and those of the basins. Knoll/patch reefs rise from the floor of the basins. Many of these are situated south of the islands and passes in the north. Data are also distinguished between study sites located in the replenishment zone, the anchorage area, and other open-access areas.

A greater number of fishes were observed on the ocean side reefs (**Tables 3-11** and **3-18**) partly due to the large number of Anthiinae there. Anthiinae were not common in lagoon study sites. The ocean side reefs had higher abundance and higher family and species representation. Pomacentridae accounted for the greatest portion of the fish population at lagoon sites, nearly two times as great as all the other families combined. Topographic complexity was generally greater in lagoon sites than at ocean sites, especially due to the presence of Acroporidae, large boulder forming corals, and reef rock. Habitats were much more continuous, however, at the ocean sites.

Fish populations appeared to have varying degrees of differences in distribution and abundance between reef habitats both within and between lagoon and ocean sites (**Tables 3-11**, **3-17**, and **3-19**). The top species and their respective abundance index values appear to differ most noticeably between ocean and lagoon sites and least among lagoon sites. The Cirrhitidae as well as the Anthiinae ranked high in abundance at ocean sites. (Cirrhitidae do not appear in the abundance **Table 3-18** because they were not included in the pre-selected list of families/groups recorded). Pomacentridae, Chaetodontidae, Scaridae, and Labridae rank top in abundance index values within the lagoon. Fish communities on the ocean shelves of the atoll showed marked differences between east and west sides as well (**Tables 3-11**, **3-17**, **3-20**, and **3-21**). Reefs of the South Point unfortunately were not surveyed but likely represent a fish community distinct again from the northern reefs. In contrast, reefs of the lagoon showed more similarities among sites, yet still appear to be characterized by variable fish communities at the species and family levels (**Tables 3-11**, **3-17**, **3-22**, and **3-23**).

Stationary and roving surveys of the shelf and shelf edge found the ocean side reefs at Cannon, Simpson, and Cust Points to have by far the greatest abundance of fishes (**Figure 3-5**). Surveys (**Table 3-11**) conducted at greater reef depths (Navy stationary/roving method) show high abundance levels at all ocean side sites: Cust Point, Barton Point, Cannon Point, and off the airport. Deep surveys were not performed at Simpson Point.

**Table 3-15.** Sighting frequencies of the 30 most common fish species recorded via the GMI roving diver survey at Diego Garcia in August 2004.

| Species Scientific Name | Species Common Name | Sighting Frequency |
|---|---|---|
| *Chaetodon auriga* | Threadfin butterflyfish | 56% |
| *Chromis viridis* | Blue green chromis | 56% |
| *Dascyllus aruanus* | Humbug dascyllus | 53% |
| *Chlorurus sordidus* | Bullethead parrotfish | 53% |
| *Chaetodon trifasciatus* | Redfin butterflyfish | 51% |
| *Paracirrhites arcatus* | Arceye hawkfish | 51% |
| *Labroides dimidiatus* | Bluestreak cleaner wrasse | 51% |
| *Chromis weberi* | Weber’s chromis | 49% |
| *Gomphosus coeruleus* | Bird wrasse | 49% |
| *Paracirrhites forsteri* | Freckled hawkfish | 47% |
| *Cephalopholis argus* | Peacock grouper | 42% |
| *Chromis dimidiata* | Twotone chromis | 42% |
| *Parupeneus macronema* | Longbarbel goatfish | 40% |
| *Chromis nigrura* | Blacktail chromis | 40% |
| *Halichoeres hortulanus* | Checkerboard wrasse | 40% |
| *Chaetodon trifascialis* | Chevroned butterflyfish | 38% |
| *Zanclus cornutus* | Moorish idol | 38% |
| *Lutjanus gibbus* | Humpback snapper | 36% |
| *Dascyllus carneus* | Indian dascyllus | 36% |
| *Pomacentrus caeruleus* | Cerulean damsel | 36% |
| *Pseudocheilinus hexataenia* | Sixline wrasse | 36% |
| *Pomacanthus imperator* | Emperor angelfish | 35% |
| *Pomacentrus indicus* | Indian damsel | 35% |
| *Cephalopholis spiloparaea* | Strawberry grouper | 33% |
| *Acanthurus auranticavus* | Orange socket surgeonfish | 33% |
| *Acanthurus leucosternon* | Powderblue surgeonfish | 33% |
| *Chaetodon meyeri* | Meyer's butterflyfish | 31% |
| *Dascyllus trimaculatus* | Three spot dascyllus | 31% |
| *Chrysiptera biocellata* | Twospot demoiselle | 29% |

**Table 3-16.** Mean abundance index values for the top 25 species recorded at Diego Garcia reefs in August 2004 by the GMI roving diver surveys. (Abundance index values log scale: 1=1; 2=2-10; 3=11-100; 4=101 or more).

| Scientific Name | Mean Abundance Index Value |
|---|---|
| *Chromis viridis* | 2.23 |
| *Dascyllus aruanus* | 1.84 |
| *Chlorurus sordidus* | 1.82 |
| *Chromis weberi* | 1.59 |
| *Chromis nigrura* | 1.45 |
| *Chaetodon auriga* | 1.41 |
| *Labroides dimidiatus* | 1.39 |
| *Paracirrhites arcatus* | 1.27 |
| *Gomphosus coeruleus* | 1.27 |
| *Chaetodon trifasciatus* | 1.23 |
| *Paracirrhites forsteri* | 1.18 |
| *Chromis dimidiate* | 1.14 |
| *Pomacentrus caeruleus* | 1.09 |
| *Halichoeres hortulanus* | 1.09 |
| *Pomacentrus indicus* | 1.02 |
| *Cephalopholis argus* | 1.00 |
| *Dascyllus carneus* | 1.00 |
| *Pseudocheilinus hexataenia* | 1.00 |
| *Parupeneus macronema* | 0.91 |
| *Acanthurus leucosternon* | 0.91 |
| *Lutjanus gibbus* | 0.89 |
| *Zanclus cornutus* | 0.89 |
| *Abudefduf sexfasciatus* | 0.84 |
| *Cephalopholis spiloparaea* | 0.82 |
| *Chaetodon trifascialis* | 0.82 |

Navy stationary/roving surveys conducted in the two pass areas (Barton and Main Passes) showed high abundance and family representation, which was similar to both the ocean side study sites and those of the northern replenishment zone (**Tables 3-11** and **3-17**).

The reefs of the replenishment zone in the northern lagoon area had high abundance levels, but the knoll at Minni Minni patch reef had the highest population of lagoon sites surveyed by the stationary survey method (**Figure 3-5**). Navy surveys found the replenishment zone reefs (especially L-N-RZ-1-N) to have among the highest abundance levels in the lagoon (**Tables 3-11** and **3-17**). The reefs of southern lagoon as well as one at Eclipse Bay in the northwest lagoon area had the smallest fish populations of all sites surveyed at Diego Garcia. The reef at Eclipse Bay (L-N-EcBy-2-G) was located north of the entrance to the small boat basin and was heavily silted over at the time of the survey. By far the lowest abundance levels were observed at study sites located in the anchorage area. This, in part, may be a result of the greater depth and poor visibility of the anchorage area, which does not allow a reef patch to be easily located from the surface. Dredging and continued anchoring activities likely account for most of the lower abundance levels found there, as well as in contributing to the poor visibility in the area and to some degree in the lagoon in general.

Ocean side reefs showed the greatest species richness (number of fish species) per study site recorded by roving diver surveys (**Figure 3-6**). Population diversity (numbers of fishes and numbers of species) was greatest at Simpson Point. Replenishment Zone sites within the lagoon were high in species richness as were the sites in Rambler Bay. The reefs of the southern lagoon showed the lowest species richness values.

Acanthuridae was consistently among the most abundant herbivorous families after the Pomacentridae at all sites except those of the southern lagoon and at Simpson Point (where carnivores were abundant). **Figure 3-7** shows a comparison of family groups recorded by stationary surveys among the ocean and lagoon study sites. The primary herbivore group (group B) is represented by the Ancanthuridae and Scaridae while the carnivores (group C) are represented by the Serranidae, Lutjanidae, and Lethrinidae. The Pomacentridae (group A) are by far the most abundant. Pomacentridae include some herbivores, garden tending fishes, planktivores, and detritivores. At most study sites, the combined abundance of the two herbivorous families and the Pomacentridae is far greater than the abundance of the remaining families. The carnivores consistently have a distinct presence at all study sites except at southern Eclipse Bay (L-N-EcBy-2-G). **Table 3-24** presents a summary of stationary fish surveys.

### *3.2.3 Fish Sizes at Diego Garcia*

Mean fish sizes recorded by GMI stationary surveys were generally greater at ocean side reefs (Acanthuridae and Carangidae were larger at lagoon sites). All lengths recorded were of fork lengths (tip of snout to fork of tail). **Table 3-25** provides mean fish lengths for key families. The Scaridae of the ocean side reefs are of substantial sizes. Several maximum Serranidae sizes were recorded at 70 and 75 cm (28 to 30 in) (**Table 3-26**). A large Serranidae was observed at Simpson Point of 1.0 to 1.5 m (3.3 to 4.9 ft) (not observed during a stationary survey). Lutjanidae of greater than 0.5 m (20 in) refer to observations of *Aphareus virescens* (green jobfish). Labridae of 1.5 m (4.9 ft) refer to observations of *Cheilinus undulatus* (Napoleon/humphead wrasse) at Simpson Point. Observations of large unicorn fish account for the maximum Acanthuridae sizes.

**Table 3-27** shows the abundance of select species of given sizes at study sites surveyed by Navy stationary/roving surveys. The presence of large Napoleon/humphead wrasse is noted at Cannon Point and Barton Point. Large Scaridae (greater than 60 cm [24 in]) were noted at the replenishment zone at L-N-RZ-2-N and L-N-RZ-8-N. Holocentridae (squirrelfishes) at Cannon Point were noted to be large (larger than 40 cm [16 in]). Large Serranidae were noted at Main Pass with two tentative sightings of *Epinephelus lanceolatus* (giant grouper) of about 1.5 m (4.9 ft). An estimated abundance of more than 20 *Plectropomus laevis* (blacksaddle coralgrouper) of about 1.0 m (3.3 ft) in size were also seen, but not in an aggregating formation. A giant trevally (*Caranx ignobilis*) of 1.5 m (4.9 ft) was noted at Cust Point.

**Table 3-17.** Selected species abundance ranges per study site at Diego Garcia in July/August 2004 recorded via Navy fish surveys.

| index number | | estimated abundance |
|---|---|---|
| 0 | = | 0 |
| 1 | = | 1 - 5 |
| 2 | = | 6 - 10 |
| 3 | = | 11 - 20 |
| 4 | = | 21 - 50 |
| 5 | = | 51-100 |
| 6 | = | 101 - 200 |
| 7 | = | 201 - 500 |
| 8 | = | 501 - 1000 |

| | L-N-An-1-N | L-N-An-2-N | L-N-An-3-N | L-N-An-4-N | L-N-An-5-N | L-N-EcBy-1-N | L-N-PtMr-1-N | L-N-PtMr-2-N | L-N-RBy-2-N | L-N-RBy-3-N | L-N-RZ-1-N | L-N-RZ-2-N | L-N-RZ-3-N | L-N-RZ-4-N | L-N-RZ-5-N | L-N-RZ-7-N | L-N-RZ-8-N | L-S-1-N | L-S-2-N | L-S-3-N | L-S-TC-1-N | L-S-TC-3-N | O-E-CsPt-1-N | O-E-CsPt-1-N | O-N-BPt-1-N | O-W-Ar-1-N | O-W-Ar-2-N | O-W-Ar-3-N | O-W-CnPt-1-N | O-W-CnPt-1-N | P-B-1-N | P-Mn-1-N | P-Mn-1-N | Total | Mean | Site Count (33 Total) | Site Frequency (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CARCHARHINIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Carcharhinus sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 6% |
| **MURAENIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Enchelycore sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Gymnomuraena zebra** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Gymnothorax sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 6% |
| **Other Muraenidae sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **SERRANIDAE (Epinephilinie)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Anyperodon leucogrammicus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 | 1 | 5 | 15% |
| **Cephalopholis argus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 2 | 0 | 1 | 1 | 2 | 3 | 2 | 5 | 1 | 10 | 30% |
| **Cephalopholis miniata** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 | 1 | 6 | 18% |
| **Epinephelus lanceolatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Epinephelus multinotatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 4 | 1 | 6 | 18% |
| **Gracilia albomarginata** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 3 | 1 | 4 | 12% |
| **Plectropomus laevis** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 1 | 4 | 0 | 5 | 1 | 6 | 18% |
| **Variola albimarginata** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3% |
| **Variola louti** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 1 | 3% |
| **Other Tribe Epinephielinie sp.** | 4 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 1 | 0 | 5 | 2 | 1 | 3 | 1 | 2 | 3 | 0 | 0 | 2 | 0 | 0 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 0 | 3 | 7 | 2 | 23 | 70% |
| **CARANGIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Caranx ignobilis** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Caranx melampygus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 4 | 0 | 4 | 1 | 4 | 4 | 3 | 3 | 0 | 7 | 2 | 13 | 39% |
| **Caranx sexfasciatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 4 | 0 | 3 | 6 | 1 | 5 | 15% |
| **Elegatis bipinnulata** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 1 | 2 | 6% |
| **Gnathanodon speciosus** | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 3% |
| **Other Carangidae sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 6 | 1 | 5 | 15% |
| **LETHRINIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Gnathodentex aureolineatus** | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 4 | 6 | 0 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 8 | 4 | 7 | 21% |
| **Lethrinus olivaceus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 3% |
| **Monotaxis grandoculis** | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 6 | 0 | 5 | 3 | 5 | 4 | 4 | 0 | 0 | 8 | 4 | 11 | 33% |
| **Other Lethrinidae sp.** | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 4 | 2 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 3 | 0 | 4 | 0 | 4 | 0 | 3 | 3 | 3 | 0 | 0 | 7 | 2 | 13 | 39% |
| **HAEMULIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Plectorhinchus goldmanni** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3% |
| **Plectorhinchus obscurus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 6% |
| **Plectorhinchus vittatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 1 | 4 | 12% |
| **LABRIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Cheilinus undulatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 3 | 1 | 5 | 15% |
| **ACANTHURIDAE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Acanthurus xanthopterus** | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 4 | 8 | 4 | 7 | 21% |
| **Paracanthurus hepatus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 1 | 2 | 6% |
| **Acanthurus sp.** | 0 | 0 | 2 | 0 | 0 | 4 | 5 | 4 | 6 | 0 | 4 | 4 | 4 | 6 | 3 | 4 | 6 | 3 | 3 | 3 | 1 | 0 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 5 | 4 | 3 | 5 | 8 | 4 | 27 | 82% |
| **Naso sp.** | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 4 | 0 | 0 | 4 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 5 | 3 | 7 | 0 | 5 | 3 | 4 | 5 | 3 | 4 | 1 | 16 | 48% |

**Table 3-18.** Mean fish abundances recorded per family at ocean and lagoon study sites (recorded by stationary survey method).

| ***Ocean Sites*** **Family** | **Mean no. of fishes per study site** |
|---|---|
| Anthiinae | 375.00 |
| Pomacentridae | 67.65 |
| Caesioninae | 50.42 |
| Labridae | 36.02 |
| Acanthuridae | 22.02 |
| Balistidae | 14.15 |
| Carangidae | 7.96 |
| Serranidae | 5.06 |
| Kyphosidae | 4.17 |
| Lethrinidae | 4.04 |
| Chaetodontidae | 3.31 |
| Scaridae | 2.98 |
| Lutjanidae | 1.73 |
| Mullidae | 1.06 |
| Pomacanthidae | 1.04 |
| Haemulidae | 0.31 |
| Chanidae | 0.19 |
| Zanclidae | 0.13 |
| Muraenidae | 0.08 |
| Myliobatidae | 0.08 |
| Sphyraenidae | 0.06 |
| Carcharhinidae | 0.04 |
| Fistulariidae | 0.04 |
| Mobulinae | 0.04 |
| Ostraciidae | 0.04 |
| ***Total:*** | **597.63** |
| ***No. of Families:*** | **25** |

| ***Lagoon Sites*** **Family** | **Mean no of fishes per study site** |
|---|---|
| Pomacentridae | 97.30 |
| Acanthuridae | 15.84 |
| Apogonidae | 8.57 |
| Labridae | 5.24 |
| Scaridae | 4.50 |
| Caesioninae | 4.09 |
| Chaetodontidae | 3.00 |
| Carangidae | 2.68 |
| Lethrinidae | 1.98 |
| Lutjanidae | 1.83 |
| Serranidae | 1.16 |
| Nemipteridae | 1.00 |
| Mullidae | 0.98 |
| Holocentridae | 0.96 |
| Pomacanthidae | 0.16 |
| Balistidae | 0.14 |
| Zanclidae | 0.11 |
| Haemulidae | 0.07 |
| Muraenidae | 0.07 |
| Synodontidae | 0.07 |
| Mobulinae | 0.04 |
| ***Total:*** | **149.78** |
| ***No. of Families:*** | **21** |

**Table 3-19.** Abundance index values for the top 25 species recorded by roving diver surveys at ocean and lagoon study sites at Diego Garcia.

| *Ocean Sites* | | *Lagoon Sites* | |
|---|---|---|---|
| **Scientific Name** | **Abundance Index Value** | **Scientific Name** | **Abundance Index Value** |
| *Chlorurus sordidus* | 2.31 | *Chromis viridis* | 3.18 |
| *Chromis nigrura* | 2.06 | *Dascyllus aruanus* | 2.50 |
| *Pseudanthias squamipinnis* | 2.00 | *Chaetodon auriga* | 1.61 |
| *Paracirrhites arcatus* | 2.00 | *Chromis weberi* | 1.54 |
| *Melichthys niger* | 2.00 | *Chlorurus sordidus* | 1.54 |
| *Nemateleotris magnifica* | 1.94 | *Gomphosus coeruleus* | 1.43 |
| *Chromis dimidiata* | 1.88 | *Pomacentrus indicus* | 1.39 |
| *Acanthurus leucosternon* | 1.81 | *Labroides dimidiatus* | 1.39 |
| *Paracirrhites forsteri* | 1.75 | *Chaetodon trifasciatus* | 1.36 |
| *Chromis weberi* | 1.69 | *Abudefduf sexfasciatus* | 1.32 |
| *Chaetodon meyeri* | 1.63 | *Chromis nigrura* | 1.11 |
| *Thalassoma amblycephalum* | 1.63 | *Chrysiptera biocellata* | 1.07 |
| *Pseudobalistes fuscus* | 1.56 | *Stethojulis strigiventer* | 1.07 |
| *Pseudanthias sp.* | 1.50 | *Pomacentrus caeruleus* | 1.04 |
| *Forcipiger flasvissimus* | 1.50 | *Cheilodipterus quinquelineatus* | 0.96 |
| *Zanclus cornutus* | 1.50 | *Halichoeres hortulanus* | 0.96 |
| *Cephalopholis argus* | 1.44 | *Lutjanus gibbus* | 0.93 |
| *Labroides dimidiatus* | 1.38 | *Parupeneus macronema* | 0.93 |
| *Cephalopholis spiloparaea* | 1.31 | *Chaetodon trifascialis* | 0.93 |
| *Halichoeres hortulanus* | 1.31 | *Pseudocheilinus hexataenia* | 0.93 |
| *Dascyllus carneus* | 1.25 | *Dascyllus carneus* | 0.86 |
| *Cirrhitichthys oxycephalus* | 1.25 | *Paracirrhites arcatus* | 0.86 |
| *Pomacentrus caeruleus* | 1.19 | *Paracirrhites forsteri* | 0.86 |
| *Caranx melampygus* | 1.13 | *Acanthurus auranticavus* | 0.86 |
| *Parupeneus bifasciatus* | 1.13 | *Dascyllus trimaculatus* | 0.79 |

**Table 3-20.** Abundance index values for the top 10 species recorded by roving diver surveys at East and West Ocean sites at Diego Garcia.

| *Ocean Sites—East* | | *Ocean Sites—West* | |
|---|---|---|---|
| **Scientific Name** | **Abundance Index Value** | **Scientific Name** | **Abundance Index Value** |
| **Melichthys niger** | 3.00 | **Pseudanthias squamipinnis** | 2.67 |
| *Pseudobalistes fuscus* | 3.00 | **Chlorurus sordidus** | 2.58 |
| *Chromis weberi* | 2.50 | *Chromis nigrura* | 2.50 |
| *Acanthurus leucosternon* | 2.25 | *Thalasomma amblycephalum* | 2.17 |
| *Monotaxis grandoculis* | 2.00 | *Pseudanthias sp.* | 2.00 |
| *Forcipiger flasvissimus* | 2.00 | *Paracirrhites arcatus* | 2.00 |
| *Chromis dimidiata* | 2.00 | *Nemateleotris magnifica* | 1.92 |
| *Paracirrhites arcatus* | 2.00 | *Chaetodon meyeri* | 1.83 |
| *Paracirrhites forsteri* | 2.00 | *Chromis dimidiata* | 1.83 |
| *Nemateleotris magnifica* | 2.00 | *Dascyllus carneus* | 1.67 |

