SUMMARY OF CORAL CAY CONSERVATION'S DIVE SCHOOL SURVEY DATA FROM UTILA, HONDURAS

- Prepared by -

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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 dive shop survey data collected by the *Bay Islands 2000* project.

?? Surveys of the dive schools on Utila were carried out using standard questionnaires during 1999 and 2000 requesting data on the number of dives (both 'training' and 'recreational') and the dive sites used from each of Utila's dive schools.

?? During the 1999 study, an average of 133 dives per day was recorded compared to 189 per day in 2000 and hence there was some that evidence levels of diving are increasing. Via extrapolation for questionnaires that were not returned, an estimated 10,929 dives were completed around Utila during the 2000 study period, an average of 342 dives per day.

?? Approximately 25% of the dives were for training of novices. This high proportion is important to recognise as trainees are often responsible for causing significantly more damage to corals than more experienced divers.

?? The diving schools appear to be acting in a responsible manner to protect the reefs by favouring these sandy areas for training and using the system of mooring buoys to limit coral damage from anchors.

?? Overall, diving pressure around Utila appeared to be high. The sheltered southern coast of Utila was shown to be a very popular area for diving, particularly for training. Recreational dives were more widely spread and there was evidence of a concentration on the north-west side, in the Turtle Harbour Wildlife Refuge. South-western Utila did not appear to receive any divers. Dive sites on the eastern side of Utila were also used infrequently, with the exception of the offshore bank 'Black Hills' that is becoming an increasingly popular dive site.

?? There were an estimated 124,648 dives per annum in 2000. Although this study did not include any assessment of reefal damage caused by divers, such levels of diving must be causing some mechanical damage. Increased tourism has associated impacts from increased coastal development and waste caused by the expansion of resorts, higher freshwater demands and the need for fishing to keep up with the demands of restaurants.

?? The most popular site received an estimated 12,998 dives annually. Seven further sites around Utila were estimated as receiving more than 6,000 dives per year. Research indicates that the 'carrying capacity' of a site is approximately 6,000 and, therefore, some areas of Utila may be close to or exceeding their carrying capacities. Hence, diving may be better managed if dive pressure was more evenly spread across the available sites since many are under-utilised.

?? This study led to seven recommendations:

  ?? Continue questionnaires to dive schools in order to assess diving pressure (training and recreational) but extend the research to cover the whole year.

Completing daily or weekly questionnaires could be made obligatory for dive schools.

?? Research should be conducted to investigate the impacts that divers are having on the reefs via mechanical damage.

?? Establish a standard environmental awareness briefing for all divers that can be used by dive schools on Utila. Such a briefing could be developed using the PADI AWARE programme.

?? Extend the system of mooring buoys to place them at dive sites where they are currently absent.

?? Diving schools should be encouraged to distribute their diving, particularly for trainees, more evenly across all available dive sites.

?? 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 'Black Hills' reef (east of Utila) appears to be an excellent candidate for protection because of its growing popularity with divers.

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ABBREVIATIONS

BICA	-	Bay Islands Conservation Association
CCC	-	Coral Cay Conservation
COHDEFOR	-	Coorporación Hondureña de Desarrollo Forestal
IUCN	-	World Conservation Union
NGO	-	Non Government Organisation
PMAIB	-	Programa Manejo Ambiental Islas de la Bahía
PS	-	Project Scientist
SO	-	Science Officer
UNAH	-	Universidad Nacional Autonoma de Honduras
UNEP	-	United Nations Environment Programme

FIGURES AND TABLES

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 dive school survey data 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 over-fishing, 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, 2000a). 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, 2000b). 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, 2000a).

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, 2000b).

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, 2000b). 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, 2000b).

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, 2000a). 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 diving pressure data gathered during the 'Socio-economics' component of the fieldwork.

