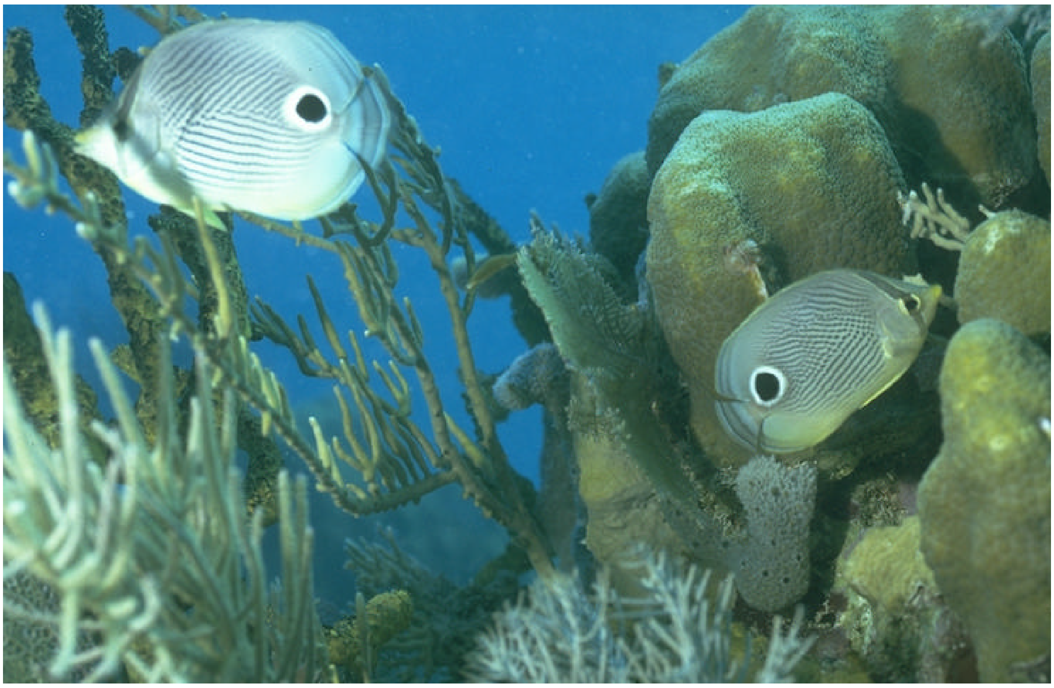
SUMMARY OF CORAL CAY CONSERVATION'S REEF CHECK DATA FROM UTILA, HONDURAS



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This report is part of a series of documents detailing CCC's science programme in Utila (1999-2000).
The series is also available on CD-Rom.

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SUMMARY

?? The coral reefs of Honduras are of vital national and international importance, both ecologically and economically, but are threatened because of rapid economic and population growth.

?? During work on Utila between 1999 and 2000 (the '*Bay Islands 2000*' project), Coral Cay Conservation developed a programme of surveys, training and conservation education aimed at assessing the status of local reefs and improving environmental awareness amongst neighbouring communities.

?? This summary report provides an overview of the 'Reef Check' data collected by the *Bay Islands 2000* project to assess reef health. Reef Check is an internationally recognised protocol used to generate standard parameters of reef health.

?? Seven Reef Check sites, evenly distributed around Utila, were surveyed during 2000. Reef Check collects data from a shallow transect (3-6 m) and a mid-depth transect (6-10 m).

?? Data were collected on: impacts (presumed and observed) affecting each site; the percentage cover of each component of the benthic community (e.g. coral species, algae and sponges) and substratum categories (e.g. sand and rubble); number of indicator fish taxa (e.g. Nassau grouper) and number of indicator invertebrate taxa (e.g. lobster).

?? Each of the seven sites surveyed during this study appeared to be exposed to generally low anthropogenic impacts when assessed using the criteria of Reef Check. However, the reefs are also known to have been significantly impacted by major bleaching events in 1995 and 1998 and Hurricane Mitch in 1998 and the mass mortality of *Diadema* urchins in the early 1980s.

?? Total coral cover was highest (42.7%) on the mid-depth transect at the 'Flight Path' site (to the south-east of Utila) and the second highest coral species richness, possibly because of intermediate levels of disturbance. The mid-depth transect at the 'Turtle Harbour' site had a lower coral cover (28.1%) but had the highest diversity and species richness (16).

?? Exposed sites on the east coast had the lowest coral cover and mid-depth transects generally had higher coral cover than shallow transects because of the reduced impacts of bleaching and hurricane disturbances.

?? Abundances of dead coral were partly linked to live coral cover since coral rich areas will have more dead colonies after major disturbances. Dead coral was also high at the 'Silver Gardens' site (southern coast of Utila), possibly linked to pollution and dredging.

?? Where coral cover was low, but there was exposed hard substratum, there was a higher coverage of algae. High algal cover on the south coast might also be linked to increased nutrient concentrations from coastal developments.

?? Filter feeders such as sponges and gorgonians were generally more abundant on the northern side of Utila where the increased water movement may provide greater food concentrations.

?? Highly prized fishery species such as the Nassau grouper were not seen at any site, highlighting the level of fishing pressure around Utila. Other important indicators of fishing pressure, such as lobster, were also rare. However, the abundance of snappers and grunts within the Turtle Harbour Wildlife Refuge may reflect the effects of protecting fish stocks in this area.

?? Parrotfish were also relatively abundant and this is encouraging since they are a key herbivore in reef systems, playing a role in maintaining coral communities despite the presence of competitively dominant algae. *Diadema* urchins are also a key reef herbivore and were seen on all transects, possibly indicating evidence of population recovery.
?? A 'conservation index', calculated using the fish and invertebrate data, indicated the importance of an area on the southern coast ('Cabañas'), the Turtle Harbour Wildlife Refuge, an area to the south-east of Utila ('Flight Path') and a site close to Raggedy Cay.
?? Correlations were seen between the abundances of commercially valuable groupers and coral species richness and diversity, showing the importance of maintaining coral health to maximise fisheries potential.
?? Overall, therefore, it is obvious that the reefs in Utila have been significantly affected by a combination of regional (coral bleaching and Hurricane Mitch) and local (particularly fishing pressure, sedimentation and nutrification) effects. This conclusion is supported by the comparisons with equivalent data from Belize and the whole Caribbean region. For example, there is some evidence that, prior to 1998, the reefs of Utila may have been of above average health, as measured by Reef Check compared to the averages for the Caribbean region.
?? This study led to seven recommendations:
    ?? One or more agencies should continue to collect Reef Check data from some or all of the survey sites used by this study as the basis of a monitoring programme of reef health around Utila.
    ?? Hondurans, from either Utila or UNAH, who have been trained to dive and conduct surveys by CCC could undertake the necessary monitoring work. CCC could provide additional training if required.
    ?? Establish a code of practise for people living and working on Utila regarding sewage and waste disposal. Provide a standard environmental awareness briefing for all visitors to the dive resorts.
    ?? Continue to aim to establish one or more additional multiple use marine protected areas around Utila, with an integrated monitoring programme to measure their efficacy, and strengthen the enforcement of regulations in the Turtle Harbour Wildlife Sanctuary. Establish regulations, and enforce existing legislation, to minimise the detrimental effects of coastal development on reef health.
    ?? The reef at the 'Flight Path' (south-east Utila) appears to be an excellent candidate for protection because of its high coral cover and species richness, abundance of staghorn coral and high conservation index.
    ?? The reef at the 'Cabañas' (south-west Utila) appears to be an excellent candidate for protection because of its high coral cover in shallow water, its popularity with divers and having the highest conservation index.
    ?? The concept of establishing a reserve at Raggedy Cay should be continued since this area has reasonable coral cover, has a high conservation index and compliments other putative reserves via its location to the west of Utila.

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ABBREVIATIONS

ANOVA	-	Analysis of Variance
BICA	-	Bay Islands Conservation Association
CCC	-	Coral Cay Conservation
COHDEFOR	-	Coorporación Hondureña de Desarrollo Forestal
IUCN	-	World Conservation Union
NGO	-	Non Government Organisation
p	-	Probability value of a statistical test.
PMAIB	-	Programa Manejo Ambiental Islas de la Bahía
PS	-	Project Scientist
SD	-	Standard Deviation
SO	-	Science Officer
UNAH	-	Universidad Nacional Autonoma de Honduras
UNEP	-	United Nations Environment Programme
KS	-	Kruskal-Wallis
M	-	Medium-depth transects
S	-	Shallow-depth transects
R^2	-	Corrleation Coefficient

FIGURES, TABLES AND APPENDICES

1. INTRODUCTION

Honduras covers approximately 112,000 km^2 of land on the widest part of the isthmus of Central America. Honduras represents the southern end of the Mesoamerican Barrier Reef System, although it's marine resources are less extensive and studied than nearby Belize and Mexico. However, the coastal zone contains mainland reef formations, mangroves, wetlands, seagrass beds and extensive fringing reefs around its offshore islands and has a key role in the economy of the country. These ecosystems have close links with the coastal zones of the other Mesoamerican countries. For example, in the Gulf of Honduras, the watershed of the Rio Ulúa is an order of magnitude greater than any river in southern Belize and hence has a significant impact on the Belize Barrier Reef (Heyman and Kjerfve, 1999).

Although the coral reefs of Honduras are of vital national and international importance, both ecologically and economically, they are threatened because of rapid economic and population growth. For example, the countries' coral reef ecosystems are being adversely affected by a range of anthropogenic activities including fishing pressure, sedimentation and pollution, which has resulted in a decrease of coral cover. The desire to generate urgently required revenue within Honduras has also led to increased tourism which provides an over-arching stress to marine resources since most tourists spend time in the coastal zone. Recent coral bleaching events and storm damage has exacerbated these effects by acting synergistically to reduce reef health further. Such impacts represent substantial long- and short-term threats to the ecological balance and health of reef ecosystems which, if left unchecked, will ultimately lead to reduced income for coastal communities and other stakeholders relying on fishing and marine-based tourism. Furthermore, any natural or anthropogenic impacts on reef health will inevitably affect other countries in Latin America, and *vice versa*, since the marine resources are linked via currents and the functioning of the system transcends geo-political boundaries.

Effective coastal zone management, including conservation of coral reefs, requires a holistic and multi-sectorial approach, which is often a highly technical and costly process and one that many developing countries cannot adequately afford. With appropriate training, non-scientifically trained, self-financing volunteer divers have been shown to be able to provide useful data for coastal zone management at little or no cost to the host country (Hunter and Maragos, 1992; Mumby *et al*., 1995; Wells, 1995; Darwall and Dulvy, 1996 and Erdmann *et al*., 1997). This technique has been pioneered and successfully applied by Coral Cay Conservation (CCC), a British not-for-profit organisation.

Founded in 1986, CCC is dedicated to '*providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests*' in collaboration with government and non-governmental organisations within a host country. CCC does not charge the host country for the services it provides and is primarily self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the guidance of qualified project scientists, prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes. Readers are referred to Harborne *et al*. (In press) for an overview of CCC's full role in Utila, which was wider than the collection of the data presented in this series of reports. CCC is associated with the Coral Cay Conservation Trust (the only British-based charity dedicated to protecting coral reefs) and the USA-based Coral Cay Conservation Foundation.

The Bay Island of Utila (Figure 1) has been the focus of tourism development in Honduras for many years and the industry is very much aware of the value of conserving the coral reefs and fostering sustainable development. Therefore, between 1995 and 1998, teams of Honduran and British undergraduates participated in 'Project Utila'. The aim of this project was to continuously monitor the state of the coral reefs surrounding Utila in order to provide data that could be used to assist with effective management of the marine resources. One of the outputs of Project Utila was the recommendation that the survey work should be expanded to include a detailed systematic survey of Utila's marine resources with the aim of establishing an environmental database and a management plan for these resources. Unfortunately, the Project Utila team was unable to continue the project beyond 1998 and sought another means of continuing the work.

Figure 1. The location of (a) Honduras and (b) the locations of the Bay Islands (Utila, Roatán and Guanaja).

In order to build on the work and achievements of Project Utila, the *Bay Islands 2000* project, therefore, was initiated as a collaborative Honduran / British partnership project between Coorporación Hondureña de Desarrollo Forestal (COHDEFOR), the Universidad Nacional Autonoma de Honduras (UNAH) and the Bay Islands Conservation Association (BICA). The *Bay Islands 2000* project was subsequently accepted as a partner of the Ministry of Tourism's 'Bay Islands Environmental Management Project' (Programa Manejo Ambiental Islas de la Bahía; PMAIB).

The project was established initially in Utila in June 1999 with the aims to:

1. undertake a systematic and detailed survey of the marine resources of Utila and provide data for the development of an integrated coastal zone management plan for the protection and sustainable utilisation of Utila's coral reefs;
2. continue and expand monitoring programmes previously established on the reefs of Utila by Project Utila;
3. establish an environmental database at UNAH for the Bay Islands;
4. provide SCUBA and scientific training and research opportunities for Honduran project counterparts;
5. provide conservation education opportunities for local communities.

This summary report provides an overview of the Reef Check data, to assess reef health, collected by the *Bay Islands 2000* project in Utila between June 1999 and August 2000.

2. PROJECT BACKGROUND

Note that a review of the status of the coastal zone of Honduras has recently been published (Harborne *et al.*, 2001). Readers are referred to this paper for further background information.

2.1 The coastal zone of Honduras

Honduras lies within the wider Caribbean region that stretches from the Gulf of Mexico to the French Guiana - Brazil border. This region has well known interactions throughout its area and the marine resources of Honduras are inextricably linked to a much larger area via water exchange. Such links lead to, for example, Sullivan Sealey and Bustamante (1999) defining the Tropical Northwestern Atlantic as the largest biogeographical province in the western hemisphere and places Honduras within the large, complex Central Caribbean 'ecoregion'. However, although there are obvious oceanographic connections between Honduras and neighbouring reefs in Central America, and also the wider Caribbean, little is known about migration of adult populations or larval interchange.