**Table 3-21.** Abundance fish families recorded by stationary surveys at East and West Ocean sites at Diego Garcia.

| ***Ocean Sites—East*** | | ***Ocean Sites—West*** | |
|---|---|---|---|
| **Family** | **Mean Abundance** | **Family** | **Mean Abundance** |
| Labridae | 104.00 | Anthiinae | 423.08 |
| Caesioninae | 85.00 | Pomacentridae | 65.15 |
| Pomacentridae | 75.25 | Caesioninae | 26.92 |
| Balistidae | 36.50 | Acanthuridae | 25.62 |
| Acanthuridae | 23.75 | Labridae | 13.92 |
| Chaetodontidae | 6.75 | Carangidae | 8.54 |
| Lethrinidae | 5.50 | Balistidae | 6.92 |
| Serranidae | 4.00 | Serranidae | 4.77 |
| Scaridae | 3.50 | Kyphosidae | 3.85 |
| Carangidae | 2.75 | Scaridae | 2.62 |
| Mullidae | 1.50 | Chaetodontidae | 2.31 |
| Pomacanthidae | 1.25 | Lutjanidae | 2.15 |
| Chanidae | 0.75 | Mullidae | 0.92 |
| Lutjanidae | 0.50 | Pomacanthidae | 0.85 |
| Sphyraenidae | 0.25 | Lethrinidae | 0.77 |
| Anthiinae | 0.00 | Haemulidae | 0.31 |
| Apogonidae | 0.00 | Zanclidae | 0.15 |
| Carcharhinidae | 0.00 | Carcharhinidae | 0.08 |
| Fistulariidae | 0.00 | Fistulariidae | 0.08 |
| Haemulidae | 0.00 | Mobulinae | 0.08 |
| Holocentridae | 0.00 | Muraenidae | 0.08 |
| Kyphosidae | 0.00 | Myliobatidae | 0.08 |
| Mobulinae | 0.00 | Ostraciidae | 0.08 |
| Muraenidae | 0.00 | Apogonidae | 0.00 |
| Myliobatidae | 0.00 | Chanidae | 0.00 |
| Nemipteridae | 0.00 | Holocentridae | 0.00 |
| Ostraciidae | 0.00 | Nemipteridae | 0.00 |
| Synodontidae | 0.00 | Sphyraenidae | 0.00 |
| Zanclidae | 0.00 | Synodontidae | 0.00 |

**Table 3-22.** Abundance index values for the top 10 species recorded by roving diver surveys at North and South Lagoon sites at Diego Garcia.

| ***Lagoon Sites—North*** | | ***Lagoon Sites—South*** | |
|---|---|---|---|
| **Scientific Name** | **Abundance Index Value** | **Scientific Name** | **Abundance Index Value** |
| *Chromis viridis* | 3.40 | **Chromis viridis** | 2.63 |
| *Dascyllus aruanus* | 2.45 | *Dascyllus aruanus* | 2.63 |
| *Chlorurus sordidus* | 2.10 | *Stethojulis strigiventer* | 2.50 |
| *Gomphosus coeruleus* | 1.95 | *Abudefduf sefasciatuts* | 1.75 |
| *Labroides dimidiatus* | 1.95 | *Chaetodon auriga* | 1.50 |
| *Chromis weberi* | 1.80 | *Ptereleotris microlepis* | 1.38 |
| *Chaetodon auriga* | 1.65 | *Cheilodipterus quinquelineatus* | 1.25 |
| *Pomacentrus indicus* | 1.60 | *Chaetodon trifasciatus* | 1.25 |
| *Chaetodon trifasciatus* | 1.40 | *Acanthurus auranticavus* | 1.25 |
| *Chromis nigrura* | 1.35 | *Apogon exostigma* | 1.13 |

**Table 3-23.** Abundance index values for the top 10 species recorded by roving diver surveys at North and South Lagoon sites at Diego Garcia.

| ***Lagoon Sites—North*** | | ***Lagoon Sites—South*** | |
|---|---|---|---|
| **Family** | **Mean Abundance** | **Family** | **Mean Abundance** |
| Pomacentridae | 119.72 | Pomacentridae | 46.00 |
| Acanthuridae | 21.88 | Lethrinidae | 6.50 |
| Apogonidae | 12.00 | Labridae | 5.88 |
| Caesioninae | 8.88 | Lutjanidae | 4.88 |
| Scaridae | 5.92 | Acanthuridae | 3.50 |
| Labridae | 5.08 | Carangidae | 2.50 |
| Chaetodontidae | 3.44 | Nemipteridae | 2.50 |
| Carangidae | 2.76 | Chaetodontidae | 1.88 |
| Serranidae | 1.52 | Scaridae | 1.63 |
| Mullidae | 1.40 | Holocentridae | 1.25 |
| Holocentridae | 1.08 | Serranidae | 0.63 |
| Lutjanidae | 0.60 | Balistidae | 0.50 |
| Zanclidae | 0.24 | Mullidae | 0.25 |
| Pomacanthidae | 0.20 | Muraenidae | 0.25 |
| Lethrinidae | 0.16 | Mobulinae | 0.13 |
| Synodontidae | 0.16 | Anthiinae | 0.00 |
| Haemulidae | 0.08 | Apogonidae | 0.00 |
| Anthiinae | 0.00 | Caesioninae | 0.00 |
| Balistidae | 0.00 | Carcharhinidae | 0.00 |
| Carcharhinidae | 0.00 | Chanidae | 0.00 |
| Chanidae | 0.00 | Fistulariidae | 0.00 |
| Fistulariidae | 0.00 | Haemulidae | 0.00 |
| Kyphosidae | 0.00 | Kyphosidae | 0.00 |
| Mobulinae | 0.00 | Myliobatidae | 0.00 |
| Muraenidae | 0.00 | Ostraciidae | 0.00 |
| Myliobatidae | 0.00 | Pomacanthidae | 0.00 |
| Nemipteridae | 0.00 | Sphyraenidae | 0.00 |
| Ostraciidae | 0.00 | Synodontidae | 0.00 |
| Sphyraenidae | 0.00 | Zanclidae | 0.00 |

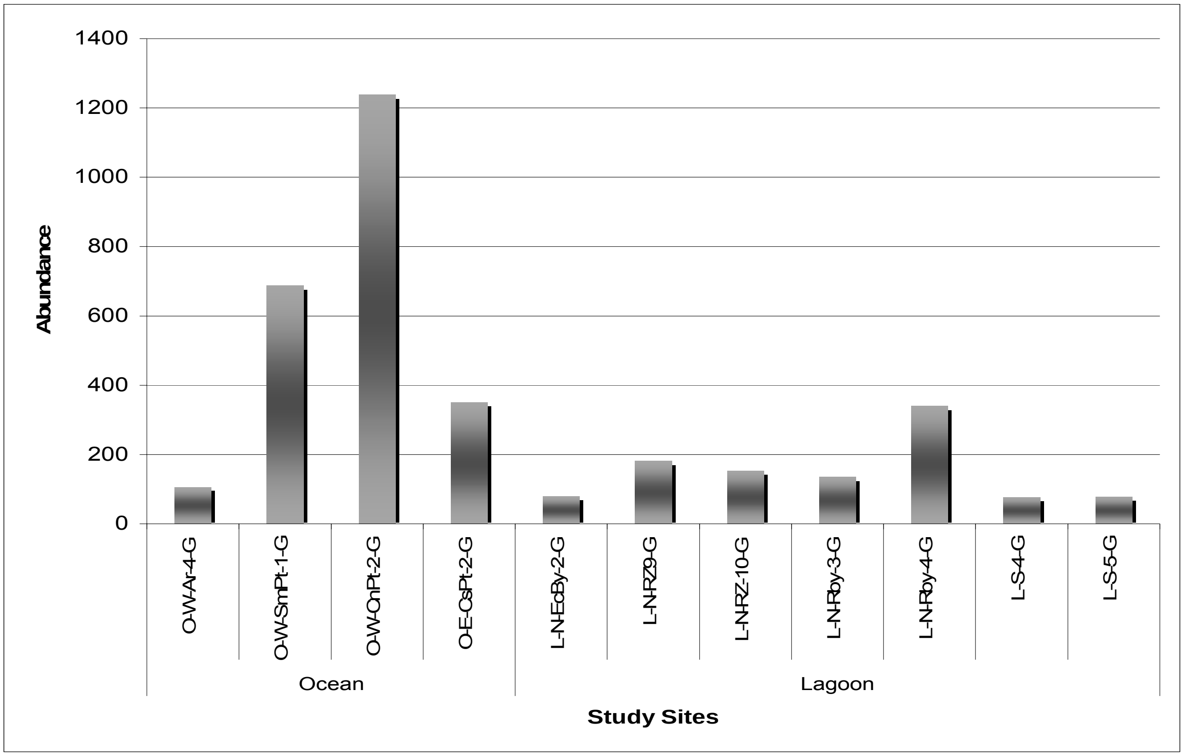


**Figure 3-5.** Mean abundance of all fish species counted using the stationary survey method.

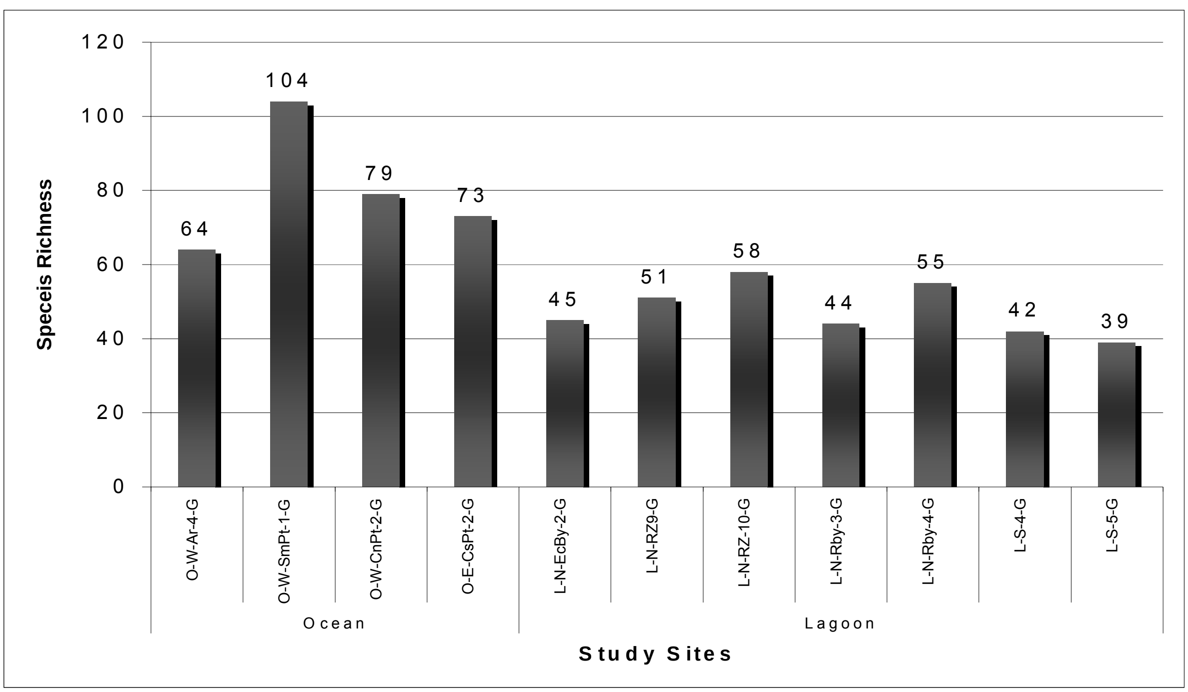


**Figure 3-6.** Fish richness at study sites at Diego Garcia (determined via the roving survey method).

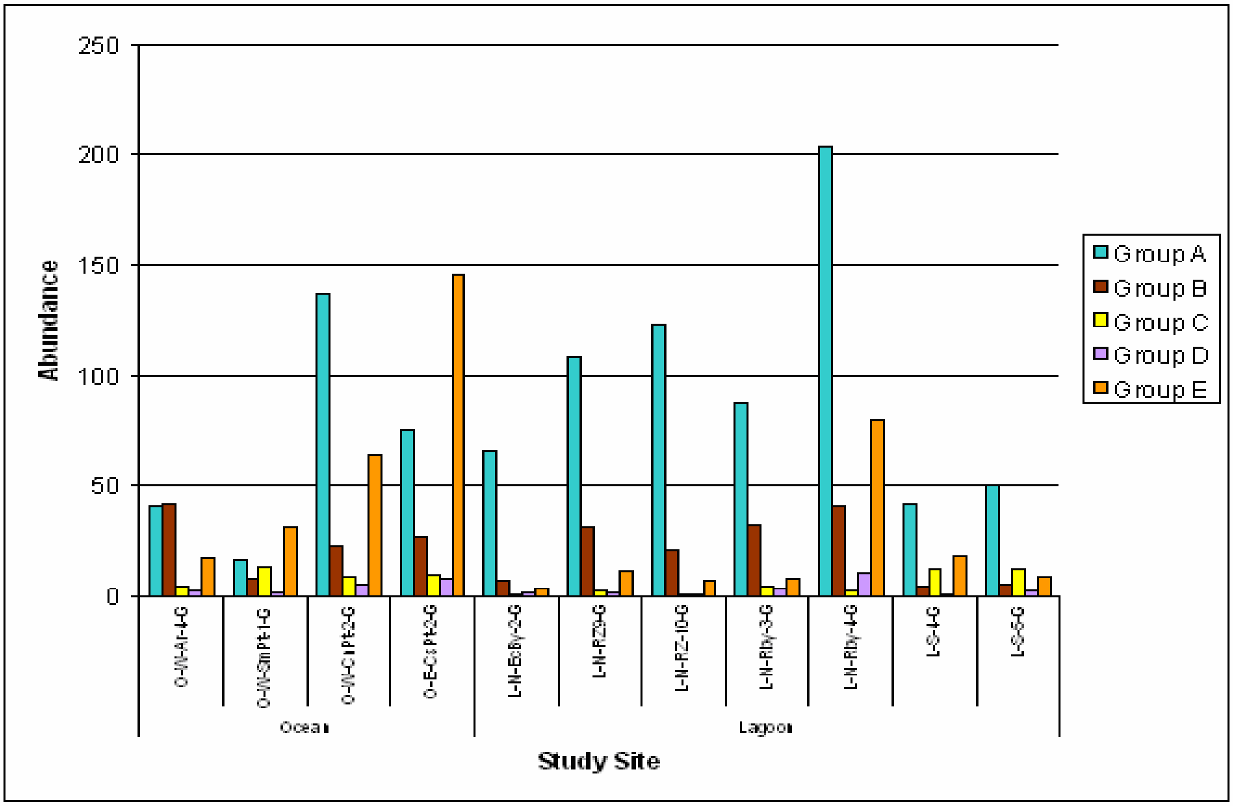


**Figure 3-7.** Mean abundance of fish family groups at Diego Garcia study sites. (Group A=Pomacentridae; Group B=Acanthuridae and Scaridae; Group C=Serranidae, Lutjanidae, and Lethrinidae; Group D=Chaetodontidae and Pomacanthidae; and Group E=Others).

Only a few size observations of a Carcharinidae sharks were made: a 1.8 m (5.9 ft) *Carcharhinus albimarginatus,* silvertip reef shark, at O-W-Ar-4-G and four of 1 to 2 m (3.3 to 6.6 ft) of uncertain species. A Carcharinidae shark hooked while fishing was estimated at 1.3 m (4.3 ft). The numbers and sizes were lower than expected.

Maximum sizes of manta rays were about 3 to 4 m (9.8 to 13.1 ft). A 1.5 m (4.9 ft) *Sphyraena barracuda* (great barracuda) was recorded at O-E-CsPt-2-G. Napoleon/humphead wrasse (*Cheilinus undulates*) were observed at O-W-CnPt-2-G and O-W-SmPt-1-G in numbers of up to five individuals ranging in size from 70 or 80 cm (28 or 31 in) to near 1.5 m (4.9 ft).

## 3.3 OPPORTUNISTIC OBSERVATIONS

All survey divers remained aware of aditional topics during survey dives to make note of if possible. These included observations of sea turtles, marine mammals, seagrasses, and anthropogenic/hazardous materials. While this information is not meant to be used for quantitative analysis or description, it is provided in order to present a more rounded picture of the Diego Garcia marine habitat and to indicate an awareness of additional issues and help with future investigations.

### *3.3.1 Sea Turtles*

Sea turtles were seen at nearly all study sites. We also saw sea turtles while in transit between study sites. Observed individuals varied in size/age and species. Species observed at the sea surface and underwater were determined to be the green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricate*);

**Table 3-24.** Summary of fish mean fish abundance per family per site at Diego Garcia in August 2004 (recorded via the stationary survey method).

| Family | L-N-EcBy-2-G | L-N-RBy-3-G | L-N-RBy-4-G | L-N-RZ-10-G | L-N-RZ-9-G | L-S-4-G | L-S-5-G | O-E-C-sPt-2-G | O-W-Ar-4-G | O-W-CnPt-2-G | O-W-Sm-Pt-1-G | Total | Mean | No. of sites (out of 11 total) | Percent Occurrence (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anthiases | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 500 | 1500 | 136 | 2 | 18% |
| Pomacentridae | 66 | 88 | 204 | 123 | 108 | 42 | 51 | 75 | 41 | 138 | 17 | 952 | 87 | 11 | 100% |
| Caesionidae | 0 | 0 | 2 | 0 | 26 | 0 | 0 | 85 | 0 | 0 | 117 | 230 | 21 | 4 | 36% |
| Acanthuridae | 6 | 23 | 34 | 16 | 24 | 3 | 4 | 24 | 42 | 15 | 8 | 199 | 18 | 11 | 100% |
| Labridae | 3 | 8 | 3 | 5 | 6 | 6 | 6 | 104 | 10 | 27 | 5 | 182 | 17 | 11 | 100% |
| Apogonidae | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 5 | 1 | 9% |
| Balistidae | 0 | 0 | 0 | 0 | 0 | 1 | 0.3 | 37 | 5 | 15 | 0 | 58 | 5 | 5 | 45% |
| Carangidae | 0 | 0 | 14 | 0 | 0 | 5 | 0 | 3 | 2 | 19 | 9 | 51 | 5 | 7 | 64% |
| Scaridae | 1 | 9 | 7 | 5 | 7 | 2 | 1 | 4 | 0 | 8 | 0.3 | 43 | 4 | 11 | 100% |
| Chaetodontidae | 2 | 3 | 10 | 1 | 2 | 1 | 3 | 7 | 2 | 4 | 0.3 | 34 | 3 | 11 | 100% |
| Serranidae | 1 | 3 | 1 | 1 | 2 | 0 | 1 | 4 | 2 | 8 | 7 | 29 | 3 | 10 | 91% |
| Lethrinidae | 0 | 0.3 | 1 | 0 | 0 | 12 | 1 | 6 | 0 | 0 | 3 | 23 | 2 | 6 | 55% |
| Lutjanidae | 0 | 1 | 1 | 0 | 0.4 | 0 | 10 | 1 | 3 | 1 | 3 | 20 | 2 | 8 | 73% |
| Kyphosidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 17 | 2 | 1 | 9% |
| Mullidae | 0 | 1 | 3 | 2 | 2 | 1 | 0 | 2 | 1 | 2 | 0 | 11 | 1 | 8 | 73% |
| Holocentridae | 1 | 0 | 1 | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 7 | 1 | 6 | 55% |
| Pomacanthidae | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0.2 | 2 | 1 | 5 | 0.5 | 6 | 55% |
| Nemipteridae | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 0.5 | 1 | 9% |
| Haemulidae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 2 | 0.2 | 3 | 27% |
| Zanclidae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.1 | 2 | 18% |
| Muraenidae | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.3 | 0 | 0 | 0 | 0.3 | 1 | 0.08 | 3 | 27% |
| Chanidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.07 | 1 | 9% |
| Synodontidae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.05 | 1 | 9% |
| Mobulidae | 0 | 0 | 0 | 0 | 0 | 0.3 | 0 | 0 | 0.2 | 0 | 0 | 0.4 | 0.04 | 2 | 18% |
| Myliobatidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.3 | 0.03 | 1 | 9% |
| Sphyraenidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0.3 | 0.02 | 1 | 9% |
| Carcharhinidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.2 | 0.02 | 1 | 9% |
| Fistulariidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.2 | 0.02 | 1 | 9% |
| Ostraciidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.2 | 0.02 | 1 | 9% |
| Total | 80 | 136 | 340 | 153 | 182 | 78 | 79 | 351 | 107 | 1239 | 688 | 3432 | 312 | | |
| No. families (out of 29) | 7 | 11 | 14 | 8 | 13 | 13 | 11 | 15 | 15 | 14 | 16 | | | | |
| Representation (% of 29) | 24% | 38% | 48% | 28% | 45% | 45% | 38% | 52% | 52% | 48% | 55% | | | | |
| Samples/Surveys | 4 | 4 | 5 | 4 | 8 | 4 | 4 | 4 | 6 | 4 | 3 | | | | |

**Table 3-25.** Mean lengths (cm) of selected fish families at Diego Garcia (values represent weighted average for the atoll region recorded via stationary surveys; recorded for fork length).