3. METHODS

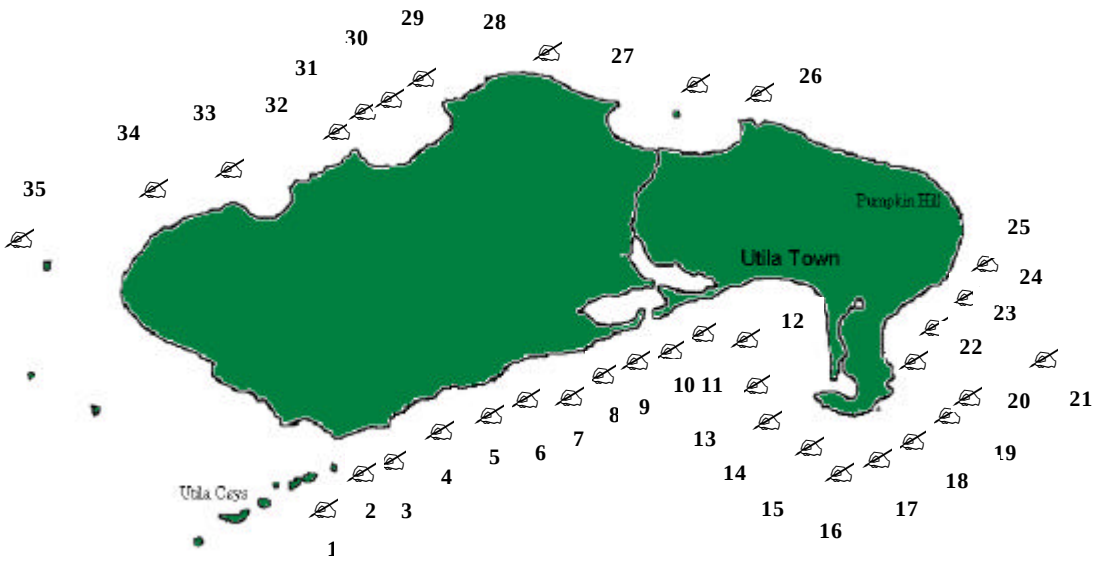
3.1 Data collection

Surveys of the dive schools on Utila were carried out using standard questionnaires during 1999 and 2000 and each of the 12 dive schools were asked to complete them on either a weekly (1999) or daily (2000) basis. Within the questionnaire, information was requested on the number of divers that had been taken to the reef, including the number of those who were learning to dive (generally PADI 'Open Water') and were, therefore, considered as 'training' dives. Training dives were monitored as novices are known to cause more damage to reefs than more experienced divers who have improved control over their buoyancy and are generally more aware of the importance of not damaging the reefs. All other dives were recorded as 'recreational', although these included some for advanced training (e.g. PADI Rescue Diver). These advanced training dives were not recorded separately in order to simplify the questionnaire since the putative damage caused by them and by true recreational dives were assumed to be equivalent. The questionnaires also asked which dive sites around the island had been used. This information could be collected because Utila has a well established system of mooring buoys and dive site names (Figure 2).

During 1999 the questionnaires were distributed over a 10-week period from 26th July to 4th October. In 2000 the questionnaires monitored diving activities over 32 days, from 14th August to 14th September.

3.2 Data analysis

Data analysis aimed to assess three key parameters, namely (i) the total number of training and recreational dives completed by each dive school during the study period, (ii) the proportion of dives visiting each dive site and (iii) the annual dive pressure at each site. Proportions of dives visiting each site were used rather than absolute numbers because the number of dive schools that responded to the surveys each day or week was inconsistent. Furthermore, in order to compare data from 1999 to 2000, the daily 2000 data was summarised by week when necessary. Data were tabulated and displayed graphically where appropriate. Note that the results represent the number of *dives* rather than the number of *divers* (many divers complete more than one dive per day).



Site number	Site name
1	Diamond Cay
2	Stingray Point
3	Cabañas
4	Big Rock
5	Jack Neil
6	Little Bight
7	Pretty Bush
8	Silver Garden
9	Black Coral Wall
10	Lagoon Beach
11	Blue Bayou
12	The Oliver Wreck
13	Light House Reef
14	Ron's Wreck
15	Moon Hole
16	Airport Caves
17	Ted's Point
18	Airport Reef
19	Rocky Point
20	Red Cliff
21	Black Hills
22	Big Bight Bank
23	Cactus Patch
24	Linda's Wall
25	Aquarium
26	Jack's Bight
27	Rock Harbour
28	Blackish Point
29	Duppy Waters
30	Pinacles
31	Willie's Hole
32	CJ's Drop Off
33	Don Quickset
34	Spotted Bay
35	Raggedy Cay

Figure 2. Map of Utila showing the location of the major dive sites.

4. RESULTS

4.1 Dives completed during the survey period

The total number of dives recorded during the 1999 study was 9319, an average of 133 per day. This increased slightly during the 2000 study when 6078 dives were recorded, an average of 189 per day. Of the 9319 dives in 1999, 7018 were recreational and 2301 were training dives (24.7%; Figure 3). The proportion of training dives was also similar in 2000 when there were 4740 recreational dives and 1338 training dives recorded (22.0%; Figure 3). Note that the numbers of dives completed are an underestimate of the total completed during the study period as not every school filled out a questionnaire every day or week.