The Caribbean coast of Honduras itself stretches from the border with Guatemala in the west to the border with Nicaragua in the east and also encompasses a number of offshore island systems including the Islas de la Bahía (Bay Islands) archipelago. Hence this coastline encompasses more than 91% (735 km) of the country's 820 km coastline (Merrill, 1995) and includes coral reefs, mangrove forests, seagrass beds, estuaries, coastal lagoons, wetlands and tropical coastal fisheries. Such ecosystems are possible because of the tropical climate that is affected by seasonal easterly tradewinds, which cause a rainy season for approximately eight months and a dry season from November to February.

There has been limited research in the coastal zone of Honduras and, for example, the marine resources of the mainland are very poorly studied and there is virtually no published literature on the presence or absence of coral reefs (UNEP/IUCN, 1988). However, Kramer *et al*. (2000) and Cortés (1997) state that because of high levels of runoff there are only scattered, poorly developed coral communities around Puerto Cortés, La Ceiba and Trujillo. It is also known that there are extensive continental mangrove forest and wetland systems along the central section of coastline and bordering the Gulf of Honduras but severe degradation from overfishing, mangrove clearance and pollution has been reported (Sullivan Sealey and Bustamante, 1999). The extensive mangrove system contains a number of lagoons, riverine estuaries as well as offshore mangrove cays (MacKenzie, Jr and Stehlik, 1996). The eastern Mosquitia region of mainland Honduras also has a complex environment of reefs, lagoons, wetlands and barrier beaches in an expansive savanna which plays a key role in fisheries health (Sullivan Sealey and Bustamante, 1999) and is an important breeding ground for waterbirds. The inaccessibility of the Mosquitia region has limited deforestation and agriculture and part of it is further protected by the Río Plátano Biosphere Reserve (Richards, 1996).

The Caribbean coastline of Honduras includes a highly developed small island reef system which can be divided into three groups, the Bay Islands and Cayos Cochinos archipelago, the Mosquitia cays and banks and the small Swan Islands with a coastline length of only 6 km (Cortés, 1997; Sullivan Sealey and Bustamante, 1999). The Bay Islands group, on the edge of the 75 km wide continental shelf, has a number of smaller cays but is dominated by three major islands; Utila, Roatán and Guanaja. These islands are the centre of both reef related tourism and the fishing industry in Honduras and in addition to the coral reefs they also contain significant mangrove wetlands.

There is only limited published information describing the reefs of Honduras (UNEP/IUCN, 1988), although the Cayos Cochinos archipelago has been relatively well studied by scientists working at the Cayos Cochinos Research Station. However, wind generated wave energies are generally higher on more exposed northern coasts and subsequently, for example, the north coasts of the larger islands of the Cayos Cochinos are dominated by massive colonies such as *Montastraea annularis* (Ogden and Ogden, 1998). In contrast, lee areas support a more diverse coral assemblage. Currently unpublished reef mapping work in the Bay Islands by the Ministry of Tourism's 'Bay Islands Environmental Management Project' and Coral Cay Conservation has extended knowledge of the extent and complexity of the reef systems in this area significantly.

The reefs of the Swan Islands and the Mosquitia cays and banks are poorly known because of their inaccessibility and the results of research visits are mainly restricted to unpublished grey literature. Cortés (1997) reports that the Mosquitia cays are surrounded by fringing reefs and patch reefs in lagoonal areas. An expedition in 1960 to the Swan Islands indicated that coral growth may be less abundant than on the reefs of Panama (UNEP/IUCN, 1988) and there is some evidence that the biota of some taxa are less diverse than the Bay Islands because they have a lower habitat diversity and less protection from severe storms (Keith, 1992). More recent anecdotal reports indicate that, because of their isolation and use for only small-scale artisanal fishing, the coral health and fish populations of the Swan Islands may be higher than those of the Bay Islands and Cayos Cochinos. However, the reefs are likely to have suffered significantly from wave damage in 1998 because of the proximity of the Swan Islands to the path of Hurricane Mitch.

The need for coastal zone management and sustainable development in Honduras is well documented and recognised both nationally and internationally. Marine protection in Honduras dates back to the 'Ley de Pescar' decree of May 1959 which declared coral reefs as 'protected areas'. More recently, a particularly significant step for marine conservation in Central America was the signing of the Tulum Declaration in 1997, when Mexico, Belize, Guatemala and Mexico agreed to work towards regional conservation of the Mesoamerican Barrier Reef System. Instigating such initiatives inevitably relies on the support of local stakeholders and despite the continued problems, Honduran ecologists are encouraged by the increasing environmental consciousness among many sectors of the community (Merrill, 1995). For example, there is some evidence that local communities appreciate the benefit of marine protected areas. A study by Barahona and Guzman (1998) showed that 77% of survey respondents believed it was important to protect the marine and terrestrial habitats of Cayos Cochinos and 66% thought that commercially important species were more abundant since fisheries restrictions were enforced.

The national government recognises the ecological and economic needs to conserve marine resources but is severely limited by capacity, funding and expertise. However, in order to co-ordinate and expand local and national initiatives, the Ministry of Tourism has established the 'Bay Islands Environmental Management Project' (Programa Manejo Ambiental de las Islas de la Bahía; PMAIB). This multi-faceted project is funded by a US$19.1 million loan from the Inter-American Development Bank, along with further funding from national government to a total of US$27 million, and has four sub-programmes covering natural resources, sanitation, real estate census and institutional strengthening. Conservation in the Bay Islands will be further strengthened by the World Bank / Global Environment Facility project 'Conservation and sustainable use of the Mesoamerican Barrier Reef System'. This project's objective is to assist the countries of Belize, Guatemala, Honduras and Mexico manage the Mesoamerican Barrier Reef System as a shared, regional ecosystem, safeguard its biodiversity values and functional integrity and create a framework for its sustainable use (Kramer *et al*., 2000).

In addition to international programmes, there is an NGO movement in Honduras but it is relatively nascent. However, there are, for example, groups present in the Bay Islands and their activities are reviewed by Forest (1998). Further assistance for coastal zone conservation initiatives in Honduras is increasingly being provided by international NGOs and for example, the Wildlife Conservation Society has assisted management planning in the Bay Island's existing reserves and the Municipalities of Utila and Roatán, along with PMAIB, have been assisted with data collection, technical advice, training and environmental education programmes by Coral Cay Conservation (Harborne *et al*., in press).

Environmental legislation in Honduras is relatively extensive and Forest (1998) reviews a series of coastal regulations relating to the Bay. The Honduran government has also set several regulations on its fisheries (MacKenzie, Jr and Stehlik, 1996). Despite the range of regulations, enforcement capacity is extremely limited and many stakeholders are able to ignore germane legislation with impunity (Fielding, 2000b). However, the recent recognition of the importance of reserves for conservation means that a total of 15% of Honduras (1.7 million hectares) is now protected via 106 'natural areas' including national parks, wildlife refuges, biological reserves, national forests, anthropological reserves, protected watersheds, natural monuments, cultural monuments and multiple-use areas (Hodges, 1997). Within this system, there are 25 marine protected areas covering 4,300 km^2 (Kramer *et al*., 2000). Indeed, in 1997 legislation was passed declaring most of the Bay Islands as a marine park with varying levels of restrictions on resource use. Among other objectives, this park aimed to strengthen the municipal reserves of Turtle Harbour in Utila and Sandy Bay in Roatán which were designated in 1982. However, although the whole perimeter of Roatán and Guanaja and parts of Utila were included, enforcement is limited and the forestry department, which is responsible for protected areas, has virtually no capacity on the islands. Furthermore, many stakeholders are unaware of the reserve's status or its consequences.

2.2 The Bay Islands

Foreign tourists are attracted to Honduras by, for example, the opportunities for SCUBA diving in the Bay Islands and impressive Mayan ruins. The importance of the income from this industry is well recognised and the Bay Islands were designated as an important tourism zone by the Honduran congress as early as 1982 and laws to promote this industry were passed in the 1990s (Rijsberman, 1999). Between 1987 and 1991, tourist arrivals in Honduras grew at average annual rates of approximately 15%, which exceeded global trends (Fielding, 2000a). By 1993, the annual number of international tourists to the Bay Islands (approximately 30,000, with a high season from September to December) exceeded the local population (Fielding, 2000b).

The Bay Islands, stretching in an arc between 29 and 56 km off the coast of Honduras, sit upon the Bonacca Ridge, an extension of the Sierra de Omoa Mountains. The Bonacca Ridge forms the edge of the Honduran shelf and, as a result, on the northern, ocean-facing side of the islands, shallow water extends only a short distance before the shelf-break. There are also several terrestrial ecological zones in the Bay Islands, including pine and oak savanna, arid tropical forest, beach vegetation, mangrove swamps and uplifted, fossilised coral or iron shore. Most of the dense forest has been removed to provide building materials and the only areas left are on the island of Barbareta and in the hills of Roatán and Guanaja. The height of the islands generally increases from west to east, from the lowland swamps of Utila to the low ridges of Roatán and the two peaks of Guanaja. The Bay Islands were once host to many animal species that have now been hunted to extinction.

The Bay Islands are generally surrounded by fringing reefs, but the north coast of Roatán, the largest and best known island, is dominated by a nearly continuous barrier and fringing reef (UNEP/IUCN, 1988). In contrast, the south coast of Roatán supports a discontinuous fringing reef broken up by channels and bights that were formed by erosion during glacial events. Reefs on both coasts have a relatively narrow landward lagoon dominated by seagrass and additional information on zonation is provided in UNEP/IUCN (1988), Fenner (1993) and Kramer *et al*. (2000). Similarly, on the reefs of Utila, zonation is much more pronounced to the north of the island and the reefs of the leeward side typically comprise of a narrow shelf characterised by a poorly developed reef crest and with little reef development beyond a depth of 25 m. Since Hurricane Mitch and the bleaching events of 1995 and 1998, coral cover is generally low, for example rarely being higher than 30% on Utila and only reaching 50% at the west end of Roatán (Kramer *et al*., 2000). In addition to the fringing reefs, throughout the Bay Islands and Cayos Cochinos there are numerous seamounts which are poorly studied but some are known to have relatively high coral cover and fish populations. These seamounts are also important locations for local fisherfolk and at least some are important as fish spawning areas (Fine, 1992).

Reefs in the Bay Islands and coastal areas are subject to the same threats as those faced by many other islands throughout the Caribbean. These threats, accentuated by rapid development of coastal areas and the influx of overseas investors wishing to build homes on the islands, include:

Sedimentation and watershed management

Corals require clear, sediment free water to ensure sufficient sunlight for photosynthesis by symbiotic algae. Similarly, physical smothering by sediment can kill coral colonies. After Hurricane Mitch and during the following 'rainy season' high levels of sediment from the mainland were evident around the Bay Islands. In the future, attempts to provide access from the sea to many of the proposed development sites may include dredging shallow channels through the reefs and / or lagoons. Dredging often results in direct disturbance of nearby habitats and wider sedimentation of adjacent coral reefs. Indeed, anecdotal reports by local researchers indicate that sedimentation caused by erosion from road building and hotel construction is one of the most important impacts to reefs of the Bay Islands (Fielding, 2000a).

Further inland, Honduras lost 1.8 million hectares of forest from 1964 to 1988 and it has continued to decline, partly from agriculture but also from the focus on logging rather than management (Merrill, 1995). As in many other countries, such deforestation threatens the health of marine resources by increasing sediment loads but such links are poorly understood in Honduras. Since Honduras is a water-rich country with numerous rivers draining the highlands, this threat is significant. For example, the large river Ulúa drains into the Caribbean west of the Bay Islands after flowing 400 km through the economically important Valle de Sula (Merrill, 1995).

Mangrove deforestation

On small islands, where good building land is at a premium, it is likely that there will be demands to remove areas of mangrove forest. Deforestation of the limited areas of mangrove will result in a loss of important nesting habitats for birds and other important terrestrial species and will remove breeding and nursery grounds for commercially important marine species such as conch and lobster.

Effluent and waste run-off

Increased nutrient levels, especially close to large towns and cities, is now regarded as a significant reef stressor throughout the Mesoamerica Barrier Reef System. Most buildings in the Bay Islands employ septic tanks to store and treat human waste, many of which are situated on low land immediately adjacent to the coast. Improper installation and maintenance of these septic systems may pollute the ground water system (causing a health risk) and leach out into the marine environment causing nutrification and excessive algal growth along the reefs. The need for better public access to water supplies and sewerage has been a major element of development programmes in Honduras and throughout Central America.

Physical damage

There is an extremely high level of diver activity around the Bay Islands (particularly Utila and the western end of Roatán), often by inexperienced or trainee divers. Physical damage from divers and boat anchors can be significant at popular dive sites. However, in Utila, the local community has done an exemplary job of installing and maintaining mooring buoys for the local dive shops to utilise (thus limiting anchor damage). If not properly controlled, diving activity may result in significant physical damage to the Bay Islands' reefs. Furthermore, cruise shipping has been promoted in the Bay Islands and the first cruise ship arrived in Utila in 2000 (Fielding, 2000a). However, this represents a significant environmental threat and case studies from elsewhere in the region show negative effects from dredging, coastal development, mechanical damage to marine resources and sewage (Fielding, 2000a).

Fishing pressure

The population of the Bay Islands is now supplemented by hundreds of tourists each month who all enjoy eating the local fish catch and this has placed significant pressures on local fisheries. For example, finfish, particularly groupers (Serranidae), snappers (Lutjanidae), grunts (Haemulidae) and jacks (Carangidae) are targeted by artisanal fisherfolk via a variety of traditional techniques. Although quantitative data are sparse, intensive fishing effort has clearly impacted populations and now, for example, fishermen in the Bay Islands favour more remote offshore banks compared to the heavily exploited fringing reefs. Furthermore, decreases of herbivorous fish populations, in conjunction with the disease induced loss of sea urchins and decreasing water quality, also contributes to increasing reef coverage by algae, to the detriment of corals.

Similarly, lobster and conch are a significant fishery resource on reef formations bordering the islands and mainland (Tewfik *et al.*, 1998a). These species are caught by both artisanal and industrial fisherfolk and indeed Honduras maintains the largest lobster fleet of all Central American countries with 190 vessels by the early 1990s (Ehrhardt, 2000). Although detailed data are lacking, the lobster and conch fisheries are generally considered to be over-exploited.