| Atoll Region | Serranidae* | Lutjanidae** | Lethrinidae | Acanthuridae | Scaridae | Carangidae | Chaetodontidae | Pomacentridae |
|---|---|---|---|---|---|---|---|---|
| **Ocean, West** | 36 | 42 | 15 | 18 | 36 | 36 | 14 | 8 |
| **Ocean, East** | 34 | 60 | 21 | 20 | 36 | 46 | 13 | 8 |
| ***Ocean, Total*** | *36* | *43* | *19* | *19* | *36* | *37* | *14* | *8* |
| **Lagoon, North** | 25 | 23 | 25 | 22 | 18 | 49 | 14 | 8 |
| **Lagoon, South** | 18 | 24 | 20 | 18 | 16 | 30 | 12 | 9 |
| ***Lagoon Total*** | *24* | *24* | *20* | *21* | *18* | *45* | *13* | *8* |
| ***DG Total*** | *25* | *25* | *21* | *22* | *19* | *46* | *14* | *9* |

*Include groupers only (Tribe Epinephilinie)
**Include snappers only (Subfamily Lutjaninae)

**Table 3-26.** Maximum lengths (cm) of selected fish families at Diego Garcia recorded via stationary surveys (recorded for fork length).

| Site | Carcharhinidae | Mobulinae | Myliobatidae | Sphyraenidae | Labridae | Serranidae | Lutjanidae | Carangidae | Acanthuridae | Scaridae |
|---|---|---|---|---|---|---|---|---|---|---|
| **O-W-Ar-4-G** | 180 | - | - | - | 20 | 45 | 60 | 150 | 25 | 40 |
| **O-W-SmPt-1-G** | - | - | 130 | - | 150 | 65 | 60 | 65 | 55 | 40 |
| **O-W-CnPt-2-G** | - | - | - | - | 25 | 70 | 80 | 35 | 15 | 60 |
| **O-E-CsPt-2-G** | - | - | - | 150 | 18 | 75 | 60 | 60 | 45 | 60 |
| **L-N-EcBy-2-G** | - | - | - | - | 10 | 18 | - | - | 20 | 15 |
| **L-N-RZ9-G** | - | - | - | - | 20 | 70 | 35 | 70 | 50 | 25 |
| **L-N-RZ-10-G** | - | - | - | - | 12 | 70 | - | - | 30 | 35 |
| **L-N-Rby-3-G** | - | - | - | - | 12 | 35 | 28 | - | 25 | 19 |
| **L-N-Rby-4-G** | - | - | - | - | 20 | 35 | 25 | 60 | 40 | 40 |
| **L-S-4-G** | - | 300 | - | - | 8 | - | - | 30 | 18 | 25 |
| **L-S-5-G** | - | - | - | - | 12 | 25 | 30 | - | 40 | 10 |

**Table 3-27.** Selected species sizes per study site at Diego Garcia in July/August 2004 recorded via Navy fish surveys.

| index number | | estimated abundance |
|---|---|---|
| 0 | = | 0 |
| 1 | = | 1 - 5 |
| 2 | = | 6 - 10 |
| 3 | = | 11 - 20 |
| 4 | = | 21 - 50 |
| 5 | = | 51-100 |
| 6 | = | 101 - 200 |
| 7 | = | 201 - 500 |
| 8 | = | 501 - 1000 |

| Species | L-N-An-1-N | L-N-An-2-N | L-N-An-3-N | L-N-An-4-N | L-N-An-5-N | L-N-EcBy-1-N | L-N-PtMr-1-N | L-N-PtMr-2-N | L-N-RBy-2-N | L-N-RBy-3-N | L-N-RZ-1-N | L-N-RZ-2-N | L-N-RZ-3-N | L-N-RZ-4-N | L-N-RZ-5-N | L-N-RZ-7-N | L-N-RZ-8-N | L-S-1-N | L-S-2-N | L-S-3-N | L-S-TC-1-N | L-S-TC-3-N | O-E-CsPt-1-N | O-E-CsPt-1-N | O-N-BPt-1-N | O-W-Ar-1-N | O-W-Ar-2-N | O-W-Ar-3-N | O-W-CnPt-1-N | O-W-CnPt-1-N | P-B-1-N | P-Mn-1-N | P-Mn-1-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carcharhinus sp. (1 to 2 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Carcharhinus sp. (>2 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Taeniura meyeni (1 to 2 m wing span) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dasyatis purpureus (<1 m wing span) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aetobatis narinari (1 to 2 m wing span) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manta sp. (2 m wing span) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Manta sp. (>3 m wing span) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cheilinus undulatus (>0.5 m <1.0 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| Cheilinus undulatus (>1.0 m <1.5 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| Cheilinus undulatus (>1.5 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Various Scaridae species (<0.6 m) | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 5 | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 6 | 3 | 4 | 3 | 0 | 0 | 4 | 4 | 4 | 3 | 2 | 3 | 0 | 0 | 3 | 0 | 3 |
| Various Scaridae species (>0.6 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 1 | 0 |
| Gymnosarda unicolor (Dogtooth Tuna) (>1.5 m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

most sightings, however, were greens. Many small/juvenile turtles were observed from shore at the Turtle Cove nature area. Several large male green tutles were also observed. Throughout the survey period, sea turtles were observed in various behaviors including surface basking/floating, breathing, foraging, resting on the seafloor, and swimming underwater. Most specimens sighted did not appear to be frightened by the divers. One old curious green turtle encountered in the lagoon approached a video-graphing diver, bumped its head into the video camera, and then swam slowly away. Smallest sizes (carapace length) were estimated at 30 to 45 cm (12 to 18 in) and maximum sizes were about 1 to 1.5 m (3.3 to 5 ft). An estimated 16 individual sea turtles were observed during one visit to the observation platform at the Turtle Cove inlet to the barachois. About 14 of these were thought to be hawksbills and one possibly an olive ridley (*Lepidochelys oliveacea*).

### *3.3.2 Marine Mammals*

Several marine mammal sightings were made. One instance 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 vicinity of our dive vessel, moving to the north and out of sight while jumping and spinning. Another observation was made from the deck of our dive vessel while transiting the northern lagoon area in a heavy chop. Four or five spinner dolphins were seen and they approached our vessel with one individual riding the bow wave of our speeding boat for several minutes.

### *3.3.3 Seagrasses*

Only 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. This study site was a slightly raised patch reef with low, dispersed coral formations and sandy substrate situated at about 3 m (10 ft) of depth. 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 remnant of a seagrass bed that ran lengthwise parallel to shore between the beach and a silted/remnant near-shore coral reef in about 1.2 to 2.4 m (4 to 8 ft) of water. Only a single live blade of *T. cilliatum* was witnessed. The rhizomes were visible and top portions of the roots exposed. Some short brown stalks were attached to the rhizome and slightly green nubs were present where the grass blades should have been. Three rough strands of seagrass were observed in the survey area at L-S-2-N. Some seagrass was noted on one benthic transect at L-N-RZ-1-N. No 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. Neither floating nor beached seagrass leaves were noted. No *Halophila decipiens* was seen.

### *3.3.4 Anthropogenic/Hazardous Materials*

The majority of anthropogenic 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, which most often was encrusted. Fishing line was coiled around reef formations and strung over short distances, affecting several formations and species. Some portions of fishing line were noticeably incorporated in the skeletal structure of growing coral formations. 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). Fishing line was noted and recorded in at least six study sights both inside and outside the lagoon. A dark phase *Epinephalus multinotatus* (whiteblotched grouper) was seen at O-W-CnPt-2-G with about 60 cm (2 ft) length of fishing line extruding from its mouth.

Most of the coral formations entangled with fishing line also showed signs of breakage an/or some algal overgrowth or disease; some were toppled over. It is not possible however to determine if those conditions were pre-existing. Boat lines (ropes) of various dimensions were observed among coral formationsl in at least three study sites. Most of these were encrusted, strung over winding lengths of reef corals, and grown into the coral formation in places.

No fish traps or nets were sighted during any of the dives.

Four derelict anchors were observed and one occurrence of possible small anchor scaring was noted. Two of the derelict anchors were small boat type anchors. The other two were large ship anchors. One of the ship's anchors was a modern Navy type anchor, approximately 2.5 m (8 ft) long; it was located in 23 m (75 ft) 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. It was approximately 3 m (10 ft) long; like the Navy anchor it was heavily encrusted with *Tubastraea micrantha.*

Only two sightings of miscellaneous metallic debris were made. Several sections of wire cable approximately 4 cm (2 in) 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.

Only two observations of potentially hazardous material were made. 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 1 by 0.75 by 0.75 m (3.3 by 2.5 by 2.5 ft). No other observations of potentially hazardous or toxic materials were made during any of the dives. A short distance from these mooring blocks a sunken, but intact channel marker buoy was observed.

## 3.4 WATER QUALITY

Water quality readings of temperature, salinity, DO, and pH were consistent among the study sites and were associated with low variance (**Table 3-28**). Turbidity readings, however, showed the greatest variation among sites and ranged from 0.16 to 4.79 NTU (**Table 3-28**; **Figure 3-8**). 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 (**Table 3-28**; **Figure 3-8**). Visibility was moderate to poor at most sites. Within the lagoon, visibility was greatly affected by the presence of short mucus strings drifting in the water column as well as suspended sediment. 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) (**Figure 3-9**). DO levels were also greater outside the lagoon: the mean DO concentration was 6.2 milligrams per liter (mg/l) on seaward reefs and 5.9 mg/l on lagoon reefs.

**Table 3-28**. Mean values of water quality readings (±standard deviation [*SD*]) recorded by a Hydrolab® Datasonde unit at each Diego Garcia study site during two-hour intervals. (Data for site O-W-4-G were not available). Turbidity values were not available for site L-S-5-G. [DO: dissolved oxygen]

| Site | Depth (m) | Depth (ft) | Temperature (C) | Salinity (ppt) | DO (mg/l) | pH | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| **O-W-SmPt-1-G** | 6.13 | 20.0 | 26.04 | 35.16 | 6.33 | 7.41 | 0.23 |
| ***SD*** | *(0.26)* | | *(0.04)* | *(0.01)* | *(0.14)* | *(0.01)* | *(0.61)* |
| **O-W-CnPt-2-G** | 6.26 | 20.5 | 26.07 | 35.07 | 6.31 | 7.43 | 0.16 |
| ***SD*** | *(0.26)* | | *(0.03)* | *(0.01)* | *(0.09)* | *(0.01)* | *(0.50)* |
| **O-E-CsPt-2-G** | 8.19 | 270.0 | 25.89 | 34.83 | 5.95 | 7.56 | 2.14 |
| ***SD*** | *(0.09)* | | *(0.03)* | *(0.01)* | *(0.07)* | *(0.01)* | *(0.55)* |
| **L-N-EcBy-2-G** | 5.05 | 16.6 | 26.40 | 35.13 | 6.14 | 7.37 | 4.79 |
| ***SD*** | *(0.16)* | | *(0.01)* | *(0.00)* | *(0.12)* | *(0.00)* | *(1.55)* |
| **L-N-RZ9-G** | 12.95 | 42.5 | 26.09 | 35.16 | 5.62 | 7.83 | 2.57 |
| ***SD*** | *(0.07)* | | *(0.06)* | *(0.01)* | *(0.19)* | *(0.01)* | *(0.54)* |
| **L-N-RZ-10-G** | 2.45 | 8.0 | 26.44 | 35.10 | 5.98 | 7.70 | 3.43 |
| ***SD*** | *(0.07)* | | *(0.13)* | *(0.01)* | *(0.47)* | *(0.03)* | *(3.60)* |
| **L-N-Rby-3-G** | 1.83 | 6.0 | 26.35 | 35.09 | 5.99 | 7.44 | 0.36 |
| ***SD*** | *(0.13)* | | *(0.16)* | *(0.01)* | *(0.18)* | *(0.01)* | *(0.98)* |
| **L-N-Rby-4-G** | 5.08 | 16.7 | 26.49 | 35.10 | 5.76 | 7.63 | 0.84 |
| ***SD*** | *(0.05)* | | *(0.03)* | *(0.01)* | *(0.15)* | *(0.01)* | *(0.29)* |
| **L-S-4-G** | 1.71 | 5.6 | 26.91 | 35.00 | 5.83 | 7.48 | 2.66 |
| ***SD*** | *(0.02)* | | *(0.04)* | *(0.01)* | *(0.19)* | *(0.01)* | *(5.91)* |
| **L-S-5-G** | 0.89 | 3.0 | 26.87 | 35.04 | 5.79 | 7.46 | - |
| ***SD*** | *(0.03)* | | *(0.05)* | *(0.01)* | *(0.09)* | *(0.00)* | - |

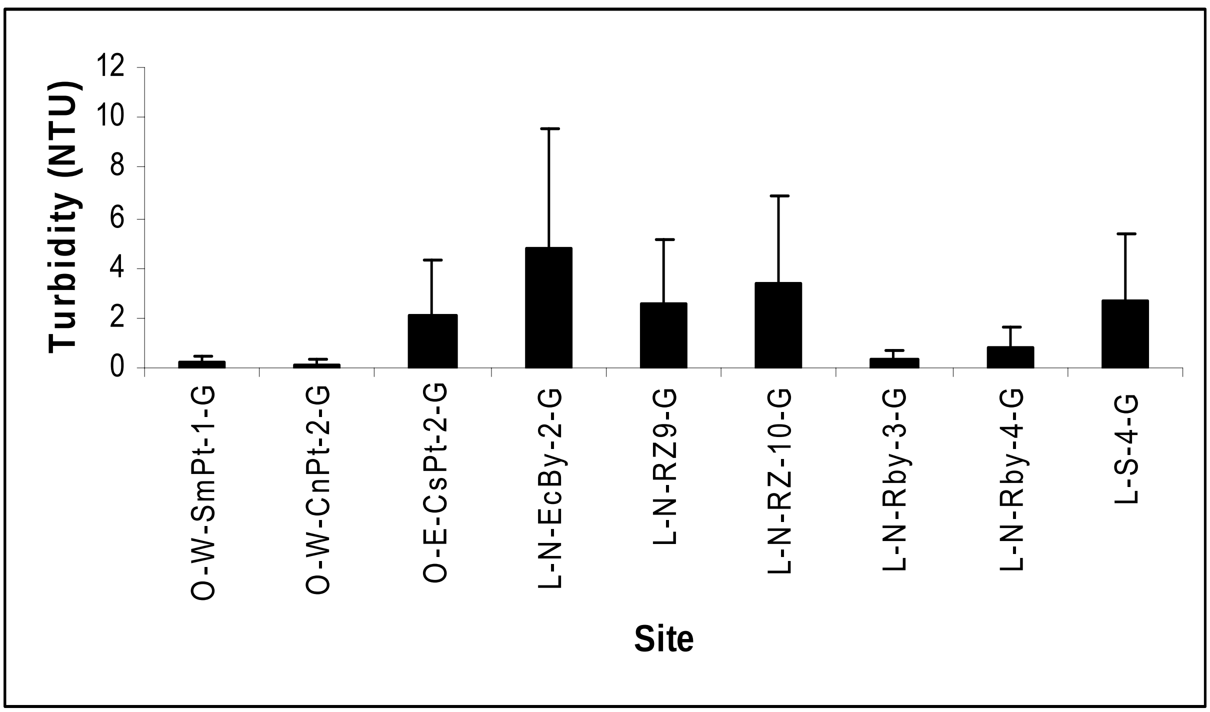


**Figure 3-8.** Mean water turbidity (±standard deviation; NTU) measured on seaward and lagoon reefs at Diego Garcia in July and August 2004. Water depths ranged from 15 to 17 m (50 to 55 ft) on seaward reefs and 3 to 15 m (10 to 49 ft) in the lagoon.

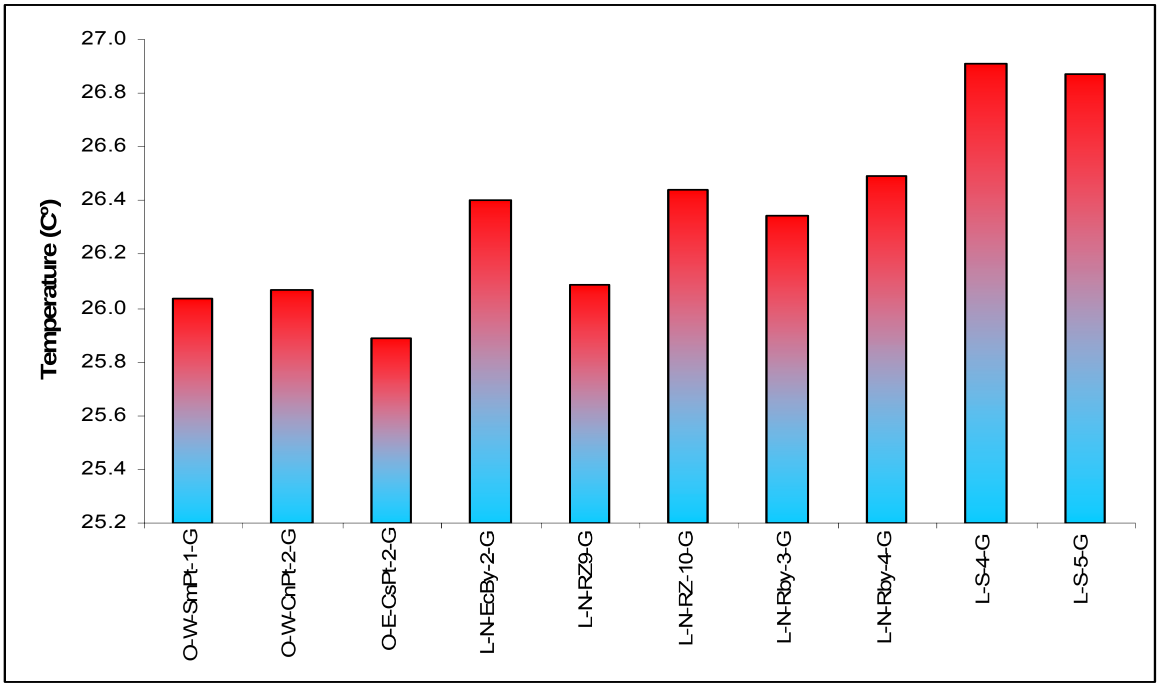


**Figure 3-9.** Temperatures recorded by Hydrolab® Datasonde unit at study sites at Diego Garcia (values for O-W-Ar-4-G).

# 4.0 DISCUSSION

## 4.1 ENVIRONMENTAL CONDITIONS

**Regional Significance of Environmental Conditions at Diego Garcia**–Geographically, Diego Garcia is an isolated bit of land in the center of the Indian Ocean. It is also to some degree separated from other islands and banks of the Chagos Archipelago. Furthermore, its current role in hosting the U.S. Naval Support Facility Diego Garcia removes it in a socio-geographic sense. Marine biological work following construction of the base focused primarily on the northern regions of the Chagos (Sheppard 1999a). Aside from the Stoddart et al. expedition in 1967 (Stoddart and Taylor 1971), a few studies have concentrated on Diego Garcia (Menzie et al. 1980, Smith 1999), however none have focused on the reef habitats in a comprehensive way.

Diego Garcia is not entirely "cut off" from the surrounding reef systems of the Indian Ocean as evidenced by its reef communities that reflect those of both eastern and western portions of the greater Indian Ocean. At the same time, overall diversity at Diego Garcia and Chagos is lower (fewer species per biological family group) than other portions of the Indian Ocean, reflecting a geographic isolation. Recovery and adaptation of reef populations on the Chagos islands therefore probably rely to a great extent on local resources. The relatively undisturbed nature of marine habitats of the Chagos may play an important role in recovery of highly degraded reefs of the surrounding Indian Ocean, a region greatly affected by direct and indirect human activities (Sheppard 2001; Linden et al. 2002). However, reefs were devestated in the Chagos by the 1998 bleaching-related mortality of corals in the Indian Ocean (Sheppard 2003). It appears that the recovery of coral populations at isolated reefs such as those of the Chagos is preceding those of other locations exposed to human disturbances (including destructive fishing, coral mining, and terrigenous runoff) (Linden et al. 2002). We witnessed abundant juvenile corals occupying dead coral substrate in all our study sites. It was estimated that the 1998 mass bleaching event caused more than 50% coral mortality in the northern and central Indian Ocean (Maldives, Seychelles, Aldabra, Chagos), East Africa (Kenya, Tanzania, Mozambique), Sri Lanka and some reefs of India. The recovery of the Chagos reefs may positively influence the recovery of downstream reefs of the Seychelles and East Africa. The critical regional condition of reefs has accentuated the importance of viable and diverse upstream sources of reef organisms. The environmental conditions of Diego Garcia and the Chagos are therefore critical on a regional scale.

**Local Environmental Setting**–The almost completely enclosed Diego Garcia lagoon creates a unique marine environment that has a limited exchange of seawater with the surrounding oceanic waters. Reefs in the lagoon are challenged by slow circulation (flushing) and sedimentation, and relatively shallow depths, particularly the south lagoon (Menzie et al. 1980; Miller 1997). Ocean side reefs have a narrow expanse for optimal reef development between the shallow algal reef flats and the precipitous fore reef drop off (Stoddart 1971a, Dumbraveanu and Sheppard 1999). The shelf that surrounds the atoll supports a continuous reef habitat (107.8 $km^2$ [41.6 $mi^2$] between the depths of 4 and 24 m (13 and 79 ft); Dumbraveanu and Sheppard 1999). The recent mass mortality of corals and Alcyonacea caused by the 1998 bleaching event may have changed more than the community structure. While abundant juvenile Scleractinia were observed during this study and indicate that recovery is taking place, the reef framework and topographic complexity were greatly diminished by the mass bleaching event (Sheppard 2002). Before 1998, the dissipation of wave energy was aided by "three lines of defense:" thickets of Acroporidae, the algal ridges along the reef flat edge, and the reef flats (Sheppard 2002). The first line of defense is now been greatly diminished which may cause accentuated coastal erosion, possibly further reef structural changes, and slow down the reef recovery process (Sheppard 2003).