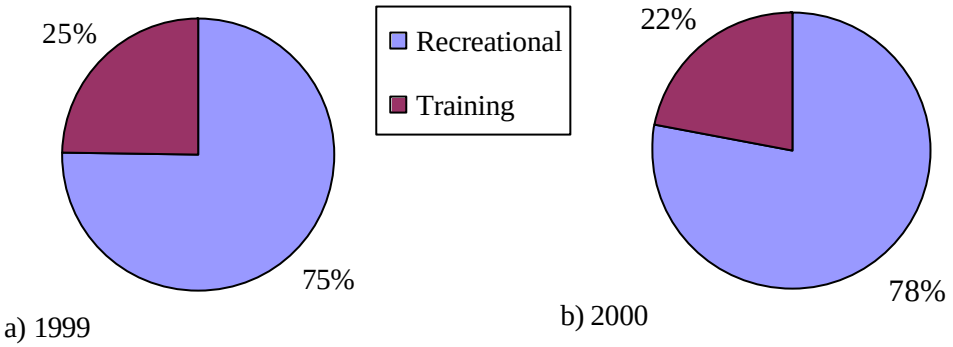


Figure 3. Proportion of dives that were for training (novice divers) during the study periods in 1999 and 2000.

The more recent 2000 data set was then used to estimate the mean daily numbers of dives completed by each school in order to estimate the total number of dives per day during the study (Table 2). Note that two of the dive schools on the island (Scuba Libre and Utila Watersports) did not return any questionnaires during the study so their mean number of daily dives was estimated as the overall mean of 28.5 dives for the other 10 schools. Days when a dive school did not fill out the questionnaire were then assumed to have had the mean number of dives for that school over the study period. It was, therefore, estimated that 10,929 dives were completed around Utila during the 2000 study period, an average of 342 dives per day.

Utila Dive Centre, Captain Morgan's and Underwater Dive Centre appeared to be the largest diving schools on the island, each completing more than 1,000 dives during the 32-day period of the 2000 study. Utila Dive Centre also completed the greatest absolute number of training dives (518.4). However, Alton's dive school had the greatest proportion of training dives (36.4 % of all dives).

Table 2. Estimated total number of dives over the 32-day 2000 study period by dives at each dive school during 2000. * Indicates schools that did not return any questionnaires and numbers given are a mean from the other schools. Figures in parentheses indicate the percentage of training dives.

Centre	Daily mean	32-day total		
		Total	Training	Recreational
Alton's	16.5	528.0	192.0 (36.4%)	336.0
Bay Islands College	28.0	896.0	220.0 (24.6%)	676.0
Captain Morgan's	36.0	1151.0	206.0 (17.9%)	945.0
Cross Creek	25.4	813.7	137.1 (16.8%)	676.6
Ecomarine	26.8	857.6	184.3 (21.5%)	673.3
Laguna Beach	19.7	629.3	24.4 (3.9%)	605.0
Paradise	29.7	951.3	203.6 (21.4%)	747.6
Parrot's	18.1	579.0	124.0 (21.4%)	455.0
Scuba Libre *	28.5	910.7	212.3 (23.3%)	698.5
Underwater Vision	32.8	1048.9	312.9 (29.8%)	736.0
Utila Dive Centre	51.6	1652.5	518.4 (31.4%)	1134.1
Utila Watersports *	28.5	910.7	212.3 (23.3%)	698.5
Total	**341.5**	**10928.7**	**2547.3**	**8381.4**

4.2 Distribution of diving pressure

The popularity of dive sites around Utila was assessed via the proportion of dives visiting each one (Table 3). Table 3 shows that the proportion of dives at each dive site varied from 1999 to 2000 but spatial patterns were much more obvious than temporal changes. For example, the southern coast of Utila was shown to be popular, particularly for training. Indeed, the most popular dive site was Jack Neils (on the south coast of Utila) during both 1999 and 2000. Note that within this study, 'Jack Neils' refers to an amalgamation of three sites very close together (Jack Neils, Jack Neils Cove and Jack Neils Point) that could not be reliably separated from the questionnaires. Similarly 'Little Bight' is an amalgamation of Little Bight, Little Bight Cove and Little Little Bight.

In order to summarise the patterns of dive site use shown in Table 3, the data from 1999 and 2000 were combined and displayed schematically in Figures 4-6 (total, training and recreational dives respectively). Figures 4-6 show the relative proportions of dives at each site based on the busiest site (Jack Neils) being 100% i.e. a dive site that received 50% of the pressure of Jack Neils is represented as 50%. Figures 4-6 clearly show the high number of dives along the southern coast of the island, especially for training. Recreational dives were more widely spread and there was evidence of a concentration on the north-west side, in the Turtle Harbour Wildlife Refuge (dive sites 29-32). South-western Utila did not appear to receive any divers and there are no mooring buoys in this area. Dive sites on the eastern side of Utila were also used infrequently, with the exception of Black Hills, which was popular for recreational dives.