Coral bleaching

Coral bleaching events occur during occasional periods when climate conditions raise seawater temperatures and solar irradiance (summarised in Westmacott *et al.*, 2000). Coral bleaching, the paling of coral tissue from the loss of symbiotic zooxanthellae, has presumably occurred previously in Honduras but evidence of severe events prior to the mid-1990s is sparse. However, a mass bleaching event was recorded in 1995 by Guzmán and Guevara (1998) which affected 73% of scleractinians along with over 90% of all hydrocorals, zoanthids and octocorals. More detailed information is available for the more severe mass bleaching event in 1998 when high sea-surface temperatures affected Honduras in September and October. Interestingly there is some evidence that the water movements caused by Hurricane Mitch may have reduced sea-surface temperatures and allowed some corals to recover. However, the effects of bleaching were severe, leading to an average regional coral mortality of 18% on shallow reefs and 14% on forereefs along with subsequent increases in the prevalence of diseases and will have long-term ecological and socio-economic consequences (Kramer *et al.*, 2000; Kramer and Kramer, 2000). Although the community of the Bay Islands cannot change global warming, there is evidence to suggest that a well managed reef will recover quicker than a stressed one.

Coral disease

Caribbean corals have been affected by a number of diseases, defined as an impairment of an organism's vital functions or systems. Diseases have many causes, especially micro-organisms, and can affect not only an individual organism but also the community in which it lives. Diseases can alter the reproductive potential of a population, alter interactions among populations and cause mortalities, leading to changes in ecosystem composition, structure, processes and function. Corals become susceptible to diseases from natural and human-induced physical and chemical changes in water conditions; abrasion or smothering by sediment; changes in temperature and salinity and increased exposure to nutrients and toxic chemicals. Many of these causes are present around the Bay Islands. Furthermore, Kramer and Kramer, 2000 present evidence that Hurricane Mitch increased the prevalence of disease in the Bay Islands.

Hurricane damage

Honduras lies within the hurricane belt but hurricanes are relatively infrequent. However, damage has been reported from, for example, Hurricane Fifi in 1974 which killed 8,000 people (Merrill, 1995; Ogden and Ogden, 1998). Hurricane Mitch in 1998 (category 5 with occasional wind speeds greater than 250 km per hour) is regarded as the most deadly hurricane to strike the western hemisphere for the last two centuries (Fielding, 2000b). Hurricane Mitch had significant effects on the marine resources of Honduras, particularly as it occurred shortly after a mass coral bleaching event. Kramer *et al*. (2000) report losses in coral cover of 15-20% across the Central American region and damage to 50-70% of corals in parts of Honduras, although recent mortality was only moderately high (<25%). Physical damage (broken, knocked over and abraded colonies) from the hurricane's direct action was approximately 11% of corals on shallow reefs and 2% on deep reefs in Honduras (Kramer and Kramer, 2000). Damage was particularly severe in the Bay Islands as the hurricane slowed and stalled close to Guanaja for two days. Secondary effects, such as the extensive run-off of low salinity, sediment-laden water into the Gulf of Honduras are more difficult to quantify in the short-term (Kramer and Kramer, 2000).

Shipping and offshore effects

Heyman and Kjerfve (2001) state that industrial shipping is one of the largest and potentially most environmentally damaging industries in the Gulf of Honduras. Puerto Cortés, on the western coast of mainland Honduras, is one of the largest ports in the region and a spill from one of the many petroleum or chemical vessels could be catastrophic.

This combination of threats to reef health underscores the need to control land-based sources of stress through better land-use planning and environmental management.

2.3 Utila

Utila is the smallest of the three main Bay Islands and is 11 km long and 5km wide with almost two-thirds of its area covered by swamp. Two small hills on the eastern side of the island, Stuart's Hill and Pumpkin Hill, are of volcanic origin. Almost all Utilans (population approximately 2000) live in East Harbour on the south side of the island. On the southwest side of the island lie 12 small islands, referred to as the Cays. The Cays are home to approximately 400 people, mostly on Suc-Suc and Pigeon Cay.

As recently as 1992, Utila was a quiet island community that relied mainly on local industries such as fishing and farming as it's main source of income. Also, for many years the men-folk of Utila have worked overseas on ships and oil rigs, sending their salaries home to their families. However, the community has developed rapidly over recent years as a fledgling tourism industry has expanded into a major aspect of the island's economy. Many tourists visit Utila to get SCUBA certifications and it is now known as the cheapest place in the world to learn to dive. Approximately 14 dive shops supply training facilities to thousands of international travellers who visit the island each year to learn to dive and enjoy the island's reefs, bars, restaurants and night-clubs. Whilst this industry brings additional income into the local economy and provides livelihoods for many islanders, it has had an impact upon the 'traditional' way of life.

2.4 Aims and objectives

During work on Utila, CCC developed a programme of surveys, training and conservation education aimed at assessing the status of local reefs and improving environmental awareness amongst neighbouring communities (Harborne *et al*., In press). The primary aims of the project were to: map the benthic and fish communities; provide data on reef health and threats to current reef health; continue the monitoring programme of Project Utila; generate basic fish and coral species lists; provide basic socio-economic data on diving pressure; providing training opportunities for local counter-parts and environmental awareness programmes (Table 1).

Table 1. Main aims, objectives and anticipated outputs of the *Bay Islands 2000* project in Utila.

AIM	OBJECTIVE	ANTICIPATED OUTPUTS
✍ Resource assessment.	✍ Undertake a scientific survey of Utila's reefs to document the benthic and fish communities. ✍ Conduct studies on climatic, oceanographic and anthropogenic variables affecting the reefs. ✍ Provide management tools and recommendations.	✍ Baseline database and description of reef communities. ✍✍Documentation of gross climatic, oceanographic and anthropogenic variables.✍ ✍✍Habitat map using aerial photography. ✍✍Management recommendations.
✍ Reef health assessment.	✍✍ Undertake 'Reef Check' surveys to quantitatively assess benthic and fish communities and anthropogenic impacts. ✍ Establish a Reef Check database for Utila. Provide data for the global Reef Check databases. ✍ Continue monitoring the sites established by 'Project Utila'. ✍ Provide management tools and recommendations.	✍✍Quantitative assessment of reef health. ✍✍Data set for comparison with future surveys.✍ ✍✍Information on the change of benthic communities over time.✍ ✍✍Management recommendations.
✍ Taxonomy.	✍✍ Complete a basic biodiversity assessment by generating fish and coral species lists	✍✍Quantitative assessment of reef biodiversity. ✍✍Data set for comparison with future surveys.
✍ Socio-economics.	✍✍ Undertake a basic assessment of diving pressure around Utila. ✍ Provide management tools and recommendations.	✍✍Quantitative assessment of diving pressure. ✍✍Data set for comparison with future surveys.✍ ✍✍Management recommendations.
✍ Training and conservation education.	✍✍ Provide scientific and SCUBA training for CCC volunteers and local counterparts. ✍✍ Heighten awareness of marine resources, their use and protection. ✍✍ Begin to develop a sense of community stewardship in managing the coastal zone.	✍✍ Trained project members. ✍✍ Advice on coastal zone management issues around Utila. ✍ Increased awareness amongst local communities.

The results of CCC's work in Utila are documented in a series of reports. This report is concerned with the Reef Check data gathered during the 'Resource health assessment' component of the fieldwork.

3. METHODS

3.1 Surveyors

All data presented in this report were collected by CCC volunteers and staff during August 2000. Volunteers underwent a week of intensive science training and testing which enabled them to implement the survey protocols, including measuring given parameters and identifying species precisely and consistently. Volunteer divers in Utila were co-ordinated by a Project Scientist (PS) and Science Officer (SO). The primary responsibilities of the PS and SO were to train CCC volunteers in marine life identification, survey techniques and other supporting skills. The PS and SO also co-ordinated and supervised the subsequent surveys and data collection.

3.2 Survey protocol

Reef Check's survey methods are specially designed for recreational divers, so that training is rapid and organism identification is accurate. The following sections provide a synopsis of the Reef Check protocol. Full details of the methodology and regular updates can be found on the website[1].

3.2.1 Laying transects

The Reef Check survey protocol utilises two transects at depths of approximately 3 and 10 m below chart datum, chosen for practical reasons of time and safety. Along each contour, four 20 m long line transects are deployed and surveyed. The transects follow the designated depth contour in sequence but the start and end points are separated by a 5 m space. The distance between the start of the first transect and end of the last transect is, therefore, 20 + 5 + 20 + 5 + 20 + 5 + 20 = 95 m. Figure 2 provides a diagrammatic overview of the positions of the transect lines on the reef and the areas covered during data collection.

3.2.2 Data collection

Five types of data are recorded via three surveys along the transect line at each depth.

Site description

The Site Description Sheet includes anecdotal, observational, historical, locational and other data. These data are important for interpreting local, national and global trends in the data set.

[1] http://www.ReefCheck.org/

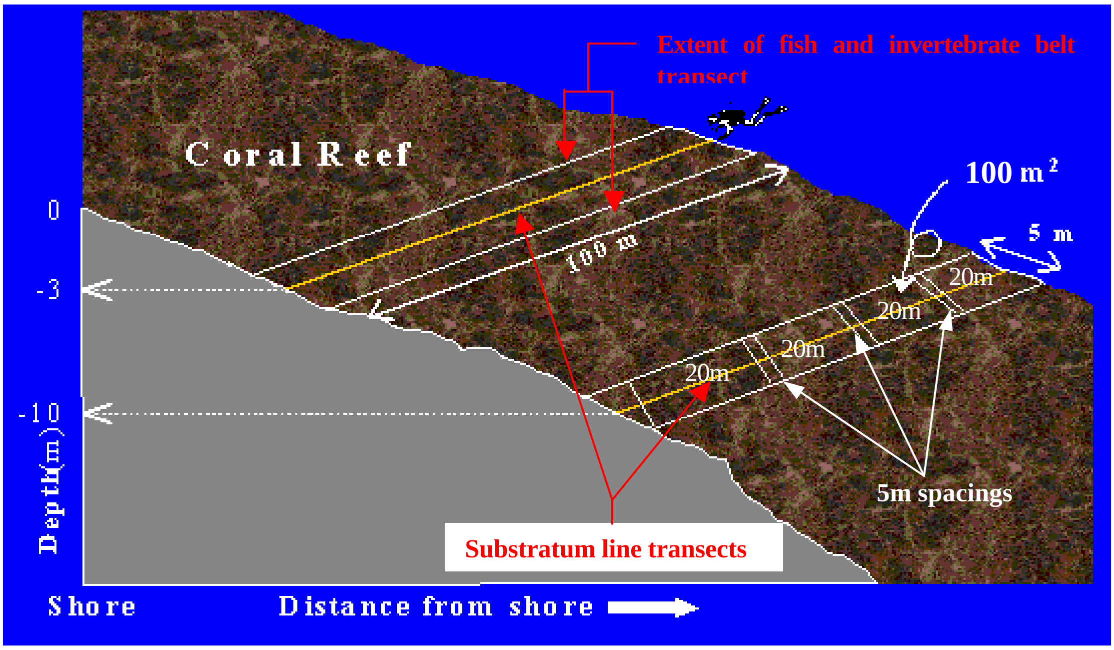

Figure 2. Schematic diagram showing the position of the transect lines during a Reef Check survey. 100 m transect is divided into four 20 m replicates so area of each belt transect is 20 x 5 m = 100 m^2. In addition to the standard 3 and / or 10 m transects, CCC used one or more deeper transects when appropriate. *Source*: modified from figures on http://www.reefcheck.org.

Anthropogenic data

During each survey anthropogenic impacts are assessed for coral damage via either anchors, dynamite, or 'other' factors and trash from fishing nets or 'other'. Divers rated the damage caused by each factor using a 0-3 scale (0 = none, 1 = low, 2 = medium, 3 = high).

Substratum line transect.

Reef Check was designed to be used by non-professional divers to assess reef health and hence generates relatively simple, but quantitative, information. During the *Bay Islands 2000* project the standard Reef Check protocol was modified to collect more detailed data (e.g. via greater taxonomic resolution) and hence provide a better assessment of reef health. Such modifications were possible because all CCC volunteers in Utila received more intensive training than regular sport divers.

Four 20 m long transects were point sampled at 0.5 m intervals to determine the substratum types on the reef. Point sampling was chosen by Reef Check because it is the least ambiguous and fastest method of survey and is easily learned by recreational divers. Hence CCC volunteers looked at the series of 0.5 m points where the transect tape touches the reef and notes down what lies under those points. The categories recorded under each 50 cm point were: hard coral species (normally simply 'hard coral' during standard Reef Check), soft coral, dead coral, five categories of algal cover (normally simply 'fleshy seaweed' during standard Reef Check), sponge, rock, rubble, sand, silt / clay and 'other'. In order to deal with any ambiguity, the divers are given specific guidance on these categories.

Fish belt transect

Four 5 m wide by 20 m long transects (centred on the transect line) were sampled for fish typically targeted by fisherfolk, aquarium collectors and others. In the Caribbean these species and families are Nassau grouper (*Epinephalus striatus*), any grouper over 30 cm (Serranidae), grunts and margates (Haemulidae), snappers (Lutjanidae), parrotfish over 20 cm (Scaridae) and butterflyfish (Chaetodontidae). The diver assigned to count fish swam slowly along the transect and then stopped to count target fish every 5 m and then waited three minutes for target fish to come out of hiding before proceeding to the next stop point. This was selected by Reef Check as a combination of timed and area restriction surveys of four sections (20 m long x 5 m wide = 400 m^2). At each depth contour there were sixteen 'stop-and-count' points.