**Storms and Earthquakes**–Its position in the middle of the Indian Ocean near the equator places Diego Garcia outside of most major storm tracks (Stoddart 1971c, Sheppard 1999c, Naval Central Meteorology and Oceanography Detachment Diego Garcia 2002). This leaves most of the oceanographic processes that influence reef growth at Diego Garcia to the more consistent cycle of regular ocean currents and occasional impacts from heavy storms and tropical depressions. Geologically however, the Chagos Archipelago is highly active (Stoddart 1971c, Naval Central Meteorology and Oceanography Detachment Diego Garcia 2002, Henstock and Minshull 2003). It is possibly among one of the most seismically active oceanic regions not associated with a crustal plate border region (Eisenhauer et al. 1999). Direct evidence of impacts from seismic activity on reefs is not available, although descriptions of earthquakes destroying and drowning small low-lying islands (Eisenhauer et al. 1999, Darwin 1842 *[not seen]*) certainly indicates that nearby seismic activity can have severe effects on reefs. Seismic activity at greater distances around the Chagos and the Indian Ocean can impact reefs of Diego Garcia through the production of tsunamis. The Krakatoa eruptions of 1883 generated tsunamis that affected islands and shorelines around the Indian Ocean (Choi et al. 2003). Bourne (1888) describes unusual high tides during his 1885 expedition to Diego Garcia and recent effects of a complete wash-over of a portion of the atoll's rim. Stoddart (1971c) also discusses the potential for wash-over events from ocean waves. Tsunamis generated by the 2004 Sumatra sub-sea earthquake may have affected reef habitats at Diego Garcia. As of the time of this report's production, there are no data regarding the fate of study sites surveyed for the report. Because of the great depths surrounding Diego Garcia the tsunami did not build before passing the atoll. Yet large waves washed over the eastern side of Diego Garcia and affected some of the terrestrial vegetation and accentuated shoreline erosion (Sheppard in press). Coral reefs did not seem affected by the tsunami in 2004 (Sheppard in press).

## 4.2 CORAL REEF COMMUNITIES

### *4.2.1 Condition of Coral Reefs at Diego Garcia*

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% down to 40+ m (131+ ft) (Sheppard 1999b). Scleractinia represented most of the coral cover. From 40 to 60 m, coral cover was 25%. Coral diversity was highest at 20 m (66 ft) water depth both on 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 1999b).

In 1999, 12% coral cover remained on Chagos reefs (Sheppard 1999b). Dead coral substrate covered 80% of the seafloor (1999b). 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 (Linden et al. 2002). This ENSO event trigered 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). Hard and soft corals in the southern atolls of the Chagos were affected down to a depth of 35 m (115 ft) (Sheppard et al. 2001). Seaward reefs were more affected than lagoon reefs (Sheppard 1999c). Soft corals were almost entirely removed down to a depth of 15 m (49 ft). Reefs of the northern Chagos were not as badly affected. Sponges, worms, and algae bioeroded the dead coral substrate and generated large amounts of coral rubble. Entire dead colonies of Acroporidae were removed from the reef. Diego Garcia was one the sites where branching Acroporidae were severely affected (Sheppard et al. 2001). Smith (1999) found that in 1999, inspite of the massive die off, there were large specimens from all the major scleractinian families, both in and outside the Diego Garcia lagoon that had survived the bleaching event and appeared to be in good health. However, the death and bioerosion of Chagos reefs caused significant negative changes of reef topographic complexity (rugosity) which will probably cause significant reef community structural changes.

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 (>50 m; 164 ft) may be sheltered from large temperature excursions occurring near the sea surface and may have retained pre-1998 characteristics.

In July and August 2004, evidence of massive Scleractinia mortality was still a common characteristic at most sites we surveyed at Diego Garcia. The most notable exceptions were encountered at three Anchorage Area sites (L-N-An-3, 4 and 5) and at the deep study site in the Main Pass. The monospecific reef (*Leptoseris mycetoseroides* – tentative i.d.) found in the anchorage area at L-N-An-3-Nv showed no evidence of bleaching or mortality. Likewise, the mixed Scleractinia assemblages at L-N-An-4 and 5 showed no evidence of mortality or significant bleaching. All three of these sites were at or below a depth of 23 m (75 ft). The deep study site in the Main Pass was strongly dominated by large specimens of the ahermatypic Dendropphylliidae *Tubastraea micrantha;* there was no evidence of bleaching or significant coral mortality in the Main Pass at depths below 20 m (65 ft). 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 was 25.8% (±13.7 *SD*) (12 seaward and 19 shallow lagoon sites [all lagoon sites except those in the Anchorage Zone]) (**Tables 3-1**, **3-2**, **3-5**, and **3-8**). 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*). The depth range at the seaward sites was 15 to 30 m (50 to 100 ft), and 3 to 15 m (10 to 49 ft) at shallow lagoon sites (**Table 2-3**). On the fore reef terrace edge, the Scleractinia cover was made of Acroporidae (41.1% mean occurrence), Poritidae (43.4%), Faviidae (8.8%), Pocilloporidae (4.2%), and Agaricidae (2.5%) (**Table 3-3**). 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%) (**Table 3-9**). Many of the Scleractinia recorded during our quantitative surveys on the seaward and lagoon reefs were juveniles measuring 15 cm (6 in) 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.

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 reasonable speculation 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 reefs 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 must have been a regional but temporary surge in the availability of dissolved nutrients which probably promoted the growth of macroalgae on the dead reef substrate. This in turn probably 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 as 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.

Prior to 1998, Alcyonacea and Gorgonacea were part of the major components of the reef benthos in the Chagos (Reinicke and Van Ofwegen 1999). Other major components were Scleractinia and calcareous algae. In some locations Alcyonacea covered entire reef substrates. The coral mass mortality of 1998 probably had substantial impacts on Alcyonacea of seaward reefs considering that the current cover is fairly low and highly variable 6.7% (±8.1 *SD*) (**Tables 3-1** and **3-2**). Alcyonacea cover in 2004 on shallow lagoon reefs was even lower than on seaward reefs and also highly variable: 0.2% (±0.5 *SD*).

### *4.2.2 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 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 (**Figure 3-8**).

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.

Sedimentation and sediment resuspension have probably increased in the lagoon considering human-induced changes including coastal construction, land reclamation, dredging, ship traffic, and anchoring; and bioerosional sediments produced since the mass mortality of corals in 1998. Effects of increased sedimentation and changes in the level of stress in corals within the lagoon need to be assessed physiologically. This is particularly important considering that these reefs are in a phase of recovery from a catastrophic event.

### *4.2.3 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 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 unit effort 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 strictly for sustenance, limitations on fishing (landings and fishing areas) should be considered to promote the recovery of undeniably affected reefs.

Another significant way by which humans at Diego Garcia can help with the recovery of reefs is the strict prohibition of anchoring. If anchoring has to take place, then anchors need to be carefully placed so that corals are not impacted. Indiscriminate anchoring on reefs destroys decades of growth within a few seconds. If recreational anchoring is necessary then permanent moorings should be considered as a means to protect reefs from physical damage.

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 nutrient enrichment when reefs are degraded or when herbivory is reduced (Szmant 2002). The reefs of Diego Garcia are both degraded (recovering from the 1998 mass mortality) and the fish population is mostly composed of planktivorous fishes (Spalding 1999). Disposal of nutrient-rich effluent into the lagoon should be avoided considering the limited tidal flushing and the current condition of the reefs. Hydrocarbons that come in contact with corals can cause coral mortality and reef structural changes (decreased topographic complexity) (e.g., Bak 1987; Guzman et al. 1991). Releases of hydrocarbons are to be avoided.

The designated Anchorage Area, although a necessity, is a potential source of increased sedimentation in the lagoon. Section 4.2.2 discusses potential impacts of increased sedimentation on Scleractinia of the lagoon. Ideally, the installation of permanent moorings would be preferable from an environmental stand point. The anchoring within the Anchorage Area 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 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 of sedimentation. The optional use of permanent moorings (particularly for vessels on anchor for months on end) may lessen the volume of new sediments produced in the Anchorage Area and thus help with the recovery of degraded reefs in the lagoon.

## 4.3 REEF FISHES

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 1999a). 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. 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.

#### *4.3.1 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). It is uncertain is whether biogeographic isolation or the lower number of surveys has had a greater influence on the total number of fish species currently identified at Chagos.

Chagos appears to have a lower species richness of fishes than surrounding Indian Ocean reefs and this should be kept in consideration when making direct comparisons of diversity. 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. Seeking out and recording every possible fish species present was not the purpose of this study; identification of new records were not actively sought but were secondary to the fish censuses. Fish collecting and identification techniques such as the use of nets, hook and line, spears and poison stations to collect fishes were not employed here. Our fish census relied exclusively on visual observations and focused on reef habitats and particular fish families. Poor underwater horizontal visibility during this survey hindered the discovery of previously undocumented species and potentially lowered the total number of species recorded at each study site.

During this survey, eight new occurrence identifications for fish species were made (**Table 3-4**). Also, *Paracanthurus hepatus* (palette surgeonfish), which had never been collected in the Chagos, but was sighted once at Isle Anglaise to the north, was common in two of our study sites. Two of the new records are of fairly distinct and common fishes: the caerulean damselfish (*Pomacentrus caeruleus*) and the orange socket surgeonfish (*Acanthurus auranticavus*).

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 by GMI roving surveys in 2004 at Diego Garcia (about 50 additional identifications were made outside of roving surveys by GMI and Navy dive teams which added to the overall species list, reaching nearly 200 species). An average of 59 species was recorded at 11 study sites around Diego Garcia. The roving survey method is known for recording higher species numbers than stationary surveys (as employed by Spalding [1999]). Visibility was certainly a limiting factor during our study, but more significantly, GMI roving diver surveys were conducted at shallower depths and at a variety of reef types inside the Diego Garcia lagoon as well as outside. This variety of reef types and depths also may account for the higher heterogeneity found among Diego Garcia study sites.

#### *4.3.2 Fish Communities*

Groupers (Serranidae), snappers (Lutjanidae), and emperors (Lethrinidae) were variably distributed among the reefs of Diego Garcia. Sites near points and passes had larger populations of these fishes as well as larger individuals. 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. 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 desired effects. Another indication of the healthy fish population in this general area was the popularity of Main Pass as a recreational fishing spot.

“No-take” zones work to preserve fish abundance; and if properly located, they limit extraction of the larger sized fishes as well (Berkeley et al. 2004a). This turns out to be a successful management strategy because larger female fishes have a higher reproductive potential and therefore can better contribute to sustaining fish populations (Berkely et al. 2004b; Palumbi 2004). It is also important to recognize and protect spawning aggregations during spawning seasons of groupers and snappers. These recent fish surveys indicate that the Replenishment Zone at Diego Garcia appears to be located in a prime area for conserving a high number of larger fishes. If necessary, the zone can be expanded to include Middle and East Islands and passes where some of the especially large species and individual fishes occur. Setting “no-take” periods around Simpson Point, Cust Point, Horsburgh Point, and South Point on a rotating schedule may be helpful as well. It may seem counter-intuitive and discouraging to fishers to set aside reef areas from fishing activities, but conservation zones have been found to improve fishing results over larger geographic areas (Salm 1984; Johnson et al. 1999; Roberts et al. 2001).

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 were dominated by a single species, the bullethead parrotfish (*Chlorurus sordidus*). At the predator side of the trophic spectrum, the 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 the high end of their respective recorded size ranges (Allen et al. 2003, Myers 1999, Fishbase.org 2005). One reason for this may be the decreased shark population.

### *4.3.3 Species of Concern*

As apex predators in the ocean, sharks are vital parts of healthy marine ecosystems. Sharks and barracudas (Sphyraenidae) were noticeably rare at the ocean side reefs, which is surprising considering previous reports of a large 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. This highlights the importance of BIOT administration efforts to limit commercial fishing licenses and to patrol for illegal fishing activities and the importance of local Diego Garcia fishing rules restricting the landing of sharks. And, again, it stresses the importance and potential for Diego Garcia and the Chagos as a biological refuge in the troubled waters of the Indian Ocean region.

The number of Napoleon/humphead wrasse (*Cheilinus undulates*) observed at several ocean side reefs was encouraging. A group of five Napoleon/humphead wrasse were observed on two separate dives. In each case, the speciments ranged in size from one meter to two meters in estimated fork length. Such sightings are considered significant due to the paucity of these fishes at other sites in the Indo-Pacific where they were once common. Napoleon/humphead wrasse are favored in the live fish trade because of their large sizes (US Newswire 2004). The United Kingdom, European Union, and United States support the addition of the Napoleon/humphead wrasse to the Convention on International Trade in Endangered Species (CITES) because of their slow reproductive rate and the increasing level of harvest on them (Clover 2004). The Chagos and Diego Garcia may represent a refuge for these fish since they are generally not often caught on hook and line, and they are not sought by local fishers. A recent addition to fishing regulations by the BIOT Representative at Diego Garcia has restricted the landing of Napoleon/humphead wrasse.

#### *4.3.4 Influence of Reef Habitats on Fish Communities*

The habitats of the ocean side reefs were mostly similar to each other but their fish populations varied 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 fusilears and anthiases. Groups of chubs/drummers (Kyphosidae) and breams (Lethrinidae) also frequented the terrace edge. The distribution of large groupers (greater than 50 cm [20 in]) 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*) were present at sites supporting lower live coral cover, and more rubble, such as those off the airport and north of Cust Point. These sites had fewer species and lower abundances of fishes.

The reef habitats of the lagoon varied greatly. Poor visibility, generally less than 10 m (33 ft), affected overall fish counts. 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 1.5 m (5 ft) in the southern lagoon basin and the lagoon shelf to 15 m (50 ft) at the base of knolls and deeper still to greater than 29 m (93 ft) 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. 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 jacks/trevallies (Carangidae) 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 (whiteband damselfish [*Plectroglyphidodon leucozonus*] and jewel damselfish [*P. lacrymatus*]) were frequently associated with these algal patches. Damselfishes 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. Previous reports had described a larger population (Smith 1999). 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).

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 was definitely under stress. We witnessed high turbidity and sedimentation 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 1980). The skeletal remains of corals showed that this reef had previously 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. Despite the high turbidity, we observed one large grouper (40 cm [16 in], peacock grouper). Visual hunters probably have a difficult time catching prey in such low visibility. The presence of the large grouper and the scarcity of small ones may indicate that visibility fluctuates at this site. The effects of turbidity and sedimentation on the reef habitat and associated biota are probably exacerbated by the resuspension of sediments caused by wave action and tidal circulation (Rogers 1990; Telesnicki and Goldberg 1995; Fabricius 2005).

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. 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), we observed a small mono-specific coral reef (*Leptoseris mycetoseroides*). 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.

#### *4.3.5 Recreational Fishing at Diego Garcia*

Recreational fishing logs are an important part of grasping the “big picture” of fish populations at Diego Garcia. These records provide a continuous (yet more species restricted) look at the fish populations. Naughton and Tribble (1994) conducted a limited fishery survey and described some of the fishing activities at Diego Garcia. The fishery report by Mees and Polunin (1994) also details fishery activity and estimated total catch for Diego Garcia. The Marine Resources Assessment Group, Ltd. (MRAG) (1999) conducted a BIOT recreational fishery survey of the Chagos and Diego Garcia. These fishery reports urged caution and further study. No commercial, artisinal, or strictly subsistence fishery operates directly at Diego Garcia; however, the potential impact of recreational fisheries should not be held lightly. It has been found increasingly that recreational or “sport” fisheries can greatly impact fish stocks, rivaling and even surpassing commercial fisheries in areas (Coleman et al. 2004). More important than any label given to a fishery activity are the fishing statistics that indicate the level of resource extraction or the impact to a group of fishes. Efforts by the BIOT administration and fisheries officers to monitor and manage fishing activity at Diego Garcia have been positive resource management steps and are vital to maintaining the strength of the fish population. Evidence of fishing pressure was noticed during this study at most sites (e.g., fishing line tangled around reef formations and fishing poles). It is important to note that the reefs at Diego Garcia can easily be affected by over fishing, and recovery could be delayed due to geographical isolation and weakened reef conditions in the Indian Ocean in general.

### 4.4 OPPORTUNISTIC OBSERVATIONS

**Sea Turtles**–Sea turtles appear common around Diego Garcia (see results section 3.3.1). Individuals of varying sizes were seen regularly both inside the lagoon and outside. Turtles were often seen at the surface from the research vessels. Green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricate*) sea turtles are the primary species recorded from the Chagos (Dutton 1980); however, additional species may visit the islands or may have smaller populations. Only a single possible observation of an olive ridley sea turtle (*Lepidochelys olivacea*) was made from an observation platform at Turtle Cove. The green and olive ridley sea turtles have been listed on the IUCN (World Conservation Union) Red List, assessed in 2004 and 1996 respectively, as endangered. The hawksbill sea turtle has been listed as critically endangered as assessed in 1996. Surveys of beaches around the Chagos and Diego Garcia indicate that nesting does occur (Dutton 1980). Seagrass beds, a favored habitat for some sea turtle species, are not common at the Chagos or Diego Garcia. For more information on sea turtles at Dieqo Garcia see Mortimer and Day (1999) and Pepi (2005).

**Marine Mammals**–No significant conclusions can be drawn from the observations of marine mammals made during the reef surveys other than acknowledgment of at least one species, the spinner dolphin (*Stenella longirostris*; see results section 3.3.2). From our discussion with long-term residents at Diego Garcia, we know that spinner dolphin occur year round at Diego Garcia. Other marine mammals seen by these long-term residents included the humpback whale (*Megaptera novaeangliae*), a possible pilot whale, and a seal or sea lion.

**Seagrasses**–The condition of seagrasses at Diego Garcia is currently unclear. Historically, seagrasses have been underreported in the Chagos (Drew 1980). The primary species that does occur in the Archipelago and at Diego Garcia is *Thalassodendron ciliatum*, but was misidentified originally by Willis and Gardiner (1931 [*not seen]*) as *Cymodocea serrulata*. Prior to Drew (1980), reports of seagrasses had been restricted to Peros Banhos and Diego Garcia. Reports of seagrasses specifically at Diego Garcia are somewhat inconsistent in certain areas of the lagoon. Drew (1980) describes a wider distribution of seagrass in the Chagos, but a more limited distribution at Diego Garcia. Drew (1980) also describes the occurrence of *Halophila decipiens* at Peros Banhos, a previously unrecorded seagrass species for the Chagos. No *H. decipiens* was noted at Diego Garcia during the 2004 reef surveys. *T. ciliatum* in general does have limited distribution in area in places it does occur as described by Coles et al. (2004) because it is restricted to reef platforms and exposed reef edges. Ironically, though, the Saya de Malha Banks support what may be the largest seagrass beds in the world, covering a calculated 40,000 $km^2$ (15,444 $mi^2$) (Hilbertz et al. 2002). The Saya de Malha are a completely submerged set of banks located to the southeast of the Seychelles and about 1,300 km (808 mi) southwest of Diego Garcia. Seagrasses of the genus *Thalassodendron* are described as being dioecious perennial with woody, branched rhizomes. *T. ciliatum* is dispersed in the western Indian Ocean and western portion of the Pacific (Green and Short 2003).

The Stoddart and Taylor (1971) expedition of 1967 found the greatest distribution of seagrasses (recorded as *Cymodocea serrulata*) at Diego Garcia. A review of invertebrates collected around the atoll produces a list of 63 invertebrate species collected in seagrass beds (Stoddart and Taylor 1971). Several species of fishes collected in the Chagos have been recorded only from seagrass beds (Rajasuriya et al. 2004). Eight distinct sites at Diego Garcia are identified or referred to in Stoddart and Taylor (1971) as having seagrass: 1) Point Marianne, lagoon shore and flats; 2) Eclipse Point, seaward reefs and flats; 3) East Point, lagoon reef; 4) West Island, lagoon shore and reefs; 5) Rambler Bay, lagoon shore and reefs; 6) Cust Point, seaward reef; 7) Barton Point, seaward reef; and 8) Turtle Cove area/southern lagoon basin, near shore. In contrast, Drew (1980) described five sites with seagrass at Diego Garcia: 1) Eclipse Bay *extensive beds*, lagoon reef flat (area encompassing the marina to the end of POL pier); 2) Orient Bay *extensive beds*, lagoon reef flat (area along shore from Observatory Point to just north of Rambler Bay); 3) southern lagoon basin, southeast shore; 4) Eclipse Bay, lagoon reef; and 5) West Island, lagoon flats.

Of the extensive sites surveyed in the August 2004 reef surveys, only four locations contained minimal signs of *T. ciliatum*. Two sites in the southern lagoon basin (L-S-2-N and L-S-4-G) contained only a few sprigs. Some seagrass was noted along a benthic transect in the north lagoon near east island (L-N-RZ-1-N). A site in Rambler Bay (along the shore just north of L-N-Rby-3-G) looked to be a dead seagrass bed with only a single living blade noticed over a distance of 20 to 30 m (66 to 98 ft). The corals of the adjacent reef appeared mostly dead as well. No loose leaves were noted as detritus or washed ashore on beaches.