Table 3. Proportion (as percentages) of dives visiting each site during the study. See Figure 2 for the location of each dive site.

Dive site	Total (%)		Training (%)		Recreational (%)	
	1999	2000	1999	2000	1999	2000
Diamond Cay	1.3	0.6	1.3	0.5	1.3	0.6
Stingray Point	3.3	5.1	3.7	3.0	3.1	5.6
Cabañas	2.9	2.0	1.2	0.6	3.5	2.4
Big Rock	5.0	3.2	7.0	6.5	4.4	2.5
Jack Neils	10.5	10.4	17.0	18.8	7.9	8.0
Little Bight	4.3	2.2	7.5	5.9	3.3	1.4
Pretty Bush	5.4	5.1	8.4	8.4	4.4	4.2
Silver Garden	3.7	4.4	4.6	5.6	3.3	3.9
Black Coral Wall	7.6	7.4	9.5	9.6	6.8	6.6
Lagoon Beach	0.6	0.5	0.2	0.1	0.8	0.7
Blue Bayou	0.3	0.4	0.0	0.0	0.4	0.5
The Oliver Wreck	0.0	0.0	0.0	0.0	0.0	0.0
Light House Reef	3.4	1.1	5.4	1.2	2.6	1.1
Ron's Wreck	1.6	3.8	1.7	5.8	1.5	3.3
Moon Hole	4.0	5.4	4.4	6.2	3.8	5.0
Airport Caves	4.9	4.4	4.2	4.8	5.3	4.3
Ted's Point	5.9	6.6	6.7	6.4	6.0	6.5
Airport Reef	0.8	0.0	0.9	0.0	0.7	0.0
Rocky Point	2.6	1.5	0.6	1.2	3.2	1.7
Red Cliff	0.4	0.6	0.3	0.7	0.4	0.6
Black Hills	3.4	5.6	1.6	2.7	4.1	6.3
Big Bight Bank	0.0	0.2	0.0	0.0	0.0	0.3
Cactus Patch	0.0	0.0	0.0	0.0	0.0	0.0
Linda’s Wall	0.0	0.0	0.0	0.0	0.0	0.0
Aquarium	2.8	2.8	1.2	0.8	3.3	3.2
Jack's Bight	2.0	1.4	0.9	0.5	2.5	1.6
Rock Harbour	2.4	2.4	1.0	0.0	3.0	3.0
Blackish Point	1.3	1.5	0.4	0.4	1.7	1.7
Duppy Waters	2.8	1.4	1.0	0.8	3.4	1.6
Pinnacles	3.8	3.6	1.1	0.4	4.8	4.5
Willie's Hole	4.9	7.0	3.0	4.8	5.7	8.0
CJ's drop-off	1.5	2.7	0.5	0.1	2.0	3.7
Don Quickset	1.0	1.0	1.0	0.8	1.1	1.1
Spotted Bay	2.9	1.8	2.4	1.3	3.1	1.9
Raggedy Cay	2.4	3.7	1.3	2.0	2.9	4.1