Invertebrate belt transect

Four 5 m wide by 20 m long transects (centred on the transect line) were sampled for invertebrate taxa typically targeted as food species or collected as curios. In the Caribbean these taxa are banded coral shrimp (*Stenopus hispidus*), long-spined black sea urchins (*Diadema* spp.), lobster (all edible species), pencil urchin (*Eucidaris* spp.), triton shell (*Charonia variegata*), flamingo tongue (*Cyphoma gibbosum*) and gorgonians (sea fan, sea whip). Quantitative counts were made of each species. In addition, surveyors noted the presence of coral bleaching or unusual conditions (e.g. diseases) along the transects.

3.3 Data analysis

All data were transferred to field recording sheets and subsequently to standardised spreadsheets. CCC spreadsheets were also submitted to Reef Check for integration into the global data set. For this study, line transect data were converted to mean percentage cover of each substratum category per depth contour. Belt transect data were used to calculate the mean abundance of each fish and invertebrate taxa. Anthropogenic data were represented by median abundance ratings.

Visual comparisons between sites and depths were facilitated via data tabulation and a series of piecharts and univariate statistics, including regression analysis to test for correlations. Quantitative assessment of these trends was achieved using Analysis of Variance (ANOVA) and subsequent least significant difference multiple range tests (benthic data) and Kruskal-Wallis (KS) tests (fish and invertebrate data). Percentage cover data for the benthic taxa and substratum categories were Arcsin transformed prior to ANOVA to ensure they met the assumptions of normality (Sokal and Rolf, 1981).

Comparative data were obtained from Belize (Turnbull and Harborne,1999) and for the Caribbean region (from Reef Check 1997) via extraction from Hodgson (1999). Data were extracted from Hodgson (1999) as accurately as possible but there was a degree of error since raw data were not available.

Note on statistical conventions: during this report the results of statistical tests are given by showing the 'p' (probability) value of the test. Under statistical conventions, a p value of less than 0.05 is regarded as 'significant' (the error of the test is less than 1 in 20) and a p value of less than 0.01 is regarded as 'very significant'.

4. RESULTS

4.1 Survey sites

Surveys on seven sites were completed during August 2000 (Figure 3). Table 2 provides further details, from the Site Description Sheets, for each site.

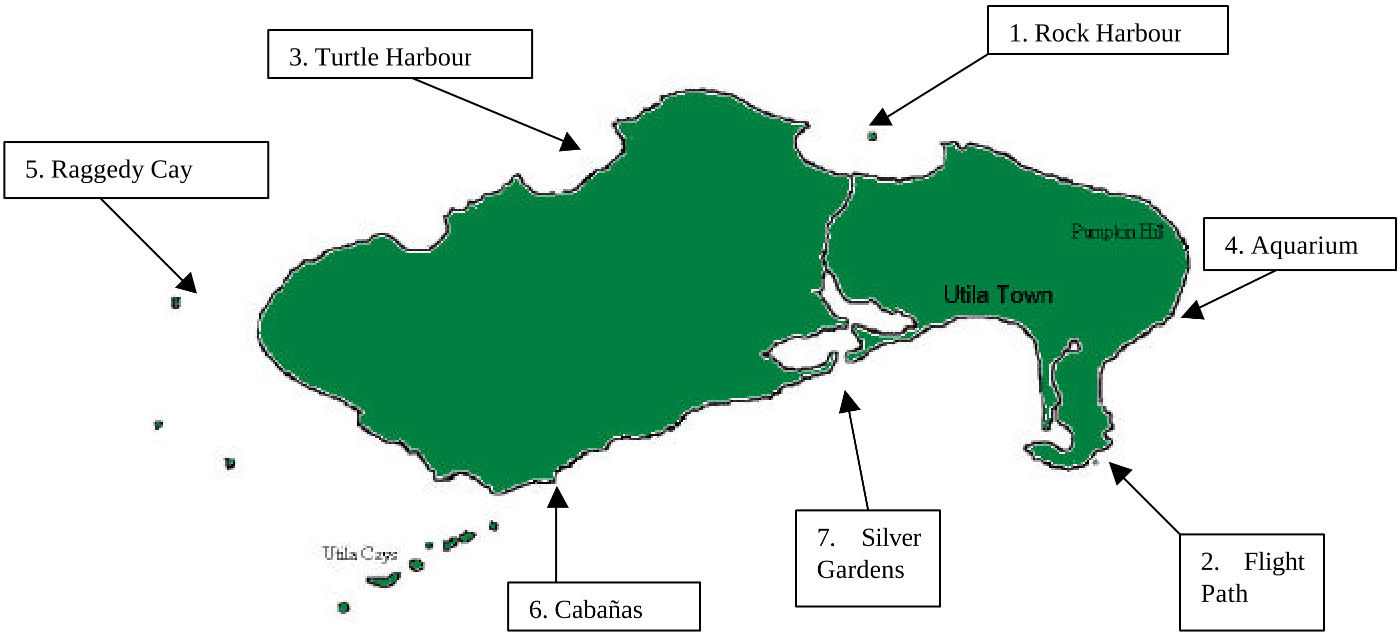

Figure 3. The locations of the seven Reef Check sites completed around Utila.

Table 2. Detailed data on the location, depth and date completion of the seven Reef Check sites completed around Utila. See Figure 3 for locations of sites.

Site		Co-ordinates	Date	Depth	Transect orientation	Distance from shore	Distance to Utila town
1	Shallow	16º07'26.6" 86º56'06.0"	28/8/2000	6m	SE-NW	200m	4.8km
	Medium	16º01'27.8" 86º56'08.9"	11/8/2000	11m	SE-NW	200m	4.8km
2	Shallow	16º05'16.8" 86º53'06.8"	21/8/2000	6m	SW-NE	50m	0.5km
	Medium	16º05'13.9" 86º53'06.6"	21/8/2000	11m	SE-NW	200m	0.6km
3	Shallow	16º06'45.0" 86º56'55.0"	24/8/2000	4m	NE-SW	250m	1.6km
	Medium	16º06'53.4" 86º56'50.9"	10/8/2000	9m	NE-SW	200m	1.6km
4	Shallow	16º06'27.4" 86º52'30.1"	23/8/2000	9m	NE-SW	12m	0.7km
	Medium	16º06'26.3" 86º52'27.8"	22/8/2000	12m	SE-NW	50m	0.7km
5	Shallow	16º05'10.2" 86º59'55.0"	23/8/00	5m	NE-SW	20m	3km
	Medium	16º05'31.7" 86º59'33.1"	9/8/2000	9m	NE-SW	150m	3km
6	Shallow	16º04'17.0" 86º57'03.5"	24/8/2000	5m	SE-NW	45m	5km
	Medium	16º04'10.9" 86º57'11.8"	15/8/2000	8m	SE-NW	50m	5km
7	Shallow	16º04'59.9" 86º55'02.9"	16/8/2000	4m	E-W	50m	1km
	Medium	16º04'58.9" 86º55'02.5"	16/8/2000	12m	E-W	100m	1km

The basic oceanographic and climatic conditions during Reef Check surveys were also recorded. The mean air temperature was 29.6ºC (standard deviation (SD) 2.0ºC), mean sea surface temperature was 29.1ºC (SD = 0.6ºC), mean temperature at 3 m was 29.1º (SD = 0.6ºC) and mean water temperature at 10 m was 28.6ºC (SD = 0.5ºC). The mean estimated underwater visibility was 14.3 m (SD = 2.3 m).

4.2 Anthropogenic impacts

As shown in Table 2, the seven Reef Check sites were situated between 0.5 and 4.8 km from Utila Town, which has an approximate population of 2000 people. Hence each site is subjected to a range of perceived anthropogenic impacts, as recorded on the Site Description Sheets (Table 3). Table 3 shows that the impacts recorded on the Site Description Sheets are relatively minor at the seven Reef Check sites around Utila. However, it should be noted that the Site Description Sheets do not request information on hurricanes or coral bleaching events, both of which had major effects on the reefs of Utila in 1998.

Table 3. A summary of the perceived impacts at each of the seven sites from the Site Description Sheets.

Impact	Rock Harbour		Flight path		Turtle Harbour		Aquarium		Raggedy Cay		Cabañas		Silver Gardens	
	Shallow	**Medium**	**Shallow**	**Medium**	**Shallow**	**Medium**	**Shallow**	**Medium**	**Shallow**	**Medium**	**Shallow**	**Medium**	**Shallow**	**Medium**
Dynamite fishing	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Poison fishing	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Aquarium fish collection	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Harvest of inverts for food	None	None	None	None	Moderate	Moderate	None	None	Moderate	Moderate	None	None	None	None
Harvest of inverts for curio sales	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Tourist diving	Low	Low	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Heavy	Heavy
Sewage pollution	None	None	None	None	Low	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate	Moderate
Industrial pollution	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Other form of fishing	None	None	None	None	Moderate	Moderate	None	None	None	None	None	None	None	None
Other impacts	None	None	None	None	None	None	None	None	None	None	None	None	Moderate	Moderate

In addition to the information on the site Description Sheets, Table 4 shows a summary of the anthropogenic impact data recorded at each site during belt transect surveys.

Table 4. Mean values of anthropogenic impact data recorded using a 0-3 ordinal scale at each survey site during fish and invertebrate belt transects. Data given separately for shallow and medium depth transects. Figures in parentheses represent standard deviation.

Site	Depth	Coral damage: anchor	Coral damage: dynamite	Coral damage: other	Trash: fish nets	Trash: other
1. Rock Harbour	Shallow	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
	Medium	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.5 (0.6)
2. Flight Path	Shallow	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.8 (0.9)
	Medium	0.3 (0.5)	0.0 (0.0)	0.8 (0.9)	0.0 (0.0)	0.0 (0.0)
3. Turtle Harbour	Shallow	0.0 (0.0)	0.0 (0.0)	0.5 (0.6)	0.0 (0.0)	0.0 (0.0)
	Medium	0.3 (0.5)	0.0 (0.0)	0.8 (0.5)	0.3 (0.5)	0.0 (0.0)
4. Aquarium	Shallow	0.0 (0.0)	0.0 (0.0)	1.0 (0.0)	0.0 (0.0)	0.0 (0.0)
	Medium	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
5. Raggedy Cay	Shallow	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
	Medium	0.0 (0.0)	0.0 (0.0)	1.0 (0.0)	0.0 (0.0)	0.0 (0.0)
6. Cabañas	Shallow	0.0 (0.0)	0.0 (0.0)	1.0 (1.2)	0.0 (0.0)	0.5 (0.6)
	Medium	0.0 (0.0)	0.0 (0.0)	0.5 (1.0)	0.0 (0.0)	0.8 (0.9)
7. Silver Gardens	Shallow	0.0 (0.0)	0.0 (0.0)	1.0 (1.2)	0.0 (0.0)	0.8 (0.9)
	Medium	0.0 (0.0)	0.0 (0.0)	1.5 (0.6)	0.0 (0.0)	0.8 (0.9)

Similarly to qualitative information on the site description forms, the majority of sites had limited obvious anthropogenic impacts. The most common impact was generic ‘coral damage’, which occurred at both shallow and medium depths. There were also incidents of ‘trash’ at three of the seven sites. There were no incidents of coral damage by dynamite and only a few impacts by anchors. Lost fish nets were only seen once.

4.3 Benthic data

4.3.1 Site characteristics

Table 5 summarises the gross characteristics of each of the seven Reef Check sites. Note that for clarity, all coral species have been summed and are represented as total coral cover. Coral cover by species is shown in Appendix1.

Table 5. Percentage cover of each benthic category at each Reef Check site. Shallow transects (S) at approximately 3 m and mid-depth transects (M) at approximately 10 m. Standard deviation shown in parentheses. Shading highlights greatest value of each benthic category.

.

Taxa / Substratum category	**1. Rock Harbour**		**2. Flight Path**		**3. Turtle Harbour**		**4. Aquarium**		**5. Raggedy Cay**		**6. Cabañas**		**7. Silver Gardens**	
	S (%)	M (%)	S (%)	M (%)	S (%)	M (%)	S (%)	M (%)	S (%)	M (%)	S (%)	M (%)	S (%)	M (%)
Coral cover	6.2 (0.5)	11.9 (0.7)	13.8 (1.1)	42.7 (3.5)	12.0 (0.7)	28.1 (1.4)	3.6 (0.2)	16.2 (0.8)	10.6 (0.8)	22.6 (1.8)	19.9 (1.1)	16.8 (1.1)	20.0 (1.5)	23.1 (1.7)
Soft corals	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)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Dead coral	0.0 (0.0)	0.6 (1.3)	2.5 (3.5)	12.7 (8.3)	3.1 (4.7)	0.0 (0.0)	0.0 (0.0)	5.0 (4.6)	0.6 (1.3)	5.6 (4.3)	0.0 (0.0)	3.1 (4.7)	7.5 (6.1)	1.9 (2.4)
Green algae	36.2 (17.1)	10.0 (4.6)	1.3 (1.4)	1.8 (3.8)	3.8 (4.8)	8.1 (1.3)	3.1 (6.3)	0.6 (1.3)	3.8 (1.4)	5.6 (6.6)	5.0 (6.8)	19.4 (19.5)	16.3 (4.3)	18.8 (11.3)
Green calcified	0.0 (0.0)	0.0 (0.0)	2.5 (2.0)	6.3 (6.6)	3.8 (4.8)	1.3 (1.4)	5.6 (8.3)	1.3 (2.5)	9.4 (8.3)	3.8 (3.2)	16.9 (9.7)	1.8 (3.8)	0.0 (0.0)	0.0 (0.0)
Brown fleshy	6.3 (12.5)	0.0 (0.0)	3.1 (2.4)	6.8 (6.6)	5.0 (5.4)	1.3 (2.5)	3.8 (4.8)	3.8 (4.8)	8.8 (11.3)	6.9 (5.5)	6.3 (2.5)	0.0 (0.0)	7.5 (10.6)	0.0 (0.0)
Brown/red branching	9.4 (8.3)	13.7 (9.7)	8.1 (6.9)	10.0 (5.0)	10.6 (13.1)	1.3 (2.5)	20.0 (17.4)	3.1 (3.8)	23.1 (14.8)	9.4 (6.6)	16.3 (8.3)	5.0 (7.1)	2.5 (2.9)	5.0 (8.4)
Red coralline	0.0 (0.0)	0.6 (1.3)	0.0 (0.0)	0.0 (0.0)	1.9 (2.4)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	8.1 (9.4)	0.0 (0.0)	1.9 (2.4)	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 (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)
Sponge	0.0 (0.0)	1.9 (2.4)	3.1 (3.8)	1.8 (2.4)	3.8 (5.9)	0.6 (1.3)	1.9 (2.4)	1.9 (2.4)	1.3 (2.5)	1.9 (3.8)	2.5 (2.0)	2.5 (3.5)	1.9 (2.4)	2.5 (2.9)
Rock	0.0 (0.0)	42.5 (12.1)	12.5 (20.3)	8.7 (8.8)	25.6 (19.8)	40.0 (6.1)	0.0 (0.0)	20.6 (13.1)	15.0 (7.4)	18.8 (12.7)	7.5 (8.9)	16.9 (9.7)	21.3 (10.3)	15.6 (6.9)
Rubble	2.5 (5.0)	0.6 (1.3)	5.6 (5.4)	2.5 (3.5)	3.8 (5.9)	1.3 (1.4)	0.0 (0.0)	3.1 (4.7)	1.9 (2.4)	5.0 (7.1)	9.4 (8.0)	23.8 (7.8)	5.6 (6.6)	7.5 (11.7)
Sand	25.0 (5.4)	0.0 (0.0)	35.9 (25.4)	0.6 (1.3)	14.4 (12.1)	5.0 (4.1)	57.5 (27.6)	33.1 (19.5)	15.0 (15.9)	8.1 (10.7)	15.0 (11.7)	6.9 (9.4)	13.8 (10.3)	15.6 (10.9)
Silt	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)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Other	14.4 (4.3)	18.2 (4.7)	10.6 (11.4)	5.0 (5.4)	12.5 10.2)	13.1 (8.3)	4.4 (5.9)	11.3 (4.3)	2.5 (2.0)	12.5 (6.1)	2.5 (2.0)	3.8 (4.3)	3.8 (5.9)	10.0 (7.4)