Walker (1986) wrote in a general biological description of Diego Garcia that there were “large patches of sea grass growing on the bottom of the lagoon….” Rhyne (1971) described the seagrass beds observed during the 1967 Stoddart and Taylor expedition:

> In Eclipse Bay at 0.3 to 1.0 m (1.0 to 3.3 ft) depths patches of seagrass occurred with few algal epiphytes and large areas of coral were covered at depths of 1.0 to 2.5 m (3.3 to 8.3 ft). Leaves of *T. ciliatum* were often found in drift at the high intertidal zone. Extensive *T. ciliatum* beds surrounding the three islands in the lagoon entrance contained algal species in a thick canopy of seagrass leaves. Seagrass patches were scattered about Eclipse Point.

While the focus of the surveys in 2004 were on coral reefs, it seems likely that more seagrasses would have been noted if they existed, however it is possible that some beds were missed and some may still exist especially around the islands of the lagoon mouth and around Eclipse Point and Barton Point.

**Anthropogenic/Hazardous Materials**–Anthropogenic materials were not common at reef sites visited during this survey. We found no evidence of careless discarding of refuse into the marine environment at the study sites. The majority of human-made items present on the reefs appear to be those accidentally or unintentionally left and related to marine activities such as fishing and boating. Fishing line, ropes (boating lines), and anchors were the most common items seen. Restricted access to marine areas as well as conscientious efforts of boat operators and users may account for the minimal amount of debris found on the reefs. The several beaches and shorelines visited in the lagoon and on the ocean side were largely free of anthropogenic debris as well.

As mentioned above, fishing and boating paraphernalia were the most common form of anthropogenic materials witness at study sites. Lines most likely lost due to snagging on coral formations appeared to pose no further entanglement threats to fishes, turtles, or diving seabirds. The derelict anchors were not located in high wave-energy areas where continuous motions could cause mechanical damage to reef formations. The impact of line entanglement on reefs has recently been investigated (Yoshikawa and Asoh 2004). Lines have been found to have a significant impact on reefs on which they have become entangled in Oahu, Hawai'i. Loss of fishing line while fishing on coral reefs is not uncommon, and should be figured in with the overall impact that fishing causes on a reef habitat. Derelict lines entangling reefs in the lagoon where wave energy is lower may present a lesser threat to coral formations.

Large amounts of floating human-made debris accumulate on the western side of the atoll as noted during our conversation with long-term Diego Garcia residents. This debris originates from distant sources and not Diego Garcia.

Hazardous toxic materials were noted at only one site visited by the Navy survey team. A discarded lead/acid type engine battery was seen near the edge of the entrance channel. Oil fuel spills have occurred and a review of records may help quantify the number and extent of these types of events. No obvious or direct impacts of spills on reef habitats and shoreline habitats were evident. Tar was not noticed on any lagoon beaches visited.

**Additional Observations**–Terrigenous input from the atoll environment was observed in the form of leaves and branches on the reefs. The overall presence of this material was minimal. Mention had been made of an unknown red-brown material that clouded and covered large portions of the lagoon sea surface for a short period in the recent past. The nature and source of the substance was unknown.

**Macroscopic Invertebrates**–The low number sea cucumbers observed in the lagoon was somewhat surprising as they were known to be more abundant in the past. We saw several starfish species but none were crown-of-thorns starfish (*A. planci*). Sea urchins were not common either on the seaward or the lagoon reefs. Crustaceans, other than land crabs, were not frequently observed. There were no lobsters in our study sites. At least two species of giant clams (*Tridacna* sp.) were observed both within the lagoon and on ocean side reefs. One site in the southern lagoon basin was noted with 43 dead *Tridacna* shell halves within a belt transect survey. These shells were unbroken and appeared to have been dead for five to ten years. Many other dead bivalve shells were noted at this site. Octopuses often produce shell middens of the remains of their prey, but the cause of the giant clam and other bivalve deaths is unknown and probably unrelated to predation by octopuses.

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## 5.0 CONCLUSIONS

Reefs of Diego Garcia are currently recovering from the disastrous coral bleaching and mortality event of 1998. Within the next 50 years, the future community structure (species composition and topographic complexity) of seaward reefs will probably be significantly different from that observed prior to 1998. One key aspect to the recovery of seaward reefs is the stabilization (natural cementation) of the underlying substrate on which coral recruits and juveniles grow (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). Lagoon reefs have equally suffered from the mass mortality event of 1998 but also show signs of recovery.

The topographic complexity on seaward reefs of the Chagos changed drastically, primarily because of the loss (removal) of Acroporidae and soft corals (Sheppard 2002); the reefs of the Diego Garcia lagoon lost vast areas of Mussidae (tentatively *Lobophyllia hemprichii*). Large Poritidae and Acroporidae are still present on lagoon reefs and serve to maintain a reasonable level of topographic complexity. In spite of the 1998 mortality event, very large healthy specimens, from every major Scleractinia family were present on both the seaward and lagoon reefs. These large survivors included measured specimens of tabular Acroporidae over 2 m (6.5 ft), Poritidae over 4 m (13 ft), Agariciidae over 1.5 m (4.8 ft), and Mussidae over 1.8 m (5.8 ft). Below 23 m (75 ft) on seaward reefs gorgonian sea fans over 3 m (9.75 ft) across were frequently encountered. The presence of these large specimens has undoubtedly mitigated the severity of the 1998 mortality event and will probably enhance recovery.

The reefs of Diego Garcia support a rich fish community. Individual specimens from many fish families were estimated to be at or above their maximum recorded sizes. No tumors, sickly lesions or abnormalities were observed on any fishes, although no specimens were removed from the sea for a detailed examination. Reef fish diversity is slightly lower at Diego Garcia than other reefs within the Indian Ocean region (Sheppard 1999, Winterbottom and Anderson 1999), however, this may simply be a reflection of reduced collection efforts. Nine tentative new records were made during this survey and additional new identifications are likely if more surveys are conducted. The fish assemblages appeared to be robust in 2004. They were variable, however, and at some sites they appeared to reflect the depressed live coral cover. Fish censuses at the southern and eastern portions of the ocean side reefs would complete the assessment of fish populations at Diego Garcia. It would also help to understand the relationship these reef fish populations have with the rest of the island. Additional interesting questions include the dynamics of fish populations in relation to unique lagoon habitats, the distribution of grouper populations, the seasonal occurrence of reef fishes, and the level of shark populations at Diego Garcia. The key issues involving the reef fishes of Diego Garcia relate to fishing activities, habitat condition, and impacts of naturally-induced disturbances on reef biota.

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# 6.0 RECOMMENDATIONS

## 6.1 RECREATIONAL FISHING

While current fishing appears productive at Diego Garcia, efforts to monitor and manage fishing activities and landings should continue. Many positive and successful steps have already been undertaken (e.g., creating a no-take Replenishment Zone, catch and release regulations, clearly posting new regulations, etc.). Operating with caution should continue to be a theme of the fisheries at Diego Garcia. A general consensus of experienced fishers at Diego Garcia is that there have been definite downward trends in site productivity at reef locations inside and outside of the atoll.

Although hook and line fishing provides a significant recreational passtime for residents of Diego Garcia, it is not justifiable in its present form. The global importance of the marine resources at Diego Garcia and the other Chagos reefs and islands must take precedence over the recreational interests of local residents and visitors.

To ensure that fishing does not move beyond the sustainable level on reef fishes several options should be considered.

- The no-fishing Replenishment Zone should be expanded to include the Main Pass, Middle Pass and Barton Pass, and a 200 m (656 ft) radius around all channel marker buoys. Small reefs, with substantial numbers of fishes are present adjacent to some of these markers buoys. These reefs exist in part because no anchoring has occurred next to the buoys. Many of the fishes associated with these small reefs are very vulnerable to over-exploitation and should be protected.
- Signs should be attached to buoys to demarcate the Replenishment Zone, and other selected areas to ensure that fishermen and divers do not accidentally utilize off-limits or restricted areas,
- Bottom fishing should be limited to one day per week and bottom fishing areas should be rotated as presented in **Table 6-1**. The highly sought after larger groupers, snappers and emperors are very vulnerable to over exploitation. Large individuals of these slow growing species are over 50 years old. Their removal from the population can result in serious impacts to the overall fish population as well as to other forms of reef life.

**Table 6-1.** Recommended bottom fishing closure areas and time periods.

| Area | Closure Period | Open Period |
|---|---|---|
| Simpson Point to Barton Point | Sept 2005 to Sept 2008 | Oct 2008 to Oct 2009 |
| Cust Point to Horsburgh Point | Sept 2006 to Sept 2009 | Present to August 2006 |
| South Point (below 7°27'78") eastern and western sides of Diego Garcia | Sept 2005 to Sept 2009 | To be determined |

In addition to the above, other measures which would serve to safeguard fish stocks include the following:

- Setting catch size limits or landing limits for groupers, snappers, and emperors.
- Restricting the uses of steel leaders to minimize the necessity to bring sharks onto or near fishing vessels in order to release them.
- Collecting logbook trip records for all fishing vessels and conducting periodic landings surveys of shore fishing activities

- Preparing a yearly report on fishing activity from all monitoring records.
- Prohibiting net fishing, trap fishing, bleach fishing and spear fishing at all locations and under all circumstances. These prohibitions should include the use of small hand nets to collect specimens for aquariums. All of these techniques result in long term adverse impacts to marine organisms and result in numerous secondary adverse impacts to non-target species

## 6.2 RECREATIONAL DIVING

Recreational diving should be allowed at Diego Garcia, but only in the form of breath-hold/snorkel diving. Self contained underwater breathing apparatus (SCUBA) and surface supplied air systems are not presently allowed for recreational use. This prohibition against the recreational use of scuba or surface supplied air should continue. If recreational compressed air diving were to be allowed it should be restricted to areas of permanent mooring buoys or live boating practices should be employed.

The dominant Scleractinia in Diego Garcia belong to the family Acroporidae. Most of these species grow in tabular or branching forms that are fragile. The failure of many recreational divers to maintain proper buoyancy, to properly control their submersible pressure gauges, octopus regulators, camera gear and other dive equipment frequently results in breakage or damage to corals. Such impacts can produce significant long-term adverse effects. Divers should not be allowed to wear gloves. Individuals wearing gloves tend to grab onto corals and other marine life, damaging or killing it. Gloves are not needed from a safety perspective; wearing gloves should be prohibited. Divers frequently disturb marine life; for example, cutting up sea urchins with knives to attract fish. Moving, touching or disturbing marine life in any manner should be prohibited. Many forms of marine life do not appear to be alive, but in fact are perfectly healthy. For example, divers often think that sea fans and stony corals are dead and remove them for souvenirs. Old bottles often serve as homes for small fishes, octopus, and so on; and they are also frequently collected. The removal of all marine life, shells and submerged objects should be prohibited by recreational divers, waders or beach goers. These prohibitions also, include the prohibition of spear fishing.

## 6.3 ANCHORAGES

**Recreational Anchorage**–Anchoring by small recreational vessels has produced severe impacts to corals and fish stocks in many areas of the world. Although evidence of such anchor damage at Diego Garcia is very limited, the potential for such impacts is high. To avoid these problems, recreational boaters and fishermen should be prohibited from anchoring while fishing, swimming, or snorkeling. Drifting or live boating practices should be used instead.

**Anchorage Area**–The designated Anchorage Area, although a necessity, is a potential source of increased sedimentation in the lagoon. Section 4.2.2 discusses potential impacts of increased sedimentation on Scleractinia of the lagoon. Ideally, the installation of permanent moorings would be preferable from an environmental stand point. The anchoring within the Anchorage Area 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 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 of sedimentation on corals. The optional use of permanent moorings (particularly for vessels on anchor for months on end) may lessen the volume of new sediments produced in the Anchorage Area and thus help with the recovery of degraded reefs in the lagoon.

## 6.4 RECOMMENDED STUDIES

(1) **Long-Term Monitoring of Marine Resources**–Yearly monitoring of selected study sites established during the 2004 survey should be conducted to assess:

- Diversity, abundance, and size of bony fishes, elasmobranches, and deep demersal fishes
- Diversity and abundance of reef building corals and soft corals

- Diversity and abundance of echinoderms (asteroids, echinoids, holothurids)
- Occurrence and diversity of submerged aquatic vegetation
- Occurrence and diversity of mollusks
- Coral diseases and bleaching
- Water quality (temperature, salinity, dissolved oxygen, turbidity, pH)

In addition to visiting these selected sites, rapid ecological reconnaissance level observations of larger areas within each of the primary marine habitat types should be conducted (seaward reefs, pass reefs, replenishment zone, anchorage area, north lagoon, and south lagoon). Trained marine ecologists should perform this monitoring; this effort would require approximately ten diving days by four scientists.

Local personnel should record on a monthly basis and at noon, the sea surface water temperature, water transparency (Secchi disk method), and sea surface salinity over the same reef area. Local personnel should also routinely document all unusual events related to the marine environment. Such documentation should be done by local natural resource managers and recreational fishing boat captains. For example, if large sharks are sighted or extraordinary fishes caught, the date, time, location, sea and weather conditions should be recorded. If possible, photos should be taken and the weight and fork length of the fishes recorded. If unusual water conditions are encountered, such as a red tide or any type of sea surface discoloration, the same type of information should be recorded, along with the physical extent and duration of the event. The presence of dead fishes or other dead marine life should, of course, also be carefully documented. If possible, water samples should be obtained and fixed with a 10% formalin and seawater solution.

(2) **Delineation of Coastal Resources**–Delineate coastal natural resources (coral reefs, submerged vegetation, wetlands, coastal vegetation) using hyperspectral and LIDAR (Light Detection and Ranging) imagery.

## 6.5 ENVIRONMENTAL OUTREACH

(1) **Educational Posters**-Produce and display a series of educational posters on local marine resources and their significance.

(2) **Brochure**–Develop a brochure for military and support staff entitled “Marine Ecosystem Treasures of Diego Garcia, British Indian Ocean Territory.”

(3) **Field Guide**–Develop and distribute a field guide of marine resources specific to Diego Garcia.

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# APPENDIX A

## LIST OF FIGURES

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**Figure A-1.** Ocean side reef off southern end of airport runway (O-W-Ar-2-N; deep)
*[Photo: S. Smith]*