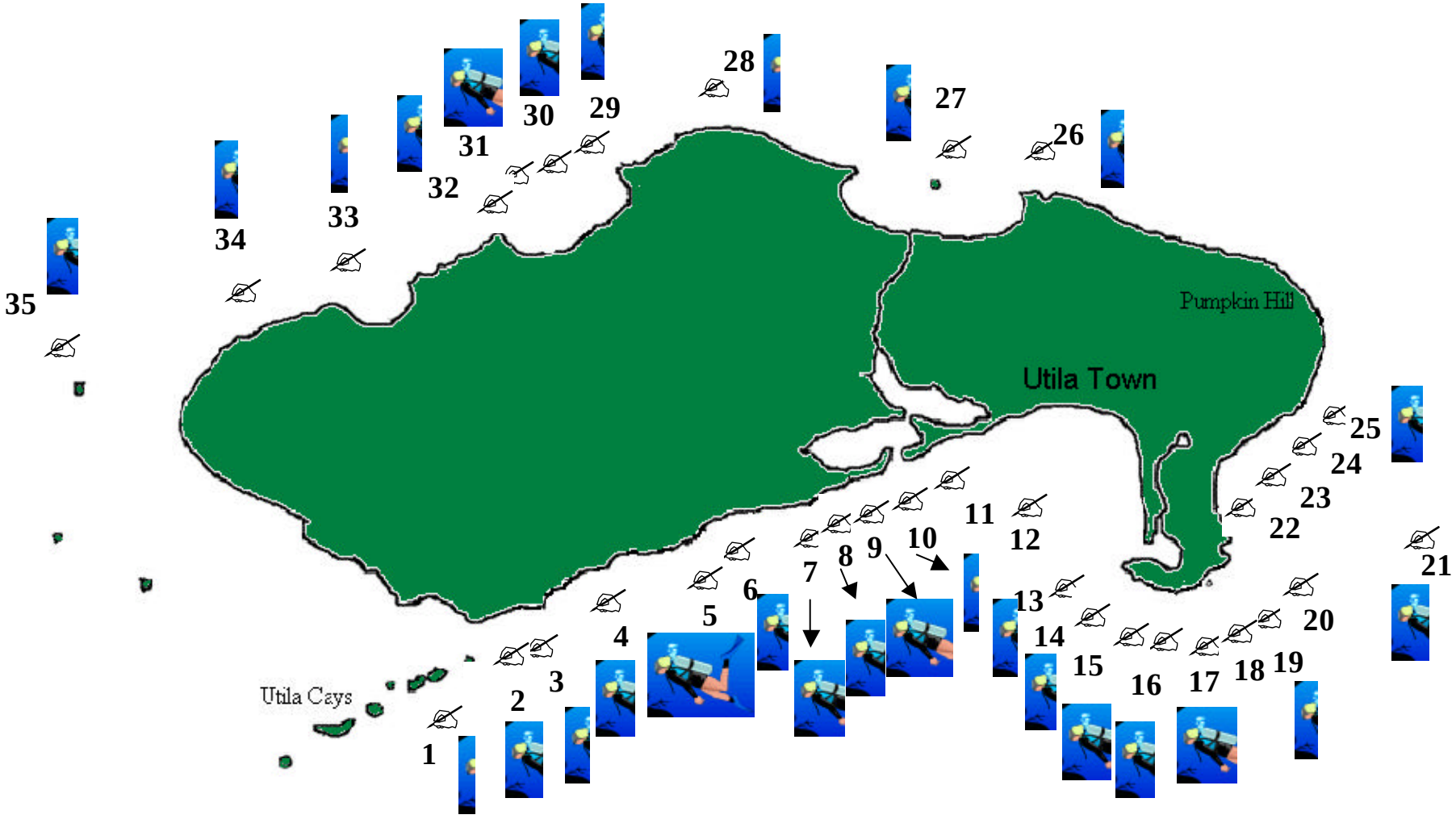


Figure 4. Schematic map of the relative proportion of total dives (size of icon) at each of the dive sites around Utila. See Figure 2 for site names.