Table 5 shows that all sites have relatively low coral cover, with Flight Path mid-depth having the highest values (42.7%). There was also generally more coral cover at mid-depths in comparison with shallow depths. Green algae and green calcified algae were generally less than 10% but had much higher values at Rock Harbour (shallow), Cabañas (mid-depth) and Silver Gardens (both depths) and Cabañas (shallow) respectively. Brown fleshy algae cover was also less than 10% and brown / red branching algae had the highest cover at Raggedy Cay (shallow) and Aquarium (shallow). Red coralline algae and sponges were generally uncommon and there was no seagrass, silt or 'other' at any of the sites. The major substratum variables (rock, rubble and sand) varied widely between sites and depths. 'Other', which was mainly gorgonians, was relatively consistent and cover was commonly less than 15%. The characteristics of each site are shown graphically in Figure 4 (shallow transects) and Figure 5 (mid-depth transects).

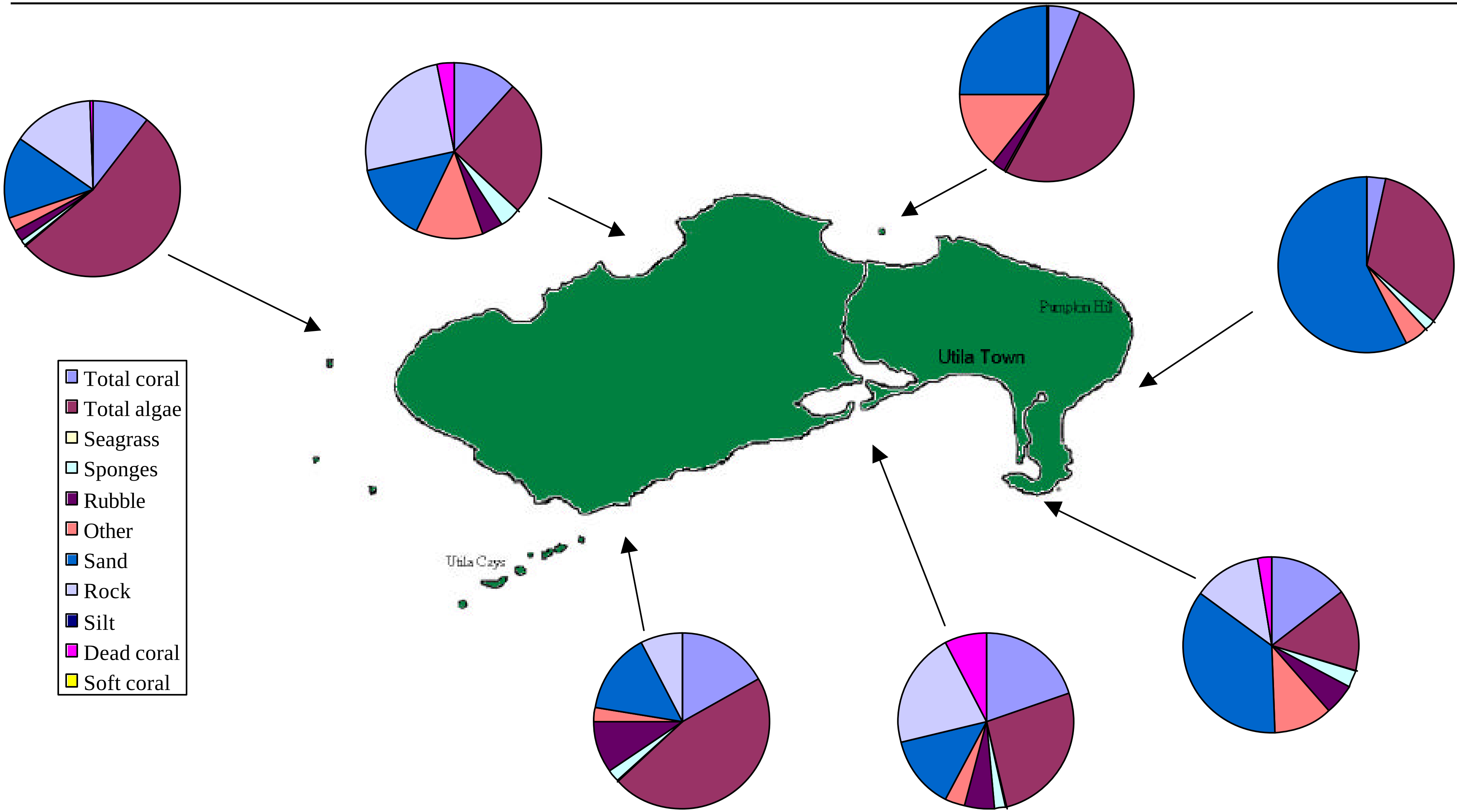

Figure 4. Graphical representation of the benthic characteristics for the shallow depth data for each site.

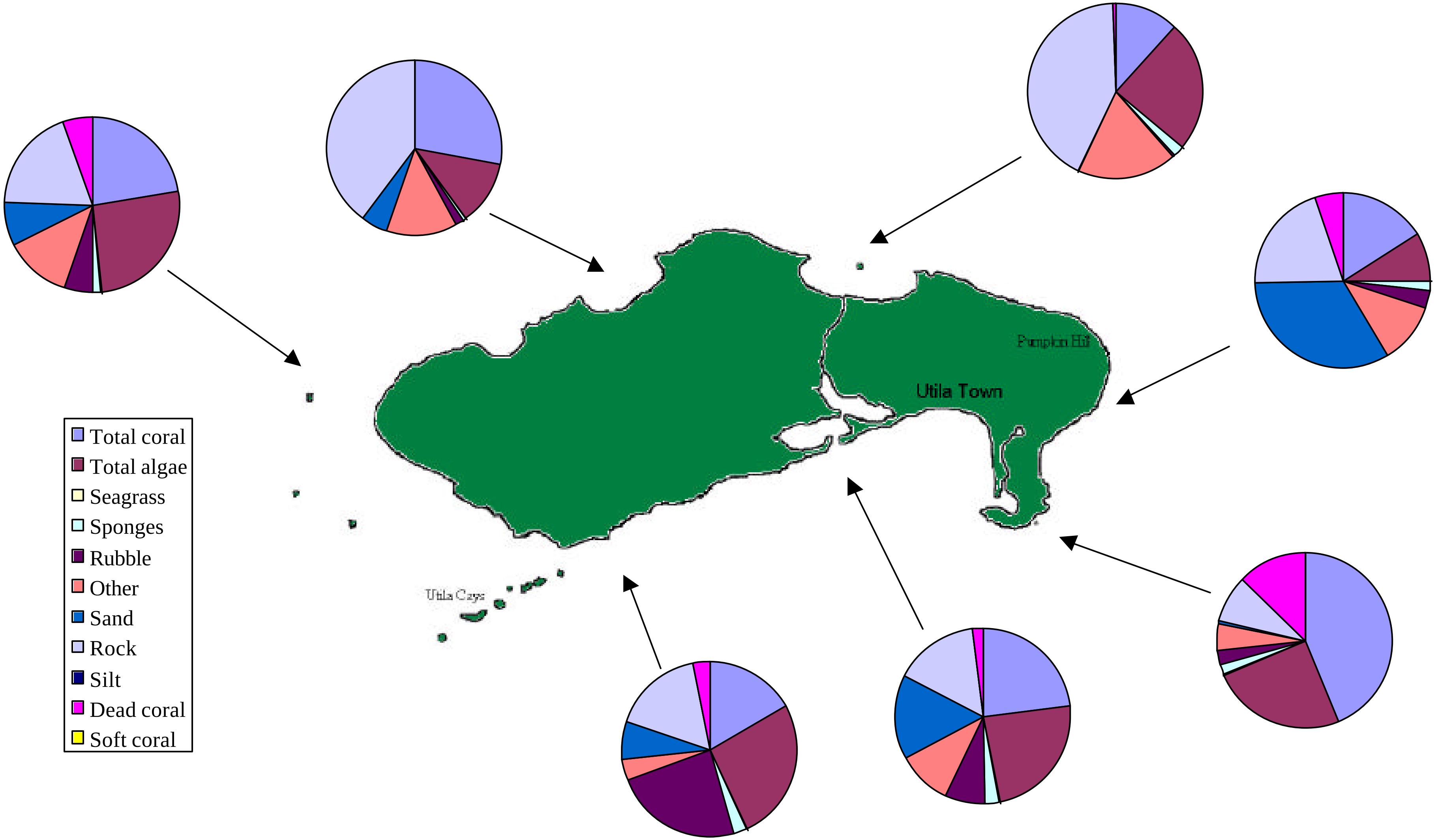

Figure 5. Graphical representation of the benthic data for the medium depth data at each site.

Table 6 summarises the coral species richness, diversity and eveness on each transect. Diversity and eveness were calculated using the Shannon diversity index (Begon *et al.*, 1990).

Table 6. Coral species richness, diversity and evenness at each of the seven Reef Check sites.

Site		Species richness	Diversity	Evenness
1. Rock Harbour	Shallow	4	1.27	0.92
	Medium	8	1.91	0.92
2. Flight Path	Shallow	9	1.82	0.83
	Medium	14	1.91	0.73
3. Turtle Harbour	Shallow	7	1.87	0.75
	Medium	16	2.42	0.73
4. Aquarium	Shallow	6	1.79	1.0
	Medium	10	2.18	0.95
5. Raggedy Cay	Shallow	7	1.61	0.83
	Medium	8	1.64	0.79
6. Cabañas	Shallow	8	1.81	0.87
	Medium	10	1.96	0.85
7. Silver Gardens	Shallow	9	1.76	0.80
	Medium	9	1.73	0.79

4.3.2 Variation between sites

ANOVA tests, and subsequent multiple range tests, were undertaken on data for each benthic taxa or substratum category to assess variation between each of the seven sites. Tests were repeated for shallow transects only, mid-depth transects only and all data combined. Tables 7 and 8 summarise the results of these tests, showing any taxa or substratum which was significant ($p < 0.05$). For each significant result the results of the multiple range tests are also shown. Note that only significant differences from the multiple range tests are shown.

Table 7. The significant results of ANOVA tests for benthic data between the seven different Reef Check sites (shallow transects and mid-depth transects). * = p<0.05; ** = p<0.01 and *** = p<0.005. Order of sites refers to the significant results from multiple range tests. Sites: RH=Rock Harbour, FP=Flight Path, TH=Turtle Harbour, AQ=Aquarium, RC=Raggedy Cay, CA=Cabañas, SG=Silver Gardens.

TAXA / SUBSTRATUM CATEGORY	**Significance**	**Order of sites**
	Shallow transects	
Mustard hill coral (*Porites astereoides)*	0.010 (*)	TH>RH, AQ; RC>RH, AQ, FP, CA †
Mountainous star coral (*Montastraea annularis)*	0.0003 (***)	CA>RH, TH, AQ, RC; SG>RH, TH, AQ, RC, FP
Cavernous star coral (*Montastraea cavernosa*)	<0.001 (***)	SG>RH, FP, TH, RC, CA
Green algae (non-calcified)	<0.001 (***)	RH>FP, TH, AQ, RC, CA; SG>FP, TH, AQ, RC, CA
Green calcified algae	0.005 (***)	RC>RH, SG; CA>RH, SG, FP, TH, AQ
Dead coral	0.033 (*)	SG > RH, AQ, CA, RC
Sea fan	0.042 (*)	TH>SG, RC, CA; RH>SG, CA, RC, AQ
Sand	0.001 (***)	AQ>RC, SG, TH, CA
	Mid-depth transects	
Leaf coral (*Agaricia agaracites*)	0.018 (*)	TH>RH; RC>RH, CA; SG>RH, CA, AQ
Mountainous star coral (*Montastraea annualris)*	0.004 (**)	SG>AQ, RH; RC>AQ, RH; FP>AQ, RH, TH, CA, SG
Pillar coral (*Dendrogyra cylindrus)*	0.007 (**)	
Staghorn coral (A*cropora cervicornis*)	0.004 (***)	FP>RH, TH, AQ, RC, CA, SG
Thin fungus coral (*Mycetpphyllia aliciae*)	0.035 (**)	FP>RH, TH, AQ, RC, CA,SG
Rough starlet coral (*Isophyllastrea rigida)*	0.003 (***)	SG>RH, FP, AQ, RC, CA; TH>RH, FP, AQ, RC, CA
Brown fleshy algae	0.015 (*)	FP>RH, TH, AQ, CA, SG; RC>RH, TH, AQ, CA, SG
Green algae (non-calcified)	0.006 (**)	TH>AQ; RH>AQ, FP; CA>AQ, FP; SG>AQ,FP,RC
Dead coral	0.008 (**)	AQ>TH; RC>TH; FP>TH, RH, SG, CA
Sea fan	0.026 (*)	AQ>CA; RC>CA, FP; TH>CA, FP; TH>CA, FP; RH>CA, FP
Rubble	0.005 (***)	CA>RH, FP, TH,AQ, RC, SG
Sand	0.002 (***)	SG>RH, FP; SG>RH, FP, CA, TH, RC

† In this example, TH was significantly greater than RH and AQ and RC was significantly greater than RH, AQ, FP and CA.