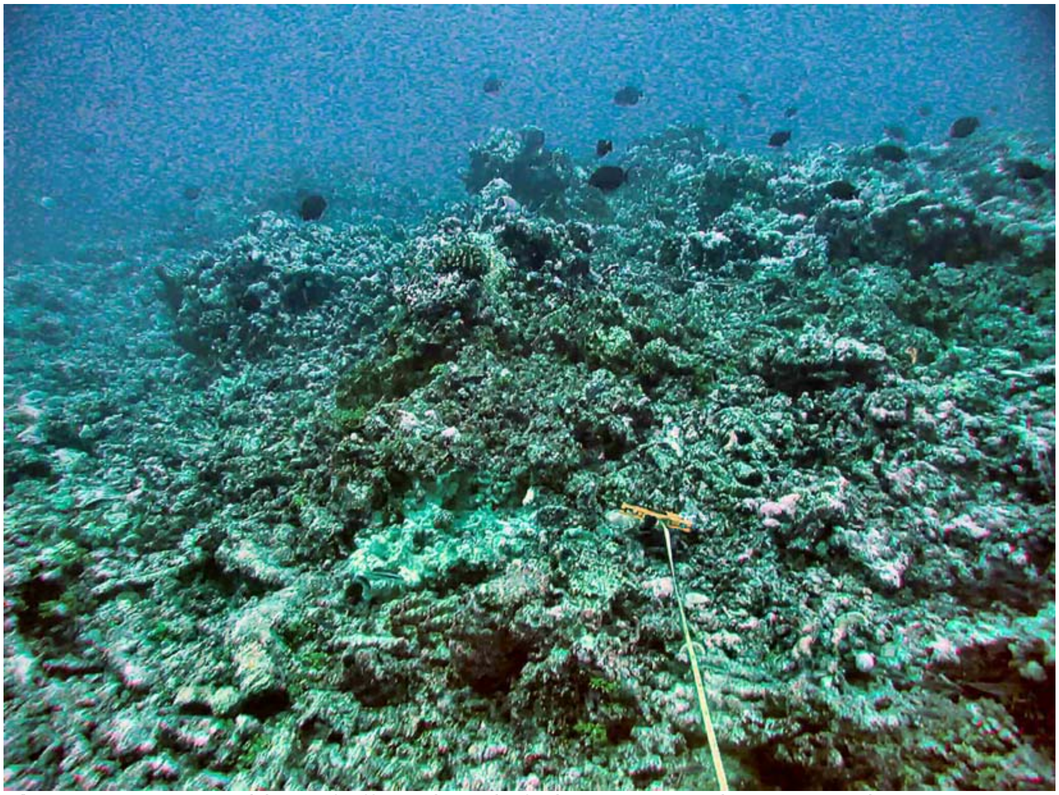

**Figure A-2.** Ocean side reef off south end of Airport runway (O-W-Ar-4-G) *[Photo: D. Evans]*

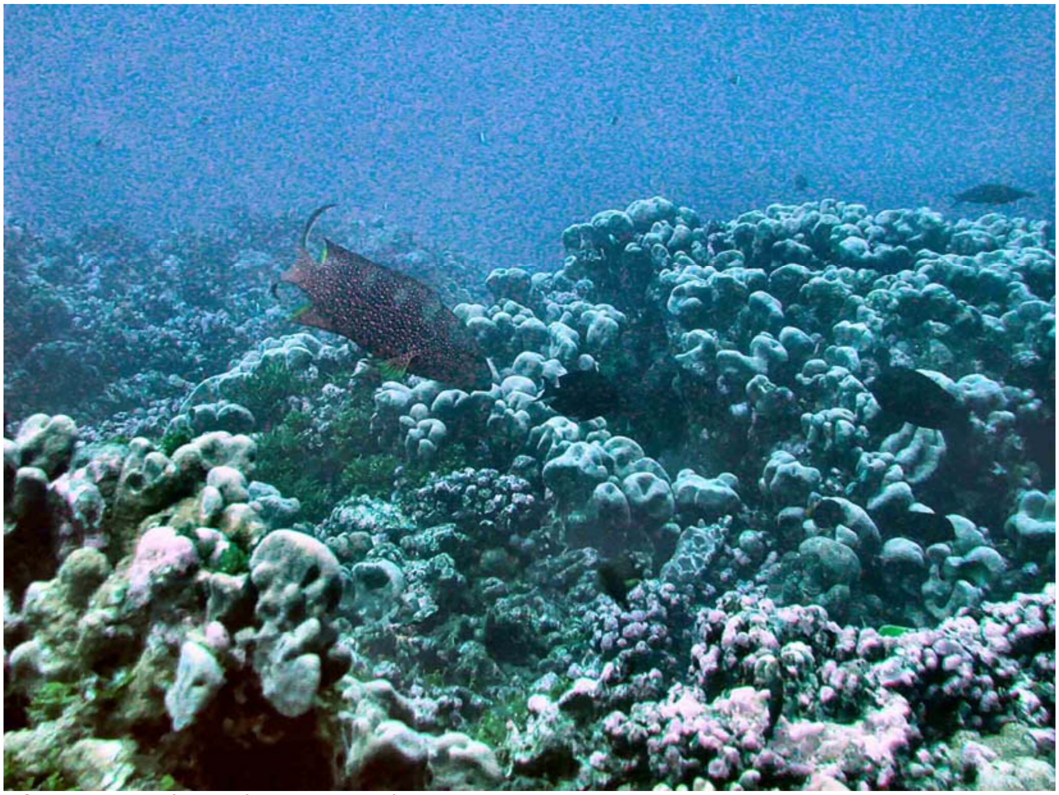

**Figure A-3.** Airport (O-W-Ar-4-G) *[Photo: D. Evans]*

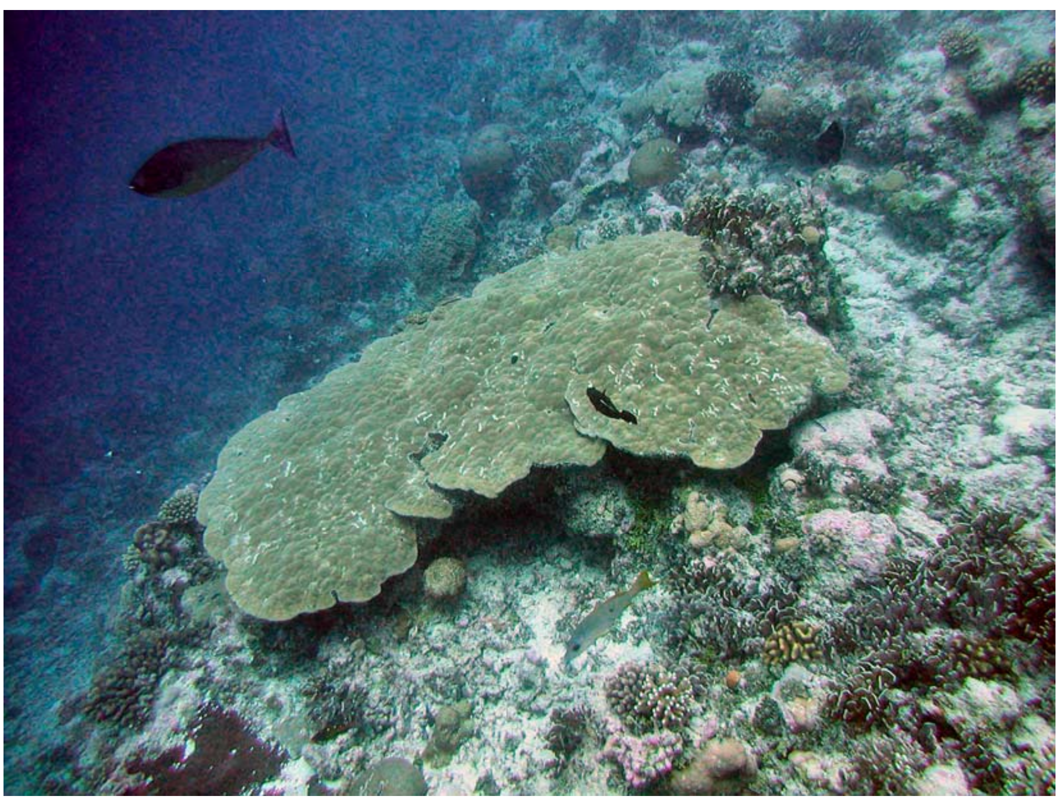

**Figure A-4.** North side of Cust Point (O-E-CsPt-1-N; deep) *[Photo: S. Smith]*

**Figure A-5.** Cust Point (O-E-CsPt-1-N; medium depth) *[Photo: S. Smith]*

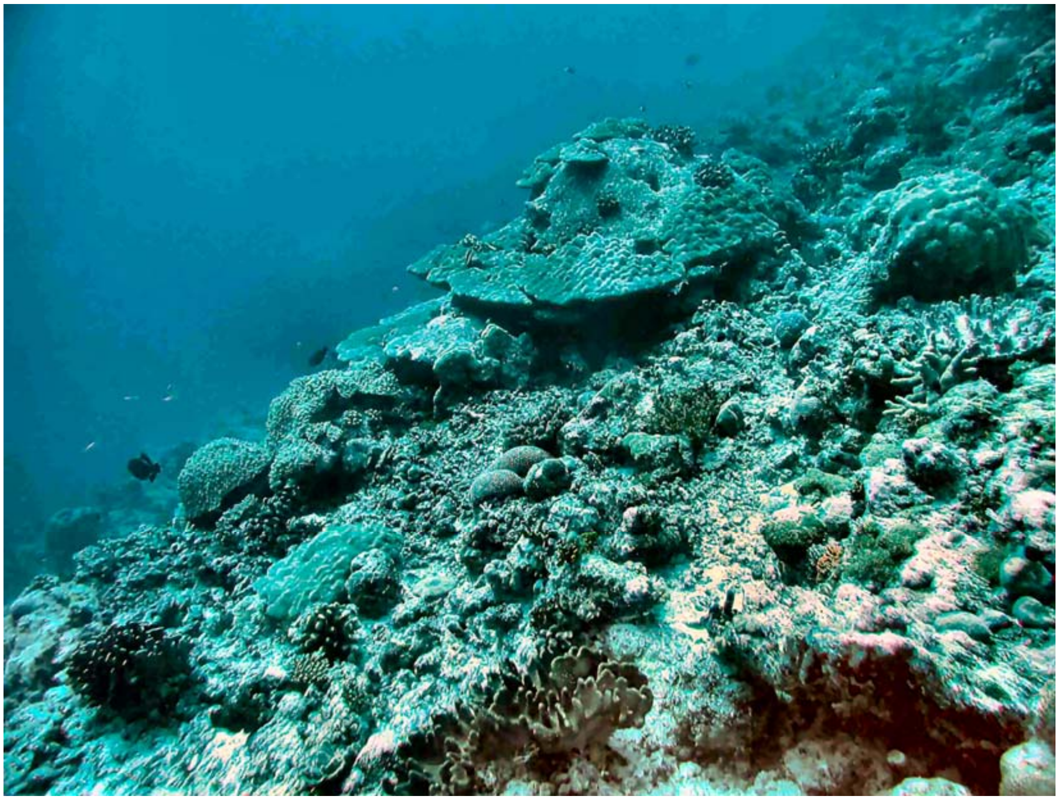

**Figure A-6.** Ocean side reef north of Cust Point (O-E-CsPt-2-G) *[Photo: D. Evans]*

**Figure A-7.** Cust Point (O-E-CsPt-2-G) *[Photo: D. Evans]*

**Figure A-8.** Ocean side reef north of Simpson Point (O-W-SmPt-1-G) *[Photo: D. Evans]*

**Figure A-9.** Simpson Point (O-W-SmPt-1-G) *[Photo: D. Evans]*

**Figure A-10.** Simpson Point (O-W-SmPt-1-G) *[Photo: D. Evans]*

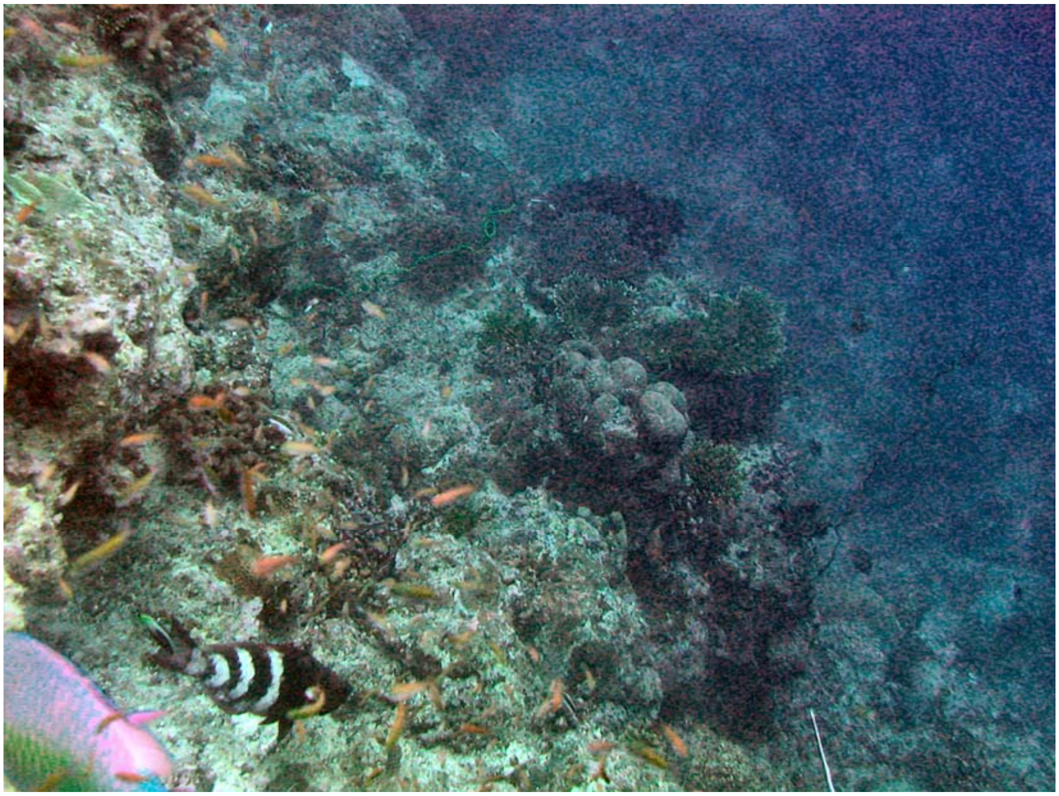

**Figure A-11.** Off Cannon Point at medium depth (O-W-CnPt-1-N) *[Photo: S. Smith]*

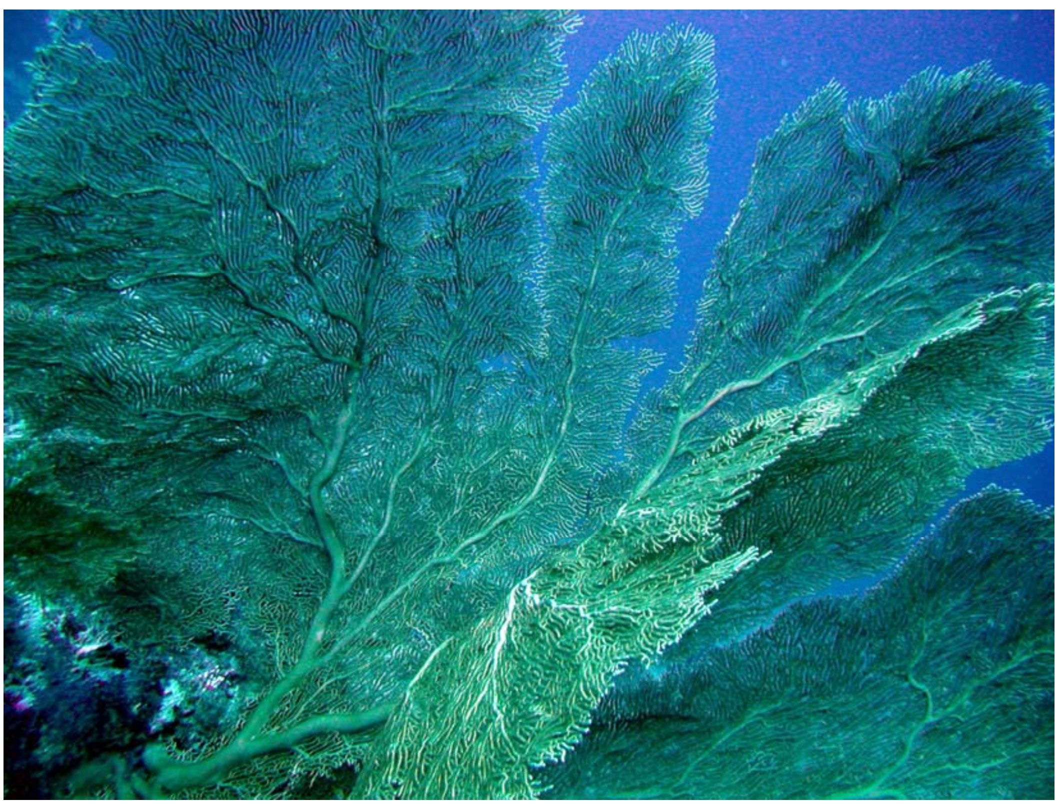

**Figure A-12.** Cannon Point (O-W-CnPt-1-N; deep) *[Photo: S. Smith]*

**Figure A-13.** Cannon Point (O-W-CnPt-1-N; deep) *[Photo: S. Smith]*

**Figure A-14.** Ocean side reef off Cannon Point (O-W-CnPt-2-G) *[Photo: D. Evans]*

**Figure A-15.** Cannon Point (O-W-CnPt-2-G) *[Photo: D. Evans]*

**Figure A-16.** Cannon Point (O-W-CnPt-2-G) *[Photo: K. Deslarzes]*

**Figure A-17.** Giant anemone with Chagos anemonefish (*Amphiprion chagosensis*) at Barton Point (O-N-BPt-1-N; medium depth) *[Photo: S. Smith]*