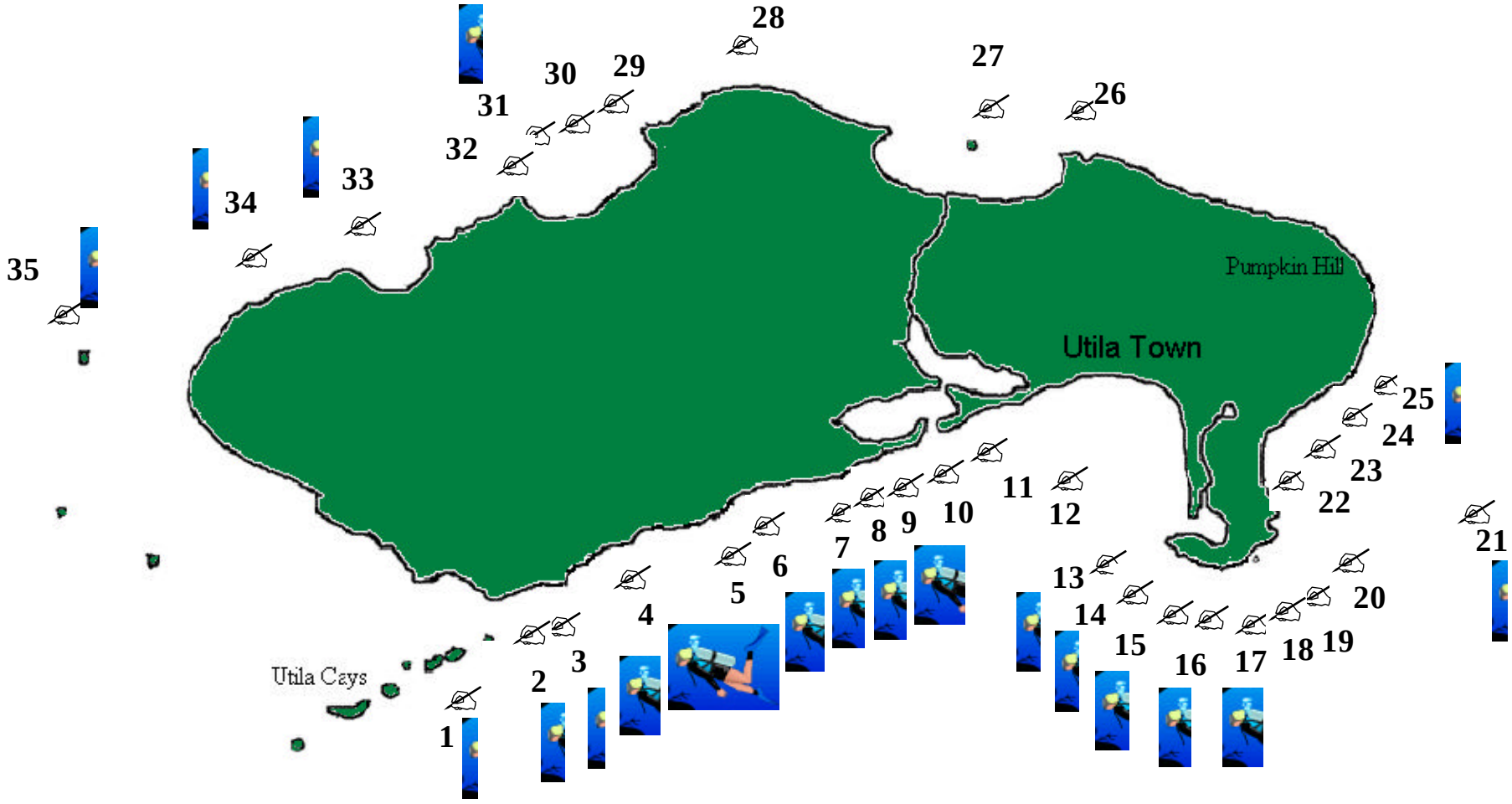


Figure 5. Schematic map of the relative proportion of training dives (size of icon) at each of the dive sites around Utila. See Figure 2 for site names.