Table 8. The significant results of ANOVA for benthic data between the seven different Reef Check sites (all transects combined). * = p<0.05; ** = p<0.01 and *** = p<0.005. Order of sites refers to the significant results from multiple range tests. Sites: RH=Rock Harbour, FP=Flight Path, TH=Turtle Harbour, AQ=Aquarium, RC=Raggedy Cay, CA=Cabañas, SG=Silver Gardens.

Taxa / Substratum category	Significance	Order of sites
Blushing star coral *(Stephanocoenia michelinii)*	0.046 (*)	FP>RH, TH, AQ, RC, CA, SG
Cavernous star coral (*Montastraea cavernosa*)	0.031 (*)	SG>RC, RH, CA
Green cactus (*Madracis decactis*)	0.003 (***)	FP>RH, SG; RC>RH, SG; CA>RH, SG
Mustard hill coral *(Porites astreoides)*	0.009 (**)	TH>RH, AQ; RC>RH, AQ, FP, CA, SG
Mountainous star coral (*Monastraea annularis)*	0.002 (***)	RC>AQ; CA>AQ, RH; FP>AQ, RH, TH; SG>AQ, RH, TH
Staghorn coral (*Acropora cervicornis)*	0.018 (*)	FP>RH, TH, AQ, CA, RC, SG
Green algae (non-calcified)	<0.001 (***)	CA>AQ, FP; SG>AQ, FP, RC, TH; RH>AQ, FP, RC, TH, CA
Rough starlet coral (*Siderastrea radians*)	0.002 (***)	TH>RH, RC, CA,AQ; FP>RH, RC, CA, AQ
Dead coral	0.045 (*)	SG>RH; FP>RH, TH, CA, AQ
Sea fan	0.009 (**)	TH>CA, RH>CA, SG, AQ, RC, FP
Rubble	0.001 (***)	CA>RH, FP, TH, AQ, RC, SG
Sand	0.007 (**)	AQ>RH, FP, TH, RC, CA, SG

The results from the ANOVA tests show that only a few parameters are significant for both shallow and medium transects: dead coral, green algae, mountainous star coral, sea fan and sand. When ANOVA tests were undertaken for both depth combined a larger number of taxa / substratum categories were significant and some parameters only showed significant variation when all the data were combined. These taxa were blushing star coral, green cactus coral and rough starlet coral.

4.4 Fish and invertebrate data

4.4.1 Site characteristics

Table 9 shows the mean abundance of each target fish and invertebrate taxa at each site and highlights that many of the indicator species were uncommon. For example, no triton shells, Nassau grouper or conch were seen. Furthermore, ‘other’ groupers and lobster had abundances of less than 1 animal per transect. Parrotfish were the commonest fish taxa and gorgonians were the most abundant invertebrates. However, butterflyfish, snappers, Diadema urchins and flamingo shells were also relatively common.

Table 9. Mean abundance of each fish and invertebrate taxa at each Reef Check site. Shallow transects (S) at approximately 3 m and mid-depth transects (M) at approximately 10 m. Standard deviation shown in parentheses. Shading highlights greatest value of each fish or invertebrate taxa.

Taxa	1. Rock Harbour		2. Flight Path		3. Turtle Harbour		4. Aquarium		5. Raggedy Cay		6. Cabañas		7. Silver Gardens	
	S	M	S	M	S	M	S	M	S	M	S	M	S	M
Butterflyfish	0.0	2.5	2.8	1.8	3.0	5.0	1.5	3.8	3.8	1.8	2.5	2.3	2.3	1.8
(Chaetodontidae)	(0.0)	(1.9)	(0.9)	(0.9)	(0.8)	(2.2)	(1.0)	(0.5)	(1.3)	(0.5)	(1.0)	(2.1)	(2.2)	(1.7)
Grunts / Margates	0.0	0.3	2.3	4.3	3.0	1.0	0.8	4.0	2.0	1.5	3.0	1.3	0.8	1.8
(Haemulidae)	(0.0)	(0.5)	(2.2)	(2.9)	(1.4)	(0.8)	(0.9)	(2.9)	(2.2)	(1.0)	(0.8)	(0.5)	(0.5)	(1.3)
Snapper	0.3	0.0	0.5	0.8	5.3	0.0	0.8	1.0	0.8	0.5	1.3	0.8	1.5	1.3
(Lutjanidae*)*	(0.5)	(0.0)	(1.0)	(0.9)	(4.7)	(0.0)	(0.9)	(1.4)	(0.9)	(0.6)	(1.3)	(1.5)	(1.3)	(1.3)
Nassau grouper	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
(*Epinephalus striatus*)	(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)
Other grouper (>	0.0	0.5	0.3	0.5	0.0	0.8	0.3	0.5	0.0	0.3	0.3	0.5	0.5	0.8
30cm)	(0.0)	(1.0)	(0.5)	(0.6)	(0.0)	(1.5)	(0.5)	(1.0)	(0.0)	(0.5)	(0.5)	(0.6)	(1.0)	(0.9)
Parrotfish	2.3	1.3	1.5	3.8	4.0	5.8	2.3	4.8	6.3	2.8	3.8	6.0	5.8	1.0
(Scaridae)	(3.9)	(0.9)	(1.7)	(2.8)	(2.2)	(2.4)	(2.6)	(2.1)	(3.6)	(0.9)	(2.2)	(3.6)	(3.6)	(0.8)
Banded coral shrimp	1.0	0.3	0.0	0.5	0.8	2.5	2.0	0.3	2.0	4.3	0.5	0.3	3.0	0.3
(S*tenopus hispidus)*	(1.0)	(0.5)	(0.0)	(0.6)	(1.5)	(1.9)	(2.3)	(0.5)	(0.0)	(2.2)	(0.6)	(0.5)	(3.8)	(0.5)
***Diadema* urchins**	0.25	0.3	2.5	1.0	1.0	5.3	0.3	1.0	4.8	7.3	1.3	14.0	4.3	0.8
	(0.5)	(0.5)	(3.1)	(0.8)	(1.4)	(4.4)	(0.5)	(1.4)	(3.2)	(0.9)	(0.9)	(14.0)	(4.0)	(0.9)
Pencil urchins	0.0	0.0	0.3	1.3	0.0	0.5	0.0	0.0	2.3	2.8	0.3	3.5	0.8	1.3
(*Eucidaris spp.)*	(0.0)	(0.0)	(0.5)	(1.5)	(0.0)	(1.0)	(0.0)	(0.0)	(1.9)	(3.1)	(0.5)	(4.4)	(0.9)	(1.5)
Triton shell	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
(*Charonia variegata)*	(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)
Flamingo shell	4.8	10.0	3.3	3.0	1.0	2 .0	0.5	1.3	3.0	3.5	1.3	1.8	0.8	1.5
(*Cyphoma gibboum*)	(1.7)	(12.4)	(0.5)	(2.4)	(2.0)	(1.2)	(1.0)	(0.5)	(0.8)	(2.6)	(1.3)	(17.0)	(0.9)	(0.6)
Gorgonian (sea fan,	63.3	20.5	40.8	43.5	42.5	42.3	25.0	17.0	15.8	18.8	32.5	35.3	21.8	21.5
sea whip)	(7.8)	(3.3)	(39.5)	(7.5)	(17.3)	(4.9)	(6.2)	(13.3)	(3.5)	(5.9)	(15.1)	(11.9)	(8.2)	(5.9)
Lobster	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.3	0.3	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.5)	(0.0)	(0.0)	(0.0)	(0.0)	(0.6)	(0.5)	(0.5)	(0.0)
Conch	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)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

4.4.2 Variation between sites

Kruskal-Wallis tests were undertaken on the fish and invertebrate data to assess variation between each of the seven sites. Tests were repeated for shallow transects only, mid-depth transects only and all data combined. Table 10 summarises the results of these tests, showing any taxa which was significant ($p < 0.05$). For each significant result the order of sites (decreasing mean abundance) is shown.

Table 10. The significant results of Kuskal-Wallis tests for fish and invertebrate data between the seven different Reef Check sites (shallow transects, mid-depth transects and both depths combined). * = p<0.05; ** = p<0.01 and *** = p<0.005. Order of sites from mean abundances. Sites: RH=Rock Harbour, FP=Flight Path, TH=Turtle Harbour, AQ=Aquarium, RC=Raggedy Cay, CA=Cabañas, SG=Silver Gardens.

Taxa / Substratum category	Significance	Order of sites
	Shallow transects	
Butterflyfish	0.029 (*)	RC>TH>FP>CA>SG>AQ>RH
Grunts / Margates	0.03 (*)	TH>CA>FP>RC>AQ>SG>RH
Diadema urchin	0.03 (*)	RC>SG>FP>CA>TH>RH>AQ
Flamingo tongue	0.009 (**)	RH>FP>RC>CA>TH>SG>AQ
	Mid-depth transects	
Parrot fish	0.017 (*)	CA>TH>AQ>FP>RC>RH>SG
Banded coral shrimp	0.013 (*)	RC>TH>FP>RH, AQ, CA, SG
Diadema urchin	0.006 (**)	CA>RC>TH>FP, AQ>SG>RH
Gorgonians	0.005 (**)	FP>TH>CA>SG>RH>RC>AQ
	All transects	
Grunts / Margates	0.013 (*)	FP>AQ>CA>TH>RC>SG>RH
Snapper	0.007 (**)	TH>SG>CA>AQ>FP=RC>RH
Banded coral shrimp	0.01 (*)	RC>TH=SG>AQ>RH>CA>FP
Diadema urchin	0.0009 (***)	CA>RC>TH>SG>FP>AQ>RH
Pencil urchin	0.003 (***)	RC>CA>SG>FP>TH>RH=AQ
Flamingo tongue	0.0008 (***)	RH>RC>FP>TH=CA>SG>AQ
Gorgonians	0.007 (**)	TH>FP>RH>CA>SG>AQ>RC

The results for the shallow and medium depths alone show considerable species differences, with only *Diadema* varying significantly at each depth. More taxa were significant for both depths combined than for each depth individually. However, of the taxa that were significant for both depths combined, only snappers were not significant for either the shallow or mid-depth transects individually.

In order to provide an overall assessment of the conservation value of each site, based on the fish and invertebrate taxa, a 'conservation index' was calculated. This index was derived using the taxa that varied significantly for either the shallow or mid-depth transects. For these taxa, the site with the highest abundance was assigned a score of 7 the second highest abundance was given a score of 6 and so on. The results were as follows:

Cabañas = 38.5; Turtle Harbour = 37; Flight Path = 34.5; Silver Gardens = 34.5; Raggedy Cay = 33.5; Rock Harbour = 22.5; Aquarium = 22.

4.5 Correlations between fish and invertebrate data and benthic parameters

In order to assess any links between the fish and invertebrate data and components of the benthic community, regression analysis was used to calculate correlation statistics. These correlations were calculated using the 14 pairs of values (seven sites at two depths) for abundance of a given fish or invertebrate taxa and the equivalent benthic parameter, including species diversity and eveness. Table 11 summarises the significant correlations that were highlighted by this analysis.

Table 11. A summary of significant ($p<0.05$) correlations from regression analysis between the fish and invertebrate data and the percentage cover of benthic parameters. R^2 is the correlation coefficient that varies from –1 (strong negative correlation) to 1 (strong positive correlation). n = 14.

Taxa	Correlated with	R^2	Significance level
Butterflyfish	Green algae	0.33	0.04
Grunts / Margates	Green algae	0.39	0.02
Other grouper (>30cm)	Total algae cover	0.34	0.03
Other grouper (> 30cm)	Red / brown branching algae	0.33	0.03
Butterflyfish	Species richness	0.33	0.03
Butterflyfish	Diversity	0.61	0.001
Other grouper (> 30cm)	Species richness	0.66	0.0004
Other grouper (> 30cm)	Diversity	0.55	0.002

Table 11 shows that fish and invertebrate taxa were only correlated with the percentage cover of algal parameters. However, butterflyfish and ‘other’ groupers (> 30cm) were more significantly correlated with coral species richness and diversity. Figure 6 shows the relationship between other groupers and coral diversity.