**Figure A-18.** Barton Point (O-N-BPt-1-N; deep) *[Photo: S. Smith]*

**Figure A-19.** Main Pass (P-M-1-N; deep) *[Photo: S. Smith]*

**Figure A-20.** Main Pass (P-M-1-N; medium depth) *[Photo: S. Smith]*

**Figure A-21.** Northern Replenishment Zone near Middle Pass (L-N-RZ-1-N)*[Photo: S. Smith]*

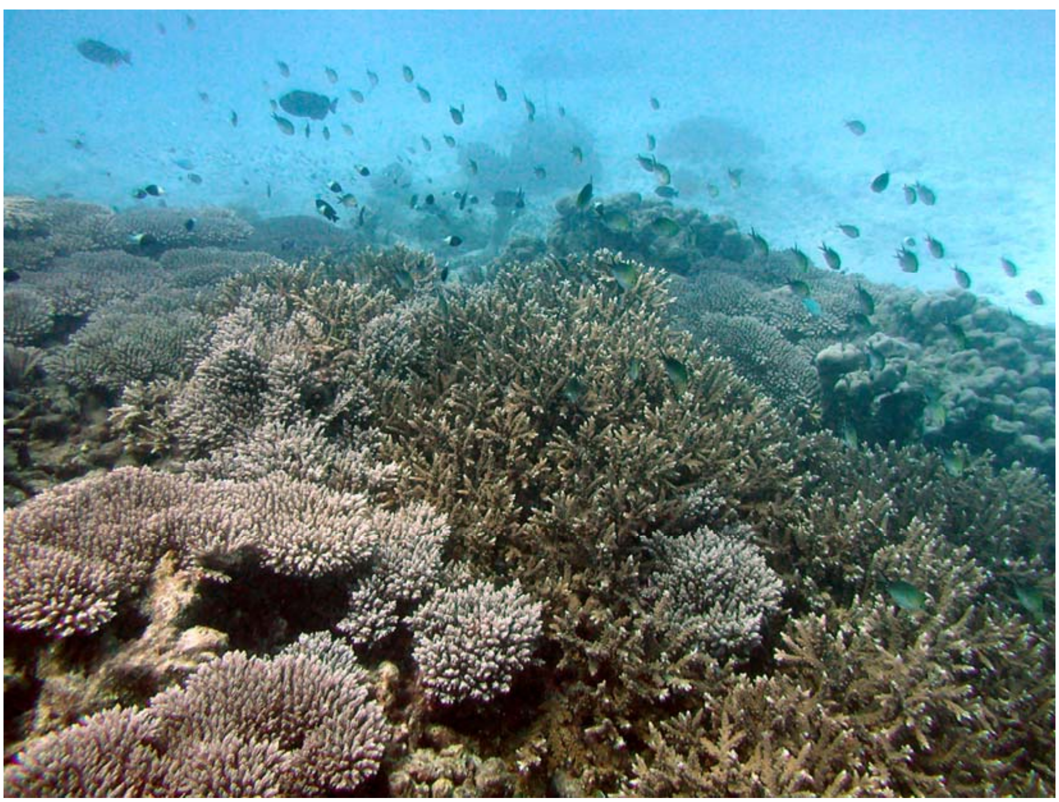

**Figure A-22.** North Replenishment Zone south of East Island (L-N-RZ-2-N) *[Photo: S. Smith]*

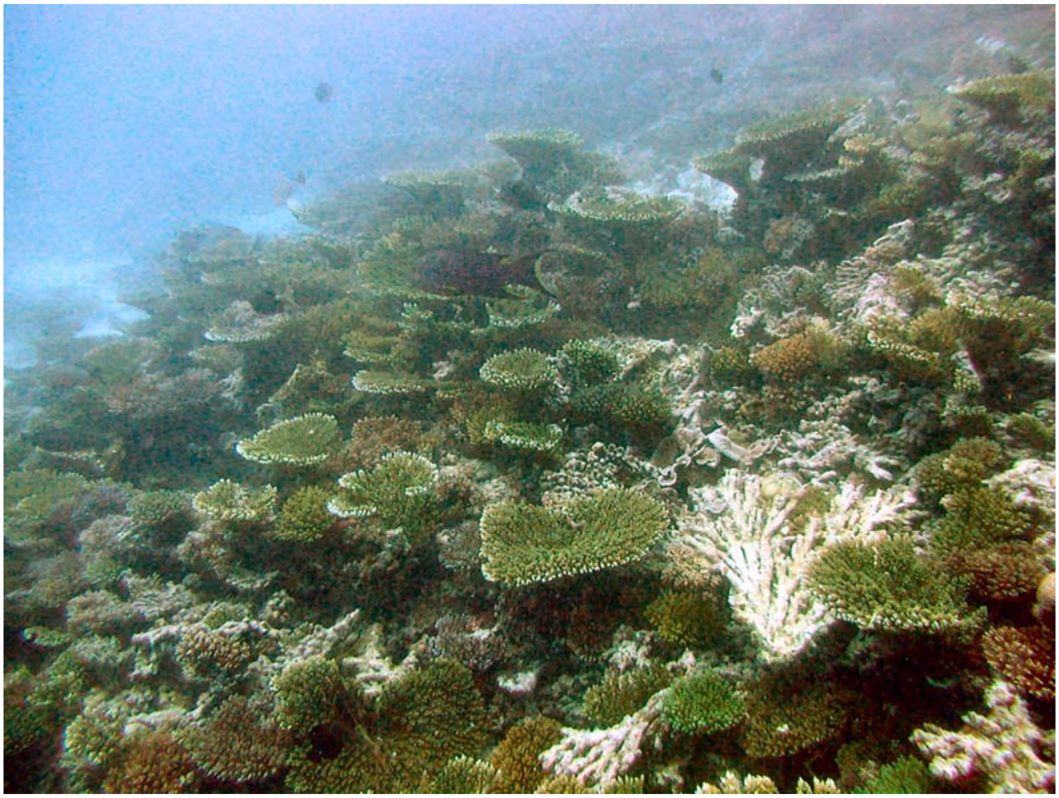

**Figure A-23.** Middle Replenishment Zone south of Spur's Reef (L-N-RZ-4-N)*[Photo: S. Smith]*

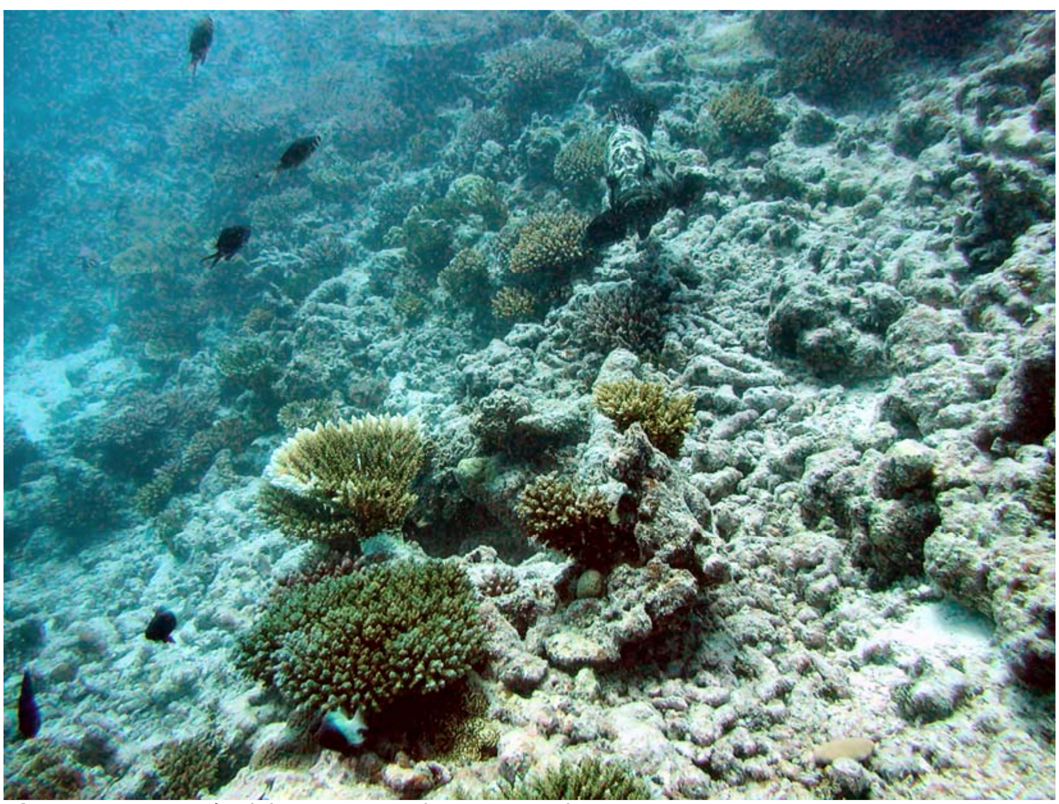

**Figure A-24.** Replenishment Zone (L-N-RZ-4-N) *[Photo: S. Smith]*

**Figure A-25.** Replenishment Zone (L-N-R-Z-4-N) *[Photo: S. Smith]*

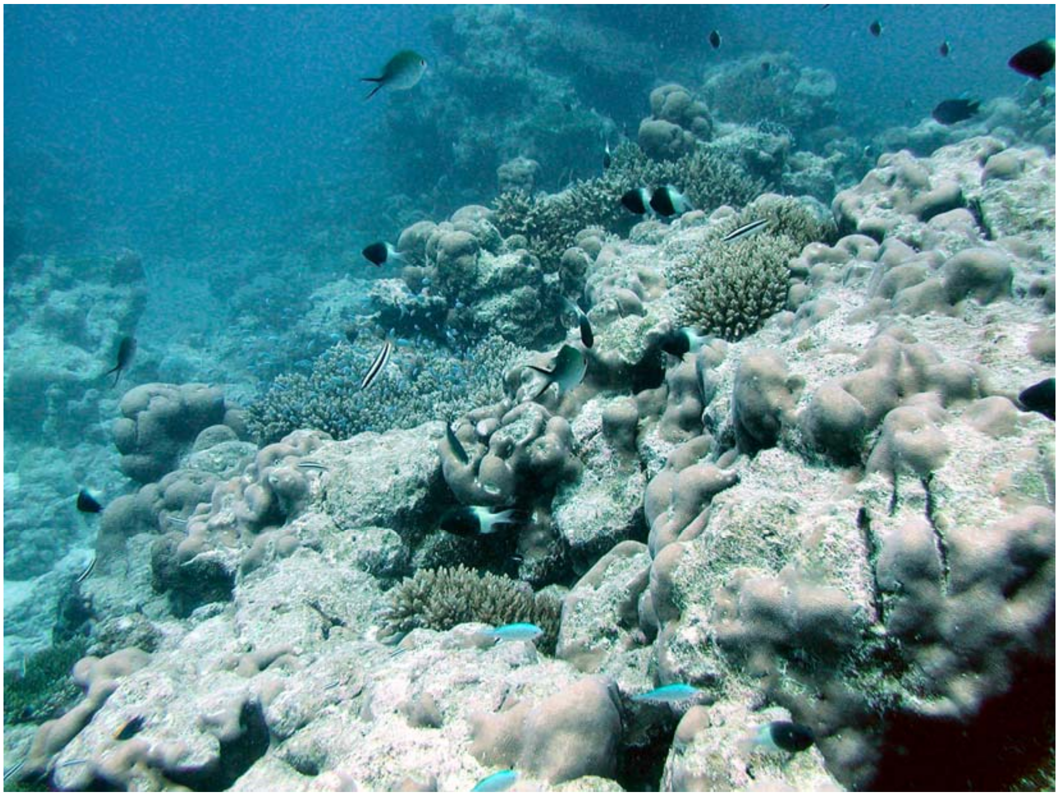

**Figure A-26.** Replenishment Zone (L-N-RZ-6-N) *[Photo: S. Smith]*

**Figure A-27.** Replenishment Zone (L-N-RZ-6-N) *[Photo: S. Smith]*

**Figure A-28.** Replenishment Zone knoll reef south of Middle Island (L-N-RZ-9-G) *[Photo: D. Evans]*

**Figure A-29.** Replenishment Zone (L-N-RZ-9-G) *[Photo: D. Evans]*

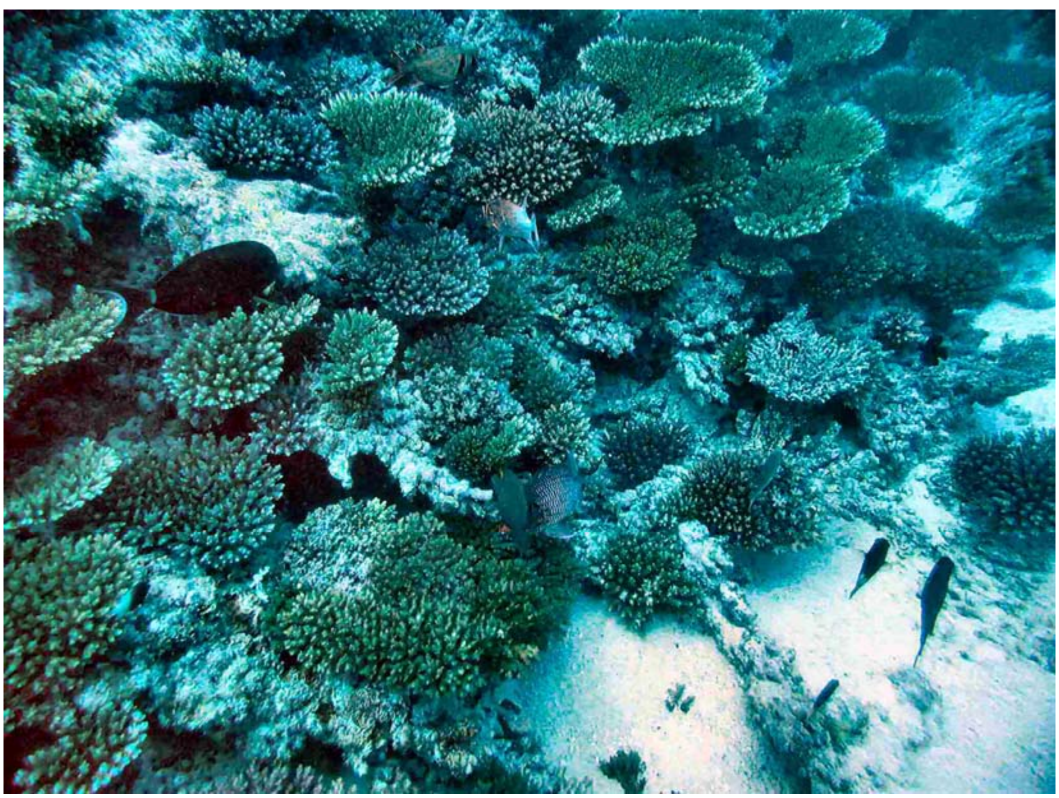

**Figure A-30.** Replenishment Zone (L-N-RZ-9-G) *[Photo: K. Deslarzes]*

**Figure A-31.** East Replenishment Zone lagoon shelf (L-N-RZ-10-G) *[Photo: P. Leahy]*

**Figure A-32.** Replenishment Zone (L-N-RZ-10-G) *[Photo: P. Leahy]*

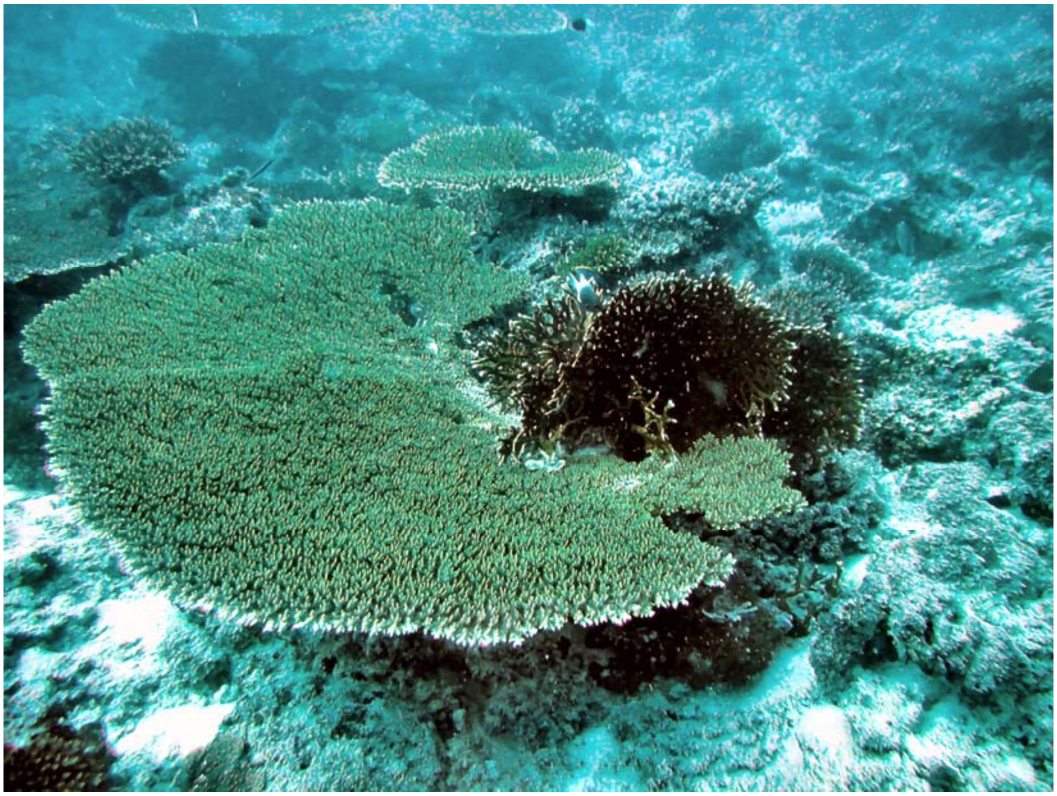

**Figure A-33.** Anchorage Area (L-N-An-1-N) *[Photo: S. Smith]*

**Figure A-34.** Anchorage Area (L-N-An-1-N) *[Photo: S. Smith]*

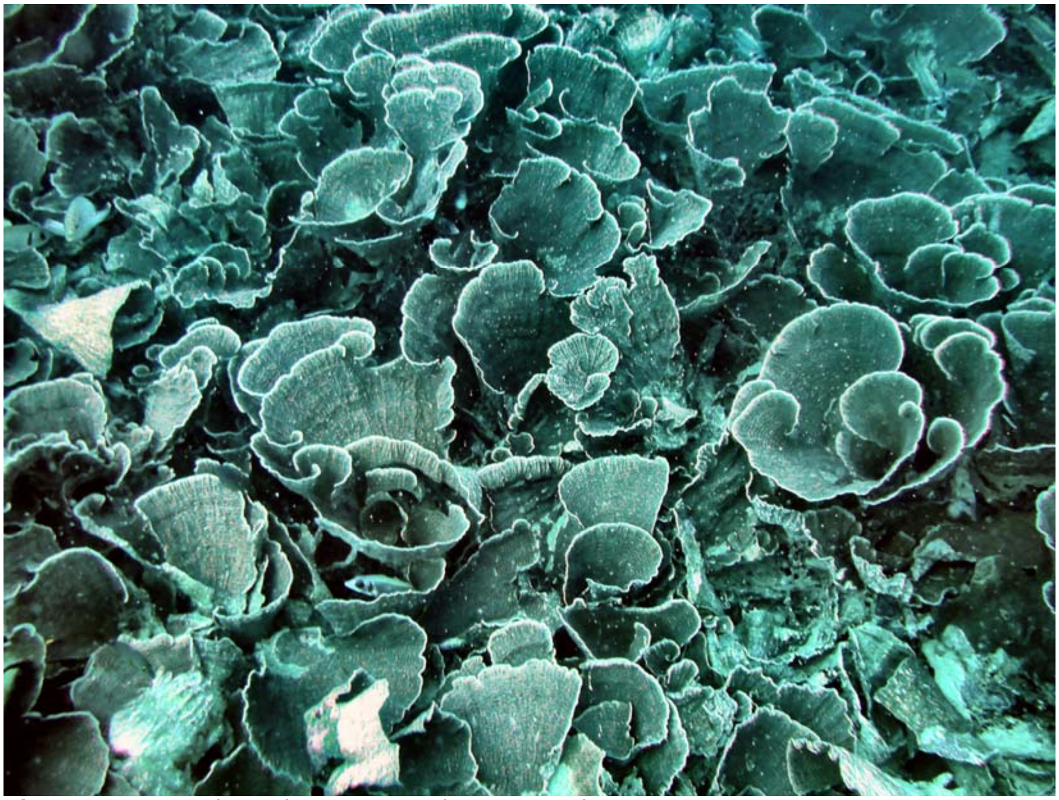

**Figure A-35.** North Anchorage Area (L-N-An-1-N) *[Photo: S. Smith]*

**Figure A-36.** Anchorage Area (L-N-An-1-N) *[Photo: S. Smith]*

**Figure A-37.** Tabular Acroporidae at Eclipse Bay (L-N-Ecby-1-N) *[Photo: S. Smith]*

**Figure A-38.** Shore patch reef in Eclipse Bay north of boat basin (L-N-EcBy-2-G) *[Photo: D. Evans]*

**Figure A-39.** Eclipse Bay (L-N-EcBy-2-G) *[Photo: D. Evans]*

**Figure A-40.** Eclipse Bay (L-N-EcBy-2-G) *[Photo: D. Evans]*

**Figure A-41.** Lagoon shelf patch reef in Rambler Bay (L-N-Rby-3-G) *[Photo: D. Evans]*

**Figure A-42.** Rambler Bay (L-N-Rby-3-G) *[Photo: P. Leahy]*

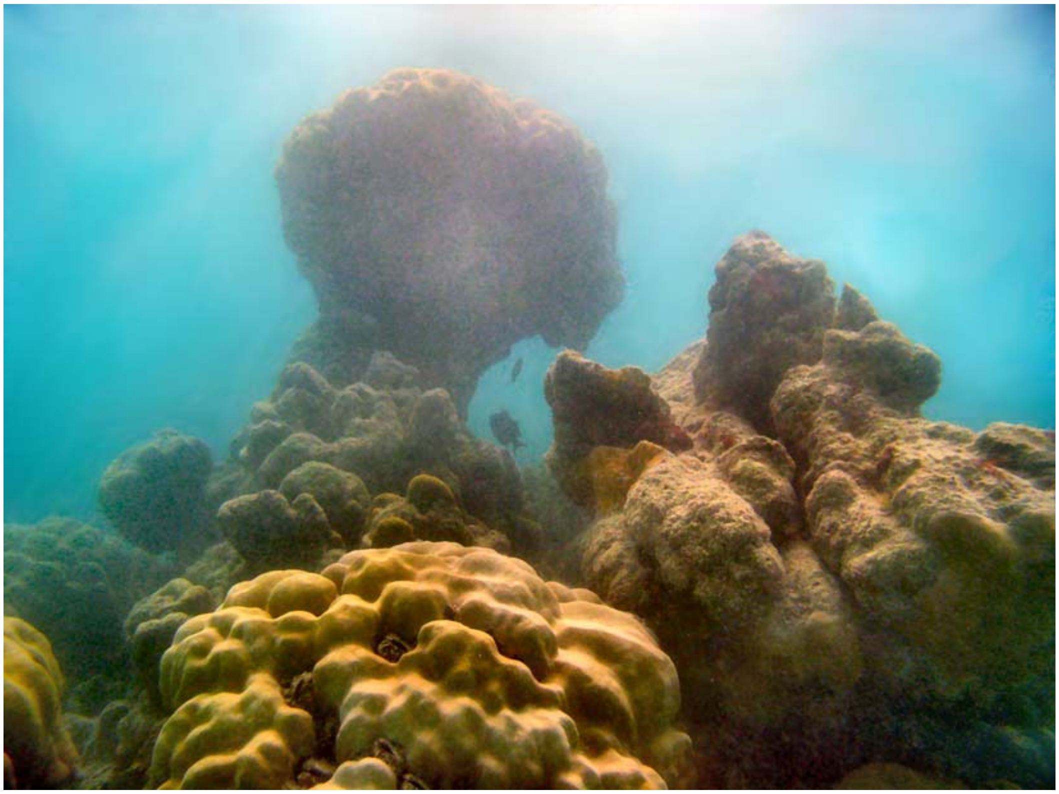

**Figure A-43.** Rambler Bay (L-N-Rby-3-G) *[Photo: D. Evans]*

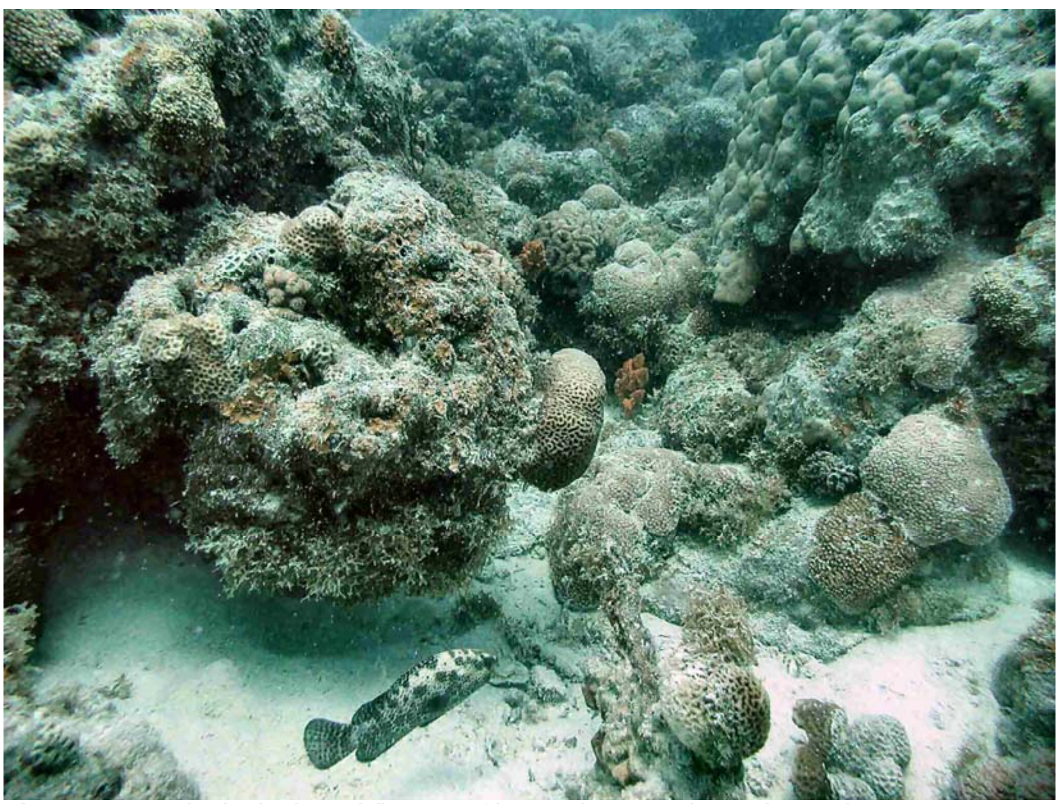

**Figure A-44.** Minni Minni patch/knoll reef in Rambler Bay (L-N-Rby-4-G) *[Photo: D. Evans]*

**Figure A-45.** Rambler Bay (L-N-Rby-4-G) *[Photo: D. Evans]*

**Figure A-46.** South lagoon basin patch reef (L-S-4-G) *[Photo: P. Leahy]*

**Figure A-47.** South lagoon (L-S-4-G) *[Photo: P. Leahy]*

**Figure A-48.** South lagoon shelf patch reef (S-L-5-G) *[Photo: D. Evans]*

**Figure A-49.** South lagoon (S-L-5-G) *[Photo: P. Leahy]*

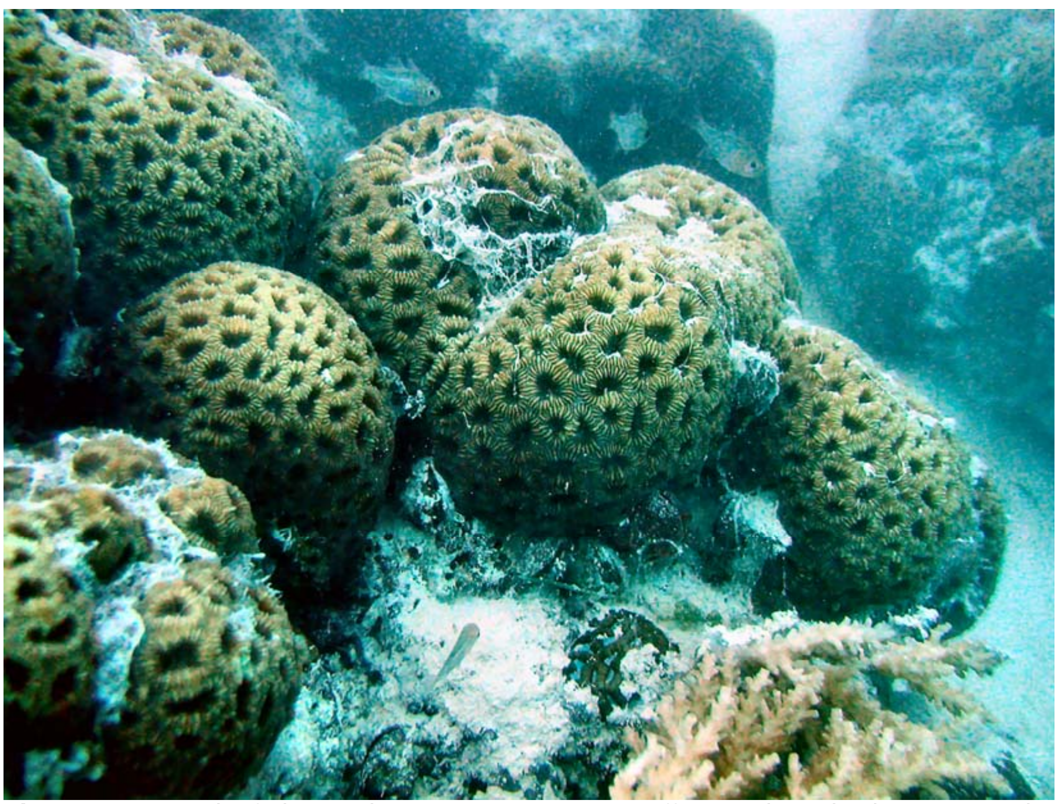

**Figure A-50.** North of observation area at Turtle Cove off transmitter site (L-S-TCv-2-N) *[Photo: S. Smith]*

**Figure A-51.** Coral formation in southern lagoon basin *[Photo: K. Deslarzes]*

**Figure A-52.** Toppled Acroporidae on a knoll reef in the northern lagoon Replenishment Zone *[Photo: D. Evans]*

**Figure A-53.** Tabular Acroporidae formation *[Photo: K. Deslarzes]*

**Figure A-54.** Mountainous coral formation *[Photo: K. Deslarzes]*

**Figure A-55.** "Bone-yard" area of dead coral fragments in lagoon *[Photo: P. Leahy]*

**Figure A-56.** Encrusted coral rubble and live coral on eastern ocean side reef
*[Photo: K. Deslarzes]*