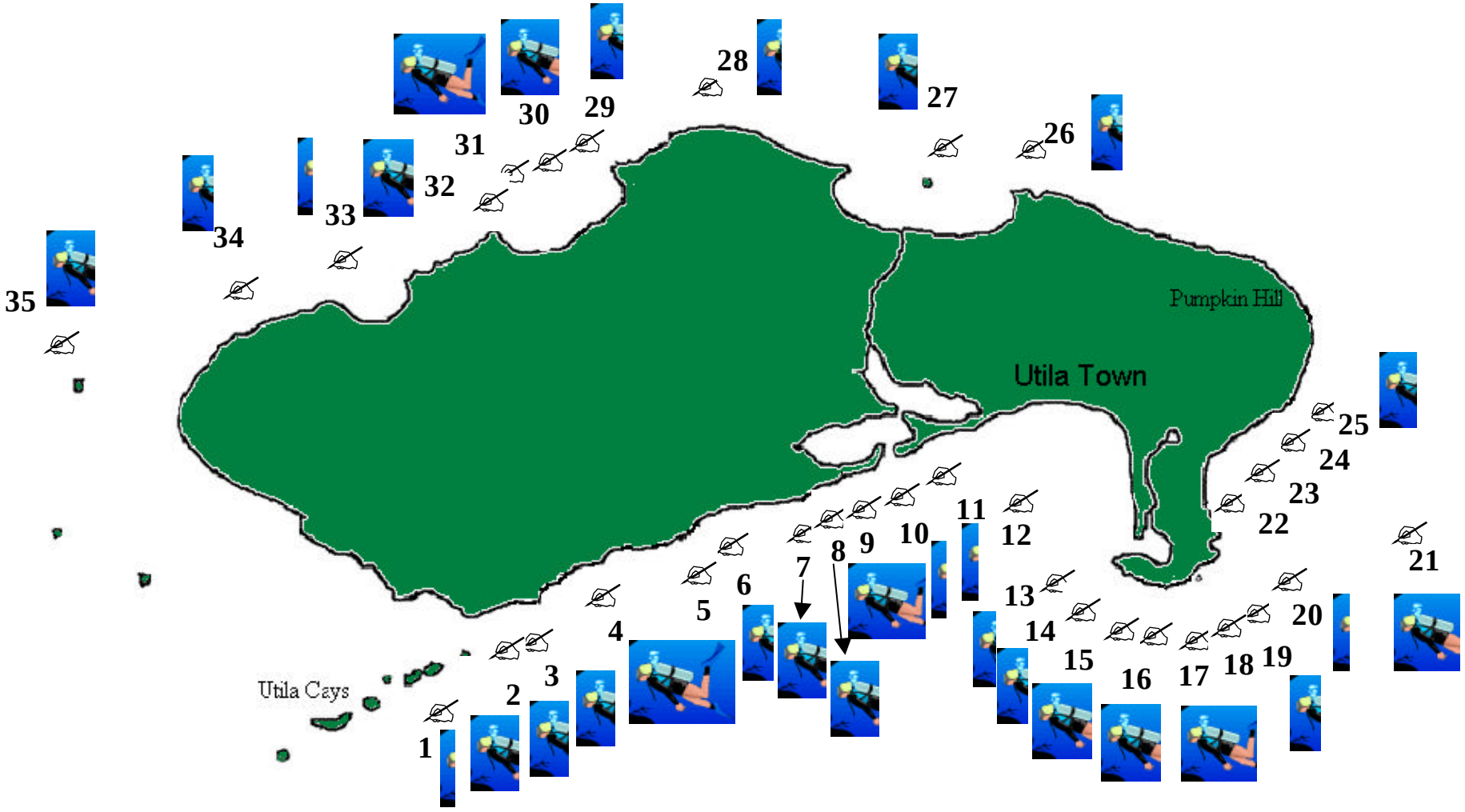


Figure 6. Schematic map of the relative proportion of recreational dives (size of icon) at each of the dive sites around Utila. See Figure 2 for site names.

Finally, Table 4 shows the 10 most popular dive sites in 1999 and 2000 (this study) and 1997 (Guest, 1997). Table 4 also shows the 10 most used sites overall (1997, 1999 and 2000) via an 'index of popularity'. To calculate this index, during each year each dive site was scored according to its ranking with the most popular site receiving a score of 10, the second most popular site receiving a score of 9 and so on. The scores for each year were then summed to generate the final index of popularity.

Table 4. The ten most popular dive sites around Utila in 1997, 1999 and 2000 and for all three years combined. Each site is coloured to allow it to be tracked across the three years. Note that there are only nine sites listed for 1997 as Jack Neils was recorded as two separate sites (both in the top 10) and these have been amalgamated so that the data are comparable to the present study.

	1997	1999	2000	Overall	Index
1	Jack Neils	Jack Neils	Jack Neils	Jack Neils	30
2	Moon Hole	Black Coral Wall	Black Coral Wall	Black Coral Wall	26
3	Black Coral Wall	Ted's Point	Willie's Hole	Moon Hole	16
4	Silver Garden	Pretty Bush	Ted's Point	Pretty Bush	15
5	Airport Caves	Big Rock	Black Hills	Ted's Point	15
6	Pretty Bush	Airport Caves	Moon Hole	Airport Caves	13
7	The Pinnacles	Willie's Hole	Stingray Point	Willie's Hole	12
8	Little Bight	Little Bight	Pretty Bush	Silver Garden	8
9	Light House Reef	Moon Hole	Airport Caves	Black Hills	6
10	-	The Pinnacles	Silver Garden	Big Rock	6

4.3 Estimated annual dive pressure

The more recent 2000 data were used to estimate the absolute number of dives that went to each site annually. These figures were calculated using the daily averages from all schools and the proportion of dives at each site (Table 5). Table 5 shows that there were an estimated 124,648 dives per annum and the most popular site during 2000, Jack Neils, received an estimated 12,998 dives annually. Seven further sites around Utila were estimated as receiving more than 6,000 dives per year (Stingray Point, Pretty Bush, Black Coral Wall, Moon Hole, Ted's Point, Black Hills and Willie's Hole).

Table 5. Estimated annual diving pressure at each of the diving sites around Utila during 2000. Shaded values indicate where there was greater than 6000 dives estimated. See Figure 2 for dive site locations.