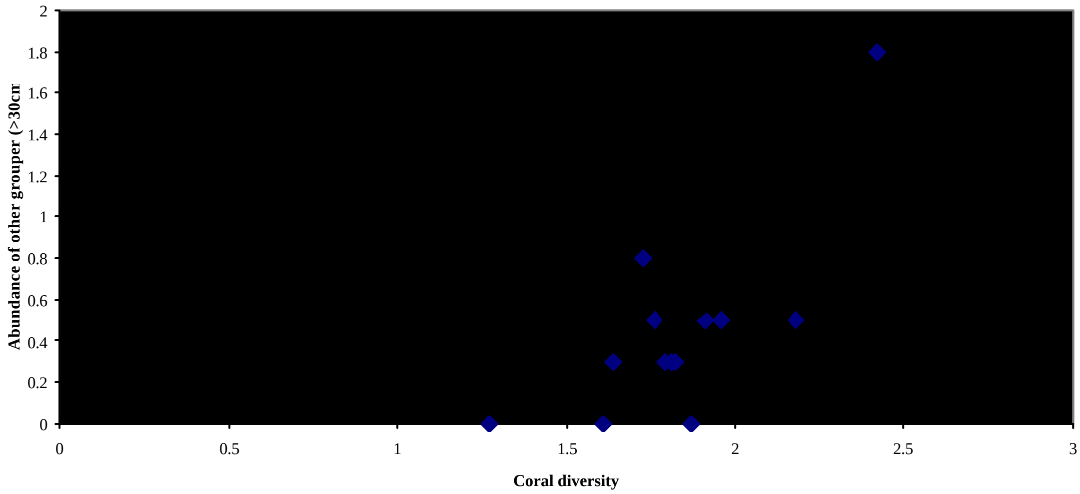

Figure 6. Graphical representation of the relationship between coral diversity (measured using the Shannon diversity index) and the abundance of ‘other’ groupers (> 30 cm). Trendline shows linear relationship via regression analysis. $R^2 = 0.55$ ($p < 0.05$).

4.6 Comparisons of Utila data with regional results

4.6.1 Comparison with Belize

In order to assess the status of reefs around Utila, benthic data were compared with 1997 / 1998 Reef Check data from Belize (extracted from reef check report Belize,1999). Note that for these comparisons, all the algal categories used in Utila were amalgamated to make the data analogous to the information collected in Belize. Furthermore, since the Belize data were taken from the perceived 'best' site on Turneffe Atoll, the comparison was made with the 'best' site from Utila i.e. the site with highest hard coral cover ('Flight Path'). The comparisons are shown in Figures 7 and 8.

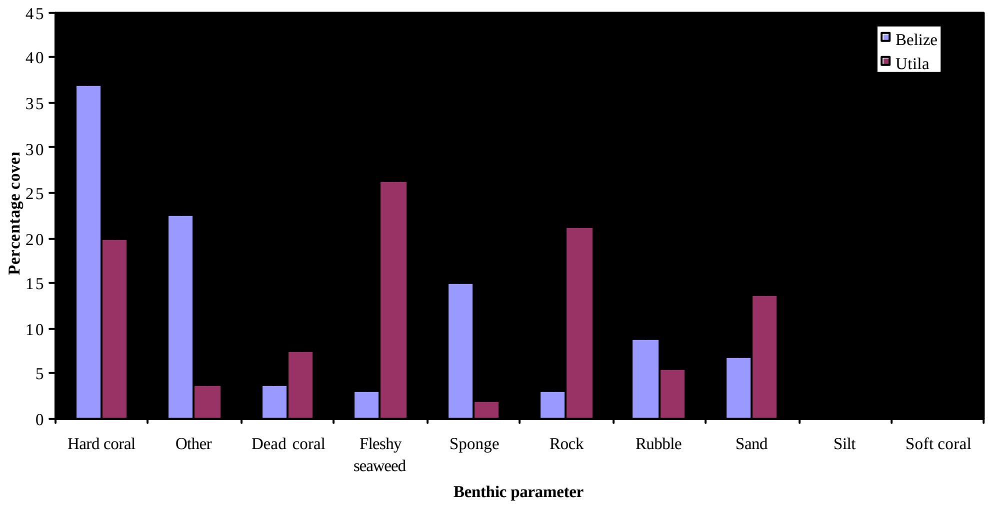

Figure 7. Comparison of benthic data from a shallow Reef Check transect from Utila (this study) and Belize (Turneffe Atoll; reef check report, 1999). Bars represent standard deviation.

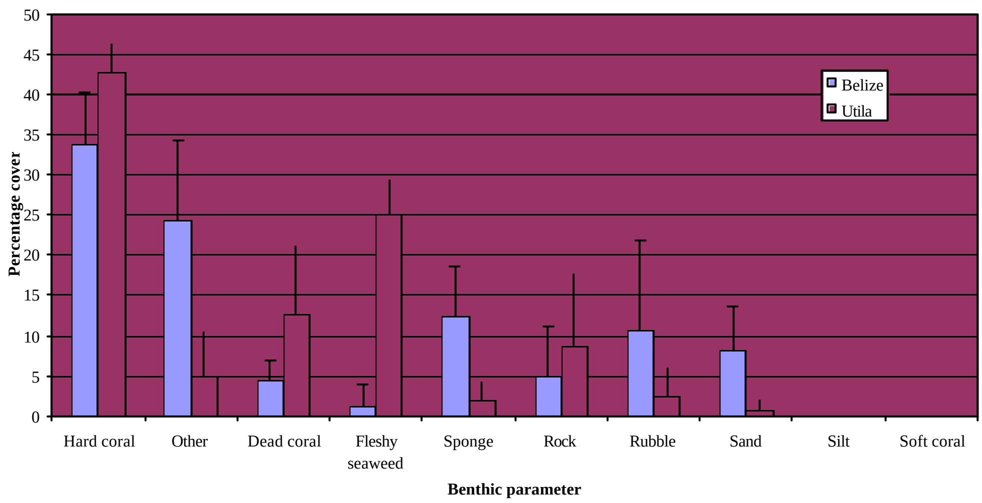

Figure 8. Comparison of benthic data from a mid-depth Reef Check transect from Utila (this study) and Belize (Turneffe Atoll; reef check report, 1999). Bars represent standard deviation.

Figures 7 and 8 show that, at shallow depths, coral cover was higher on Turneffe Atoll than Utila (37% and 20% respectively). Coral cover was similar on the mid-depth transects. At both depths, algal cover was approximately 20% higher in Utila than in Belize. In contrast, sponge and soft coral cover was higher in Belize.

4.6.2 Comparison with Caribbean results.

In addition to comparisons of the Utila data with adjacent reefs, benthic data were also compared to data from the whole Caribbean region, extracted from Hodgson (1999). However, only live coral cover and dead coral cover could be compared since additional data is not shown in Hodgson (1999). Note that all the Utila data were combined (all sites and both depths) in order to be analogous to the regional data set.

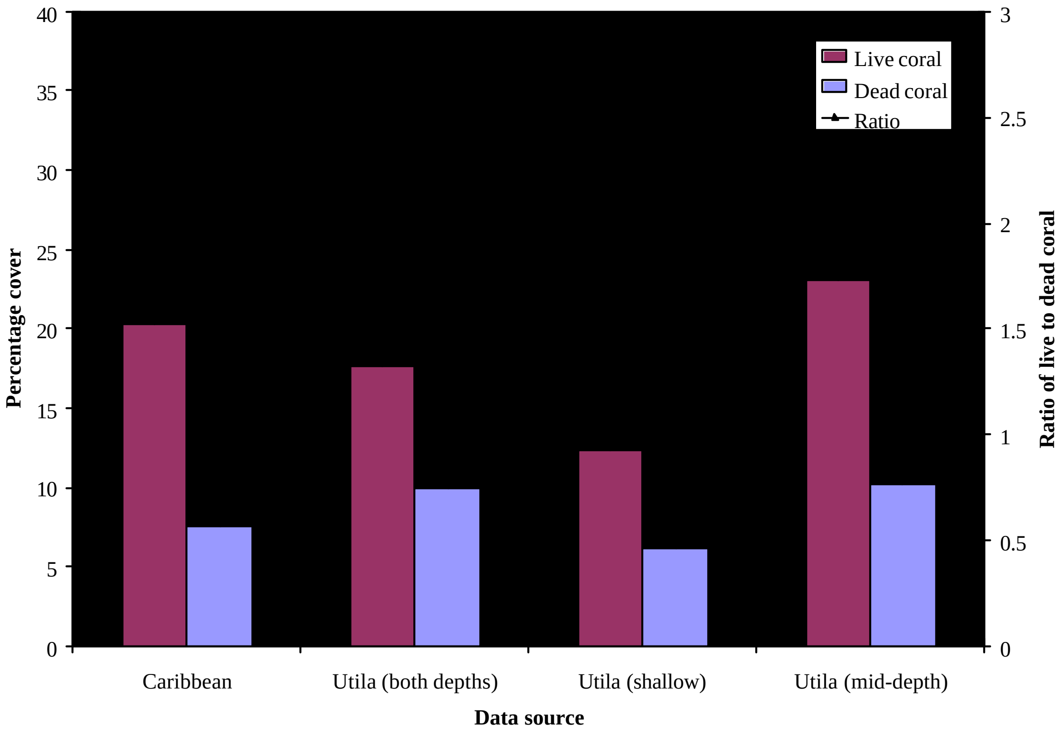

Figure 9. Comparison of live and dead hard coral cover in Utila (this study) and the Caribbean region (from Hodgson, 1999).

Figure 9 shows that the reefs of Utila have a similar mean percentage cover of live coral to the whole Caribbean region. However, the mean cover for the mid-depth transects is higher than the regional mean and conversely the mean for the shallow transects is lower. A similar pattern is shown by the dead coral data but the Utila sites have a lower ratio of live hard coral to dead coral, particularly for both shallow and mid-depth transects combined.

5. DISCUSSION

The Reef Check data collected during this study provide a general assessment of reef health around Utila. Furthermore, since the CCC volunteer programme facilitates more extensive fieldwork than is possible by host-country agencies alone, this study was able to assess reef health at more sites and to a higher taxonomic level than during standard Reef Check surveys. Hence it is possible to provide both an overall assessment of reef health and undertake comparisons between sites. Reef Check is also an excellent protocol for long-term reef health and the seven sites used for this study should form the basis of a monitoring programme for Utila.

Each of the seven sites surveyed during this study appeared to be exposed to generally low anthropogenic impacts when assessed using the criteria of Reef Check, both qualitatively on the Site Description Forms and more quantitatively during belt transects. Hence the only 'high' impact was considered to be tourist diving at 'Silver Gardens', which is a popular area close to Utila Town and there was some evidence of generic coral damage in these areas. Similarly, there was some coral damage at the mid-depth transect at 'Turtle Harbour', which is also a popular dive site. In contrast, the coral damage at the 'Aquarium' site was more likely to be caused by storm damage on this exposed reef. The only other evidence of anthropogenic impacts recorded by divers was the presence of 'trash'. The trash found at 'Flight Path', 'Silver Gardens' and 'Cabañas' may be linked to nearby coastal developments of Utila Town and further along the southern coast. Areas on the north side appeared less likely to suffer from trash, presumably because there is little or no development in this area.

Although these impacts appear limited, Reef Check does not generate data on, for example, water quality and past coral bleaching events and hurricane damage. All these factors are known to be important around Utila since there were major bleaching events in 1995 and 1998 and Hurricane Mitch affected the Bay Islands 1998 (reviewed by Harborne *et al*., 2001). Furthermore, there have been major changes in reef ecology at a regional scale since the 1980s. The major change has been a 'phase shift' towards algal dominated reefs, driven by the mass mortality of *Diadema* urchins in the early 1980s because of disease (reviewed by Lessios, 1988). The effects of losing this major herbivore have been exacerbated by the removal of herbivorous fish by fishing and the increase of nutrients in the water column.

These factors have all led to a decrease in coral cover in the Caribbean and this was reflected in the data from this study. A healthy coral reef in the 1970s would have around 70% coral cover (Hughes *et al*., 1994) but no site around Utila exceeded 45%. Coral cover was highest on the mid-depth transect at the 'Flight Path' site (42.7%), with the major reef building mountainous star coral particularly abundant. The high coral cover at 'Flight Path' could be explained by the intermediate disturbance hypothesis (Connell, 1978), which suggests that the highest diversity, and consequently coral cover, is highest where the level of disturbance is at intermediate levels. It proposes that after a disturbance a few pioneer species will arrive in the open space but if a disturbance occurs too frequently then the community will not progress past the pioneer stage and diversity is low (Begon *et al*., 1990). Conversely if there is no disturbance then the best competitors dominate the community and again diversity is low. Hence an intermediate disturbance maximises diversity and, in the context of this study, coral cover. The 'Flight Path' site is located on the south east of the island where it is exposed to the prevailing tradewinds but is more sheltered than the north-east reefs close to Pumkin Hill. There is some supporting evidence for this theory from the site having the second highest coral species richness, although it should be noted that the diversity index (1.9) is lower than some of the other sites. Intermediate levels of disturbance may also be present at the 'Turtle Harbour' site since the mid-depth transect had the highest species richness (16), highest diversity index (2.4) and the second highest coral cover (28.1%).

In contrast to 'Flight Path' and 'Turtle Harbour', the 'Rock Harbour' and 'Aquarium' sites had the lowest levels of coral cover. This could be explained by the fact that both the sites are very exposed to the prevailing winds and this disturbance limits coral growth. Disturbance levels are also likely to be the predominate factor explaining why, in general, coral cover was higher on the mid-depth transects compared to the shallow transects since shallow sites would have been most affected by Hurricane Mitch and the coral bleaching event in 1998. The only exceptions to this pattern were the 'Cabañas' and 'Silver Gardens' sites on the southern coast and it is possible that the shallow reefs in this area were less affected by bleaching and the hurricane because they are more sheltered or have a particular topography. For example, there may have been less bleaching of the major reef building mountainous star and cavernous star corals, which were particularly abundant on the shallow 'Cabañas' and 'Silver Gardens' transects, or the reef geo-morphology in the area is very favourable for these species. Further research is required to elucidate the dynamics of the shallow water reefs on the south coast of Utila.

In addition to mountainous and cavernous star corals, other individual coral species also varied significantly between sites. However, some of these variations can be attributed to the patchiness of reef communities as opposed to ecological phenomena i.e. some species are just naturally more abundant at some of the sites and this is not linked to, for example, exposure, reef topography or anthropogenic impacts. Such species include blushing star, leaf coral, thin fungus, rough starlet, green cactus and pillar coral. Perhaps more significant was the variation of mustard hill since this species is known to be influenced by sediment (Gleason, 1997). Mustard hill was significantly more abundant at the 'Raggedy Cay' and 'Turtle Harbour' sites, which is consistent with these sites, to the north of the island, having better water quality than sites to the south. The variation of staghorn coral is also very important as populations of this species have been severely decreased by disease. Staghorn was significantly more abundant at 'Flight Path' and this represents another reason, along with the overall high coral cover and species richness, why this area should be considered for protection.