**Figure A-57.** *Chlorurus sordidus* – Bullethead parrotfish *[Photo: K. Deslarzes]*

**Figure A-58.** *Paracirrhites forsteri* – Freckled hawkfish *[Photo: P. Leahy]*

**Figure A-59.** *Acanthurus triostegus* – Convict tang feeding en-mass on algae *[Photo: D. Evans]*

**Figure A-60.** *Epinephelus spilotoceps* – Foursaddle grouper *[Photo: P. Leahy]*

**Figure A-61.** *Pygoplites diacanthus* – Regal angelfish *[Photo: D. Evans]*

**Figure A-62.** *Carcharhinus albimarginatus* – Silvertip shark *[Photo: D. Evans]*

**Figure A-63.** *Amphiprion chagosensis* – Chagos anemonefish *[Photo: P. Leahy]*

**Figure A-64.** *Amphiprion bicinctus* – Twoband anemonefish *[Photo: D. Evans]*

**Figure A-65.** *Cheilinus undulates* – Napoleon/humphead wrasse *[Photo: S. Smith]*

**Figure A-66.** *Cheilinus undulates* – Napoleon/humphead wrasse off Cannon Point *[Photo: S. Smith]*

**Figure A-67.** *Chromis viridis* – Blue-green chromis *[Photo: D. Evans]*

**Figure A-68.** *Lutjanus gibbus* – Humpback snapper *[Photo: D. Evans]*

**Figure A-69.** *Plectropomus areolatus* – Squaretail coral grouper *[Photo: D. Evans]*

**Figure A-70.** *Plectorhinchus vittatus* – Oriental sweetlips *[Photo: D. Evans]*

**Figure A-71.** *Manta birostris* – Giant manta ray *[Photo: K. Deslarzes]*

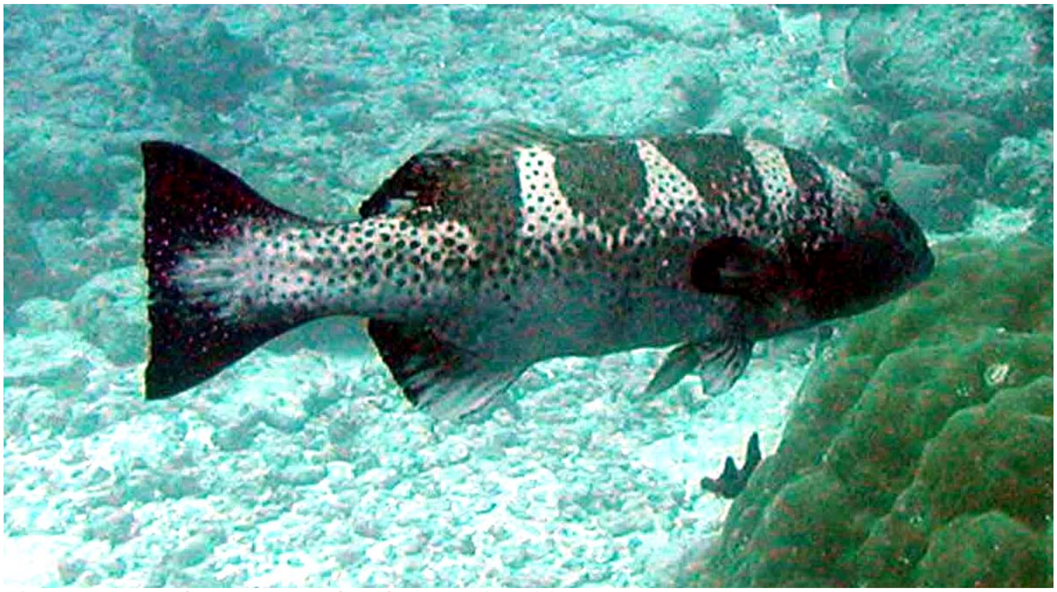

**Figure A-72.** *Plectropomus laevis* – Blacksaddle coral grouper *[Photo: S. Smith]*

**Figure A-73.** *Pterois miles* – Cleartail lionfish *[Photo: S. Smith]*

**Figure A-74.** *Chlorurus strongylocephalus* – Steephead parrotfish *[Photo: S. Smith]*

**Figure A-75***.* *Paracanthurus hepatus* – Palette surgeonfish *[Photo: S. Smith]*

**Figure A-76.** *Arothron meleagris* – Guineafowl puffer *[Photo: S. Smith]*

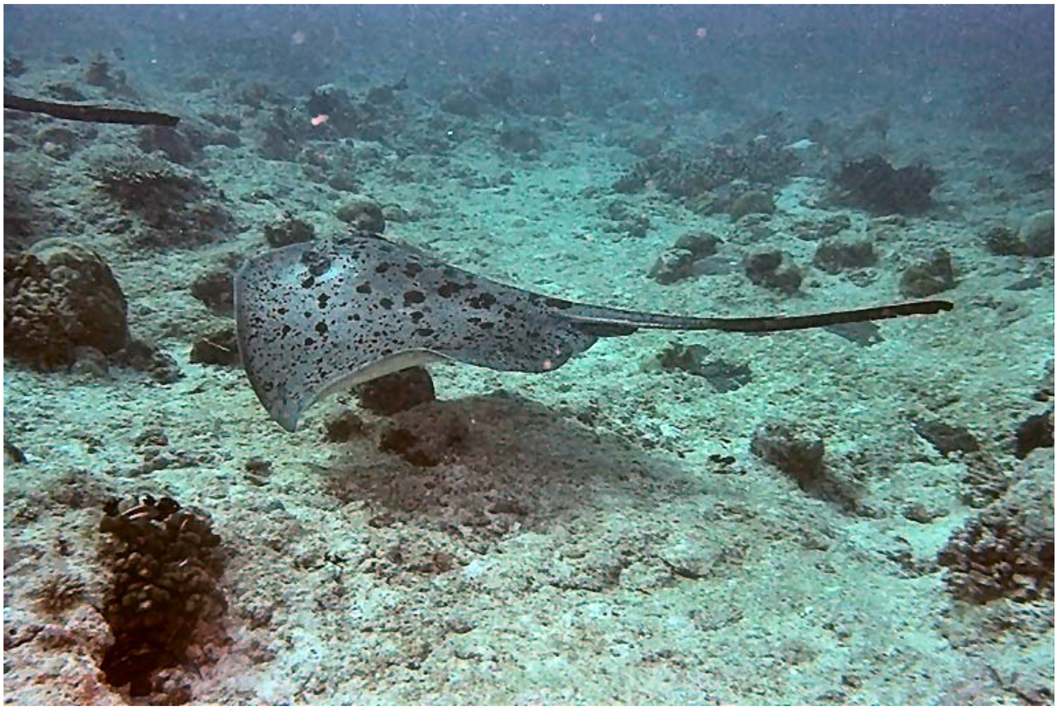

**Figure A-77.** *Taeniura meyeni* – Blotched fantail ray *[Photo: J. Nichols]*

**Figure A-78.** *Pomacanthus imperator* – Emperor angelfish *[Photo: J. Nichols]*

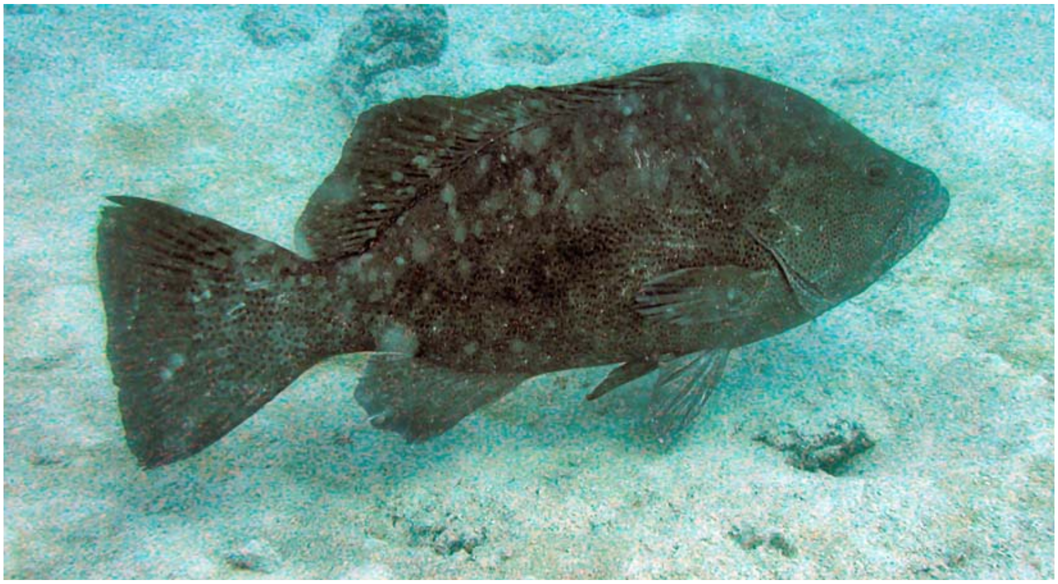

**Figure A-79.** *Epinephelus multinotatus* – Whiteblothced grouper *[Photo: S. Smith]*

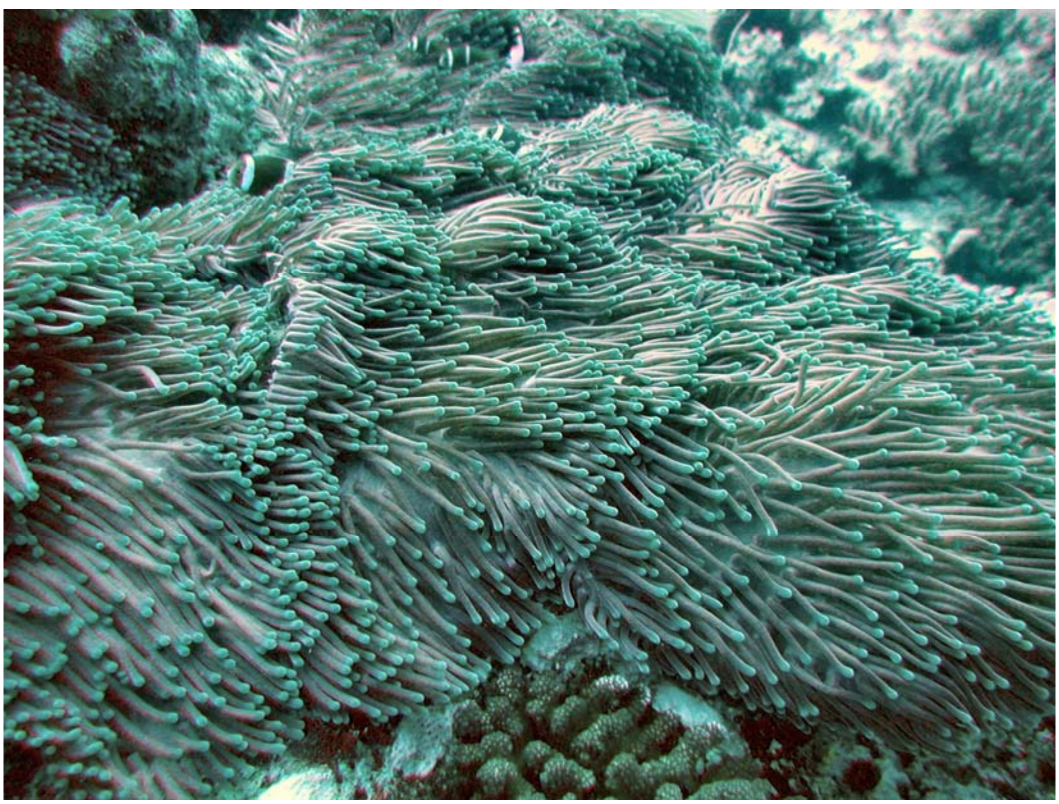

**Figure A-80.** Anemone with twoband anemonefish (*Amphiprion bicinctus* *[Photo: S. Smith]*

**Figure A-81.** *Pondylus varius* – Thorny oyster *[Photo: D. Evans]*

**Figure A-82.** *Lambis* sp*.* – Spider conch *[Photo: D. Evans]*

**Figure A-83.** *Octopus* sp. *[Photo: P. Leahy]*

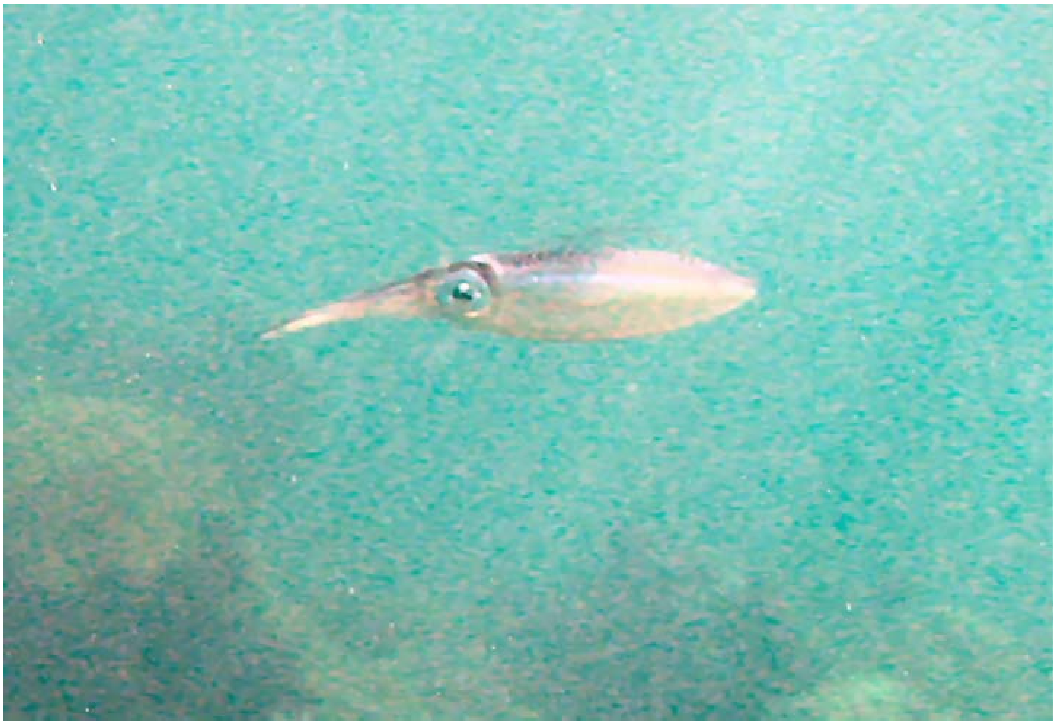

**Figure A-84.** *Sepioteuthis lessoniana* – Reef squid *[Photo: D. Evans]*

**Figure A-85.** Sea cucumber *[Photo: D. Evans]*

**Figure A-86.** *Tridacna* sp. – Giant clam *[Photo: K. Deslarzes]*

**Figure A-87.** Sea cucumber (Holothuridae) (D. Marx)
*[Photo: S. Smith]*

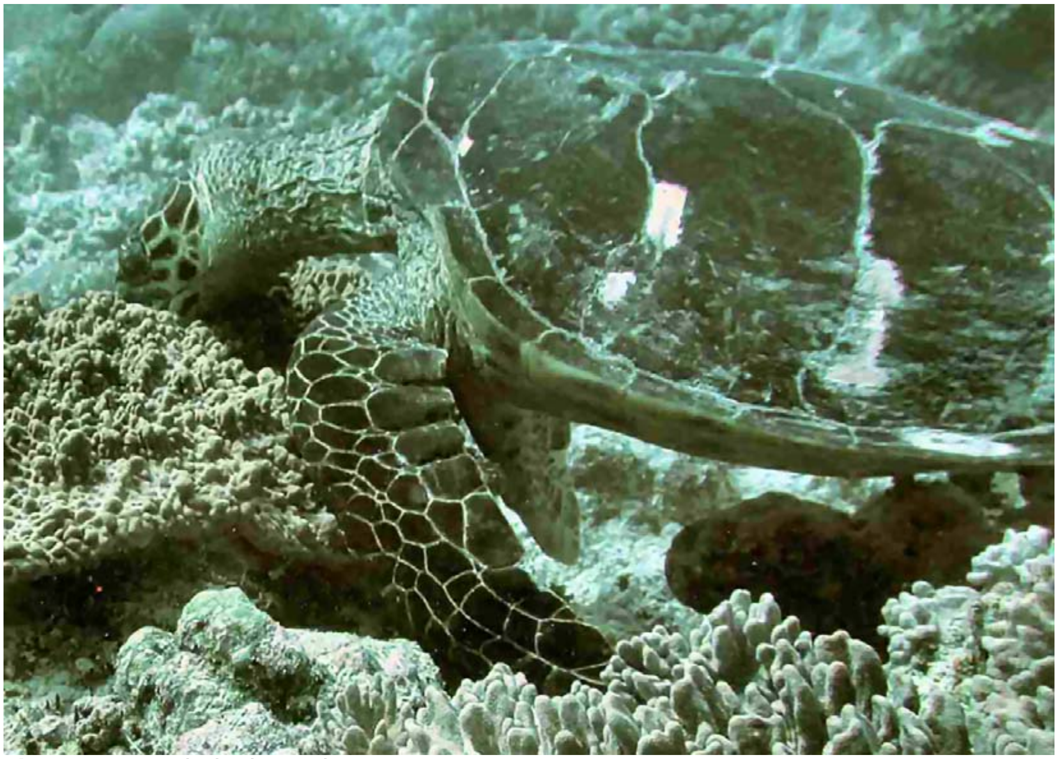

**Figure A-88.** *Chelonia mydas* – Green sea turtle *[Photo: D. Evans]*


**Figure A-89.** Hydrolab Datasonde 4a: Water quality sensor probe unit
*[Photo: D. Evans]*

**Figure A-90.** Shooting study site buoy with Trimble® PROXRS survey grade GPS unit and laser range finder (D. Evans)
*[Photo: K. Deslarzes]*

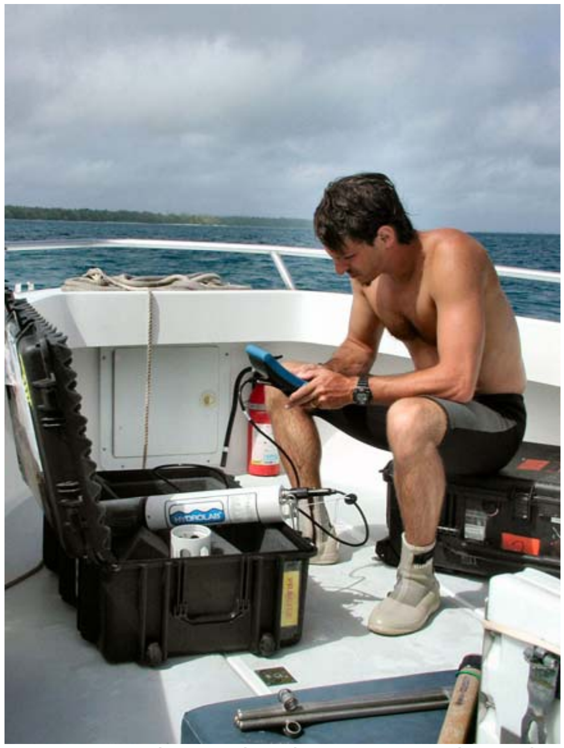

**Figure A-91.** Programming Hydrolab® water quality probe (D. Evans)
*[Photo: K. Deslarzes]*

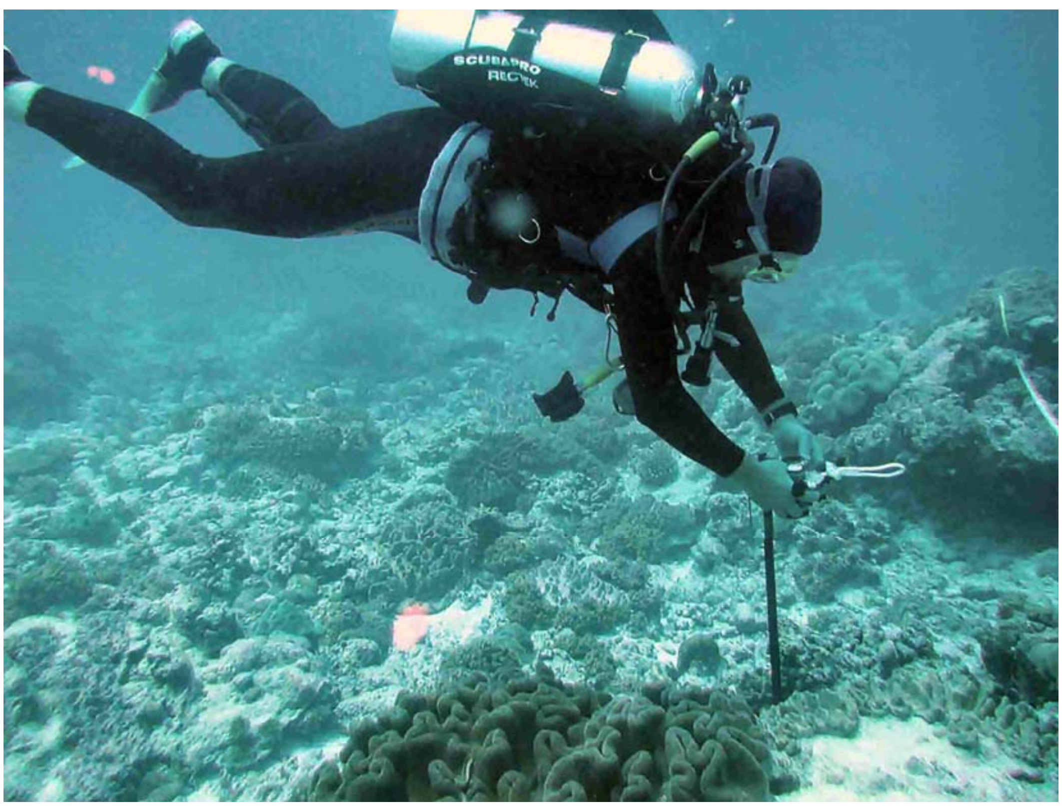

**Figure A-92.** Capturing digital photo quadrat with camera and framer (K. Deslarzes)
*[Photo: D. Evans]*

**Figure A-93.** Recording data for stationary fish survey (D. Evans)
*[Photo: P. Leahy]*

**Figure A-94.** Capturing digital video on roving fish survey (P. Leahy)
*[Photo: D. Evans]*