Abundances of dead coral were partly linked to live coral cover since coral rich areas will have more dead colonies after major disturbances such as the 1998 bleaching event and Hurricane Mitch. Hence dead coral was most common on the mid-depth 'Flight Path' transect. However, dead coral was also significantly high on the 'Silver Gardens' shallow transect and this may be linked to pollution from nearby Utila Town. The dredging in the Blue Bayou lagoon may also be causing increased coral mortality by leading to increased sedimentation onto nearby reefs.

A range of additional, non-coral parameters also varied significantly between sites, as shown by the ANOVA tests. For instance, where coral cover is low, but there is exposed hard substratum, there will inevitably be a higher coverage of algae and this was seen at, for example, the shallow transect at 'Rock Harbour' where coral cover was the second lowest of all sites (6.2%) and the abundance of green non-calcified algae was the highest (36.2%). Similarly, there were large amounts of brown / red branching algae on the shallow transects at 'Aquarium' and 'Raggedy Cay'. Green algae cover is also high at the 'Cabañas' and 'Silver Gardens' sites but since coral cover is relatively high this could be caused by increased nutrient concentrations in the water originating from coastal developments along this area of coast. Brown fleshy algae was more consistent between sites and depths. Red coralline algae was also relatively uncommon but its presence is important since it has been shown to be an important cue for coral larval settlement (Morse *et al*., 1988).

Filter feeders such as sponges and gorgonians (recorded within the 'other' category during Reef Check surveys) were generally more abundant on the northern side of Utila. For example the highest abundance of sponges was at 'Turtle Harbour' (3.8%) and 'other' was highest at 'Rock Harbour' (18.2%). The pattern was also clearly seen in the quantitative data on gorgonian densities collected during belt transects. The northern coast is more exposed and the high water movement may provide greater food concentrations. The dominant substratum varied significantly from site to site with, for example, the highest abundance of rock at 'Rock Harbour' (mid-depth transect), rubble at 'Cabañas' (mid-depth) and sand at 'Aquarium' (shallow transect). These variations are a function of the geomorphology and the exposure of the sites and, for example, the amount of rubble present may be linked to Hurricane Mitch and other major storms but there are no data to support this.

In addition to assessing benthic communities, Reef Check surveys also provide important data on fish and invertebrate taxa that are indicators of reef health. During this study highly prized fishery species such as the Nassau grouper and tritons were not seen, highlighting the level of fishing pressure around Utila. Furthermore, other important indicators of fishing pressure, such as lobster and 'other' (not Nassau) groupers, were also rare. The abundance of snappers was further evidence of fishing pressure since it was most at the 'Turtle Harbour' site. This site is within the Turtle Harbour Wildlife Refuge and may reflect the effects of protecting fish stocks in this area. One of the main aims of such reserves is to allow exploited fishery species to recover and there is a large body of literature supporting the use of reserves for this objective (reviewed by Roberts and Hawkins, 2000). The effectiveness of the Turtle Harbour Wildlife Refuge is also supported by the relatively high abundance of grunts and margates at the same site. However, it should be noted that the reserve is either not properly enforced, or has not been established long enough, to facilitate a noticeable recovery of large slow, growing species such as the Nassau grouper.

Although, grunts and margates are most abundant at the 'Turtle Harbour' site, they are generally more abundant than many of the other indicator fish species because they are relatively small and, therefore, less prized by fisherfolk. Butterflyfish were also relatively abundant, which was expected since they are small and are only taken as a bi-catch by fisherfolk. Parrotfish were also relatively abundant and this is encouraging since they are a key herbivore in reef systems, playing a role in maintaining coral communities despite the presence of competitively dominant algae. Parrotfish feed on the algae growing on hard substrates in coral rich areas or in areas of shallow bedrock that support significant algal biomass. Their distribution is linked to surge (low to moderate), food availability (high algal productivity in shallow-medium depths of 5-30 m) and shelter availability (needed for nocturnal hiding from predator fish) (Bouchon-Navarro and Harmelin-Vivien, 1981; Hay, 1981).

Diadema urchins are also a key reef herbivore and their mortality in the 1980s has significantly altered the ecology of the Caribbean (Lessios, 1988). However, they were seen on all transects and this may be evidence of some recovery as seen elsewhere (e.g. Chiappone *et al*., 2001). Reasons for variations in their abundance at different depths and sites are likely to be complex and a synergy of natural and anthropogenic factors such as nutrient input which increases algal productivity, reduction of triggerfish predators, meta-population dynamics and physical and biological habitat preferences. *Diadema* are also known to aggregate in certain areas (Pearse and Arch, 1969) and there was some evidence of an aggregation at 'Cabañas' and 'Raggedy Cay'. Again these aggregations are probably linked to a combination of nutrient input, reduction of predators and habitat preferences. These factors may also explain the distribution of pencil urchins, which although generally uncommon, were relatively abundant at 'Cabañas' and 'Raggedy Cay'.

The conservation index, which was calculated using the fish and invertebrate data, provides a crude overall summary of the indicator taxa. The 'Cabañas' site had the highest conservation index number, which, combined with the high coral cover at both shallow and medium depths and its popularity with divers, suggests it should be considered for protection. The score for the 'Cabañas' site was only slightly higher than for 'Turtle Harbour', which is already designated as a marine reserve and suggests that the reserve is well sited and may already be leading to the increased abundance of many key taxa. 'Flight Path', 'Silver Gardens' and 'Raggedy Cay' had very similar scores are also relatively high in the conservation index. Since 'Flight Path' also has the highest coral cover and species richness of all sites, the high conservation index is further justification for its consideration for protection. Furthermore, 'Raggedy Cay' has also been highlighted as the site of a new marine reserve (Pedersen, pers. comm. and by Honduran legislation reviewed in Harborne *et al*., 2001). 'Silver Gardens' is a less appropriate site for a marine reserve since it is close to 'Cabañas', which appears a higher priority, and is close to significant anthropogenic impacts from the Blue Bayou lagoon and Utila Town. The exposed, coral poor sites at 'Rock Harbour' and 'Aquarium' appeared to have a low conservation value.

Although the abundance of fish and invertebrate taxa varied between sites, there was surprisingly no obvious correlation with coral cover. This link has been well documented and it is known that the increased spatial complexity of coral rich habitats provides a larger variety of niches that support greater diversities of fish at the family and species level (Luckhurst and Luckhurst, 1978) via additional food sources (Thresher, 1983) and hiding places (Roberts and Ormond, 1987). Indeed species of butterflyfish that are obligate corallivores have been proposed as indicators of reef health because this link is so clear (e.g. Crosby and Reese, 1996). However, it seems likely that the lack of significant correlations may be caused by the limited sample size (14 data points) and limited range of coral cover values and indeed correlations were seen between the abundances of both 'other' groupers and butterflyfish and coral species richness and diversity. Since the strongest correlation was with the commercially important groupers, the importance of conserving coral health to maximise fisheries potential is obvious.

The links between groupers and algal cover is more difficult to explain and may be a statistical artefact as the correlation coefficient is low. However, it could be caused by the increased number of herbivorous prey species that might be present, feeding on the algae. The link between butterflyfish and algal cover is more likely to represent a true ecological phenomenon as it has been seen during CCC Reef Check surveys elsewhere and may be caused by the presence of food items within the algal 'clumps'. Furthermore, although they were correlated with coral richness and diversity, the link between butterflyfish and coral cover is less clear in the Caribbean since none of the species are obligate corallivores.

Overall, therefore, it is obvious that the reefs in Utila have been significantly affected by a combination of regional (coral bleaching and Hurricane Mitch) and local (particularly fishing pressure, sedimentation and nutrification) effects. This conclusion is supported by the comparisons with equivalent data from Belize and the whole Caribbean region. For example, the shallow reefs in Utila were generally less healthy (lower coral cover and more algae) than in Belize. This can be partly attributed to Turneffe Atoll being offshore with low anthropogenic impacts and better water quality. However, another key factor is that in Utila the data was taken after Hurricane Mitch and the coral bleaching event in 1998 and the data for Belize preceded these impacts. Indeed, it is likely that repeat surveys in Belize, which was also affected by bleaching and Hurricane Mitch, would show significantly lower coral cover. This suggests that the benthic communities around Utila may have been in equivalent condition to Belize before 1998. This hypothesis is supported by the similar coral cover values for the mid-depth transects, where coral bleaching and hurricane damage are less significant. However, the higher amount of algae at this deeper transect indicates that water quality and loss of herbivores is more significant in Utila.

A similar pattern was seen for comparisons with the means for the whole Caribbean region (Hodgson, 1999) with equivalent coral cover values for both depths combined comprised of lower values in the shallows and higher values at medium depths in Utila. Since the regional data was collected during 1997, the effects of the coral bleaching event and hurricane are not reflected in the regional data set, indicating that possibly the reefs of Utila could have been of above average health, as measured by Reef Check, prior to 1998. This is supported by the higher ratio of dead coral, colonies which were presumably live before 1998.

6. RECOMMENDATIONS

Analysis of Reef Check data from Utila shows that the reefs have been impacted by a suite of factors, particularly the coral bleaching events in 1995 and 1998 and Hurricane Mitch in 1998. The low numbers of commercially important groupers, conch and lobsters also provides evidence of fishing pressure and decreasing water quality (via nutrification and sedimentation) are also affecting reef health. Assessing these impacts is vital for monitoring and, since Reef Check has also been shown to be an appropriate technique for non-professional researchers to document reef health, the data presented in this study provide a foundation for a long-term monitoring programme. Furthermore, Reef Check data from Utila can contribute to the global database and assist the aims of a synoptic view of global reef health and public awareness.

Recommendation 1: One or more agencies should continue to collect Reef Check data from some or all of the survey sites used by this study as the basis of a monitoring programme of reef health around Utila.

Recommendation 2: Hondurans, from either Utila or UNAH, who have been trained to dive and conduct surveys by CCC could undertake the necessary monitoring work. CCC could provide additional training if required.

There was evidence of anthropogenic effects, particularly along the more developed southern coast.

Recommendation 3: Establish a code of practise for people living and working on Utila regarding sewage and waste disposal. Provide a standard environmental awareness briefing for all visitors to the dive resorts.

Similarly to most reefs in Central America, there are a suite of threats to reef health in Utila and pressure from, for example, fishing, development and diving, combined with effects from natural events such as coral bleaching, are likely to increase. One or more marine protected areas around Utila would help to maintain reef health. Such reserves would also provide additional ecological and economic benefits, such as increased fish catches and income for local communities (Clark, 1996).

Recommendation 4: Continue to aim to establish one or more additional multiple use marine protected areas around Utila, with an integrated monitoring programme to measure their efficacy, and strengthen the enforcement of regulations in the Turtle Harbour Wildlife Sanctuary. Establish regulations, and enforce existing legislation, to minimise the detrimental effects of coastal development on reef health.

Recommendation 5: The reef at the 'Flight Path' (south-east Utila) appears to be an excellent candidate for protection because of its high coral cover and species richness, abundance of staghorn coral and high conservation index.

Recommendation 6: The reef at the 'Cabañas' (south-west Utila) appears to be an excellent candidate for protection because of its high coral cover in shallow water, its popularity with divers and having the highest conservation index.

Recommendation 7: The concept of establishing a reserve at Raggedy Cay should be continued since this area has reasonable coral cover, has a high conservation index and compliments other putative reserves via its location to the west of Utila.

7. REFERENCES

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APPENDIX 1

Percentage cover of each individual coral species on each transect at each of the seven sites surveyed during this study.

S = Shallow transects; M = mid-depth transects.

Taxa / Substratum category	Rock Harbour		Flight Path		Turtle Harbour		Aquarium		Raggedy Cay		Cabañas		Silver Gardens	
	S	M	S	M	S	M	S	M	S	M	S	M	S	M
Elkhorn	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
Staghorn	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Club finger	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Finger	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
Thin Finger	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Green Cactus	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
Yellow pencil	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
Mountainous star	0.0	1.3	1.3	21.3	0.0	5.6	0.0	1.3	0.6	10.0	5.0	6.3	8.7	8.1
Cavernous star	0.0	0.6	0.0	4.4	0.0	3.1	0.6	1.8	0.0	0.0	0.0	0.6	3.1	5.0
Rough Starlet	0.0	0.0	6.3	0.0	1.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3
Smooth starlet	0.6	3.1	0.0	0.0	1.9	2.5	0.6	1.8	2.5	3.1	3.1	1.9	0.6	1.3
Flower coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0
Solitary disk	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
Large flower	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blushing star	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elliptical star	2.5	1.3	1.3	0.6	0.0	0.0	0.6	0.6	0.6	0.0	1.9	1.9	1.3	0.0
Rose coral	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
Sheet coral	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	0.6
Leaf coral	0.0	0.0	1.6	1.8	0.0	3.1	0.0	1.3	0.0	4.4	0.0	0.6	1.3	5.0
Massive Leaf	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ribbon	0.0	0.0	0.0	1.3	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.6	0.0
Purple leaf	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
Saucer	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
Smooth brain	1.2	1.9	0.6	2.5	2.5	5.0	0.6	3.1	0.0	1.3	1.3	1.2	1.3	0.0
Giant brain	0.0	0.0	0.0	0.6	0.6	0.6	0.6	1.3	0.6	0.0	0.6	1.9	0.0	0.0
Grooved brain	0.0	0.0	0.0	1.3	1.3	1.3	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0
Knobby Brain	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
Butterprint Brain	0.0	0.6	0.6	0.0	0.0	1.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Fat fungus	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thin fungus	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
Grooved fungus	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
Rough star	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Sinuous cactus	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
Pillar	0.0	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Mustard hill	0.0	0.0	0.6	0.6	2.5	0.6	0.0	0.0	4.4	1.3	0.6	1.2	2.5	0.0
Eight ray finger	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
Fire coral	1.9	2.5	1.9	3.1	1.9	1.3	0.6	1.3	1.3	0.6	3.8	0.6	0.0	0.6