Site	Total		Training		Recreation	
	Per day	Per Annum	Per day	Per Annum	Per day	Per Annum
Diamond Cay	2.1	775	0.4	140	1.6	592
Stingray Point	17.6	6408	2.4	879	14.6	5338
Cabañas	6.9	2523	0.5	187	6.2	2274
Big Rock	11.0	4027	5.2	1897	6.5	2370
Jack Neils	35.6	12998	14.9	5450	21.1	7690
Little Bight	7.6	2768	4.7	1728	3.8	1385
Pretty Bush	17.5	6382	6.7	2450	11.1	4040
Silver Garden	14.9	5438	4.5	1627	10.2	3724
Black Coral Wall	25.1	9170	7.6	2776	17.2	6296
Lagoon Beach	1.9	685	0.1	38	1.8	665
Blue Bayou	1.3	492	0.0	0	1.2	449
The Oliver Wreck	0.0	0	0.0	0	0.0	0
Light House Reef	3.7	1334	0.9	344	2.8	1009
Ron's Wreck	12.9	4710	4.6	1672	8.6	3141
Moon Hole	18.5	6737	4.9	1798	13.1	4773
Airport Caves	15.1	5494	3.8	1405	11.2	4092
Ted's Point	22.4	8192	5.1	1868	16.9	6185
Airport Reef	0.0	0	0.0	0	0.0	0
Rocky Point	5.3	1917	0.9	340	4.4	1604
Red Cliff	2.1	762	0.6	215	1.5	551
Black Hills	19.1	6978	2.1	779	16.6	6065
Big Bight Bank	0.8	303	0.0	0	0.8	285
Cactus Patch	0.0	0	0.0	0	0.0	0
Linda's Wall	0.0	0	0.0	0	0.0	0
Aquarium	9.6	3487	0.6	228	8.5	3089
Jack's Bight	4.6	1692	0.4	149	4.2	1532
Rock Harbour	8.2	2988	0.0	0	7.9	2872
Blackish Point	5.1	1850	0.3	105	4.5	1656
Duppy Waters	4.8	1762	0.7	237	4.2	1535
Pinnacles	12.5	4548	0.3	125	11.7	4275
Willie's Hole	23.8	8703	3.8	1400	20.9	7621
CJ's drop-off	9.3	3388	0.1	30	9.8	3583
Don Quickset	3.6	1300	0.7	245	3.0	1084
Spotted Bay	6.2	2272	1.0	365	5.1	1862
Raggedy Cay	12.5	4564	1.6	576	10.8	3954
Total	**341.5**	**124648**	**79.6**	**29054**	**261.9**	**95594**

5. DISCUSSION

The information collected in this study on the amount and distribution of diving occurring around Utila is limited because of the relatively short time period during which the data was collected and since the dive schools did not always fill out the questionnaires each day or week. However, the study did gather a large amount of data from all but one shop in the 1999 study and all but two shops in 2000. Furthermore, data on the location of dives was reliable because of the well known system of names relating to each mooring buoy.

Overall, diving pressure around Utila appeared to be high, although the actual total number of dives could not be calculated because of missing questionnaires. However, the total number of dives on Utila certainly lies somewhere between the actual numbers recorded during the survey and the extrapolated estimates (e.g. between 189 and 342 per day in 2000). There was also some indication that levels of diving had increased from 1999 to 2000 and this is consistent with the growing tourism industry throughout Honduras (Harborne *et al*., 2001) and it is likely that the number of divers will continue to grow. Although this study did not include any assessment of reefal damage caused by divers, an estimated 125,000 dives per annum must be causing some mechanical damage and increased tourism will place further pressure on coral areas.

The Caribbean is a popular tourist destination and many arrive on Utila, particularly 'backpackers', with the intention of learning to dive. The pleasant conditions of the warm tropical seas offer an attractive and cheap place to learn to dive with courses costing less than US$150. Indeed, Utila is regarded as one of the cheapest places in the world to learn to dive and prices compare very favourably to other countries (e.g. equivalent courses tends to be around £300 in Britain). Hence, this study found that approximately one in four of the dives were for novice training. This high proportion is important to recognise as trainees are often responsible for causing significantly more damage to corals (Medio *et al*., 1996). For both novice and experienced divers, the most obvious effect of diving on the reefs is breakage and abrasion of the benthos because of accidental kicking, holding, trampling and kneeling on corals and other organisms (Hawkins and Roberts, 1992). It is important to note, however, that the fragility of corals is variable and some reefs may have an increased tolerance to disturbance. In the Caribbean, for example, the proportion and percentage cover of fragile branching corals is lower than in the Indo-Pacific and thus they potentially can withstand more divers. The reduction of branching *Acropora* in the Caribbean because of disease (Peters *et al*., 1983 and many others) has also further reduced the number of particularly susceptible corals. However, the effects of divers is complex and requires further research since, for example, divers may cause disturbance through the re-suspension of sediments (Rogers, 1990).

Furthermore, the impact of high numbers of divers visiting an area extends beyond the potential physical damage to the reefs. Increased tourism has associated impacts from increased coastal development and waste caused by the expansion of resorts, higher freshwater demands and the need for fishing to keep up with the demands of restaurants. Similarly, more divers require more boats to take them out to dive sites and this results in more pollution. There are also social consequences and on Utila

there has been an increased immigration of people from the mainland because of the lure of finding work associated with the tourist trade (Fielding, 2000a).

Although diving pressure is high, there was a clear pattern of variable dive pressure around the island. For example, the south side of Utila was clearly very popular for training dives. Utila Town is situated on this southern coast and this is where the majority of tourists and all the dive schools are based. Hence, the south shore is a popular destination for the schools because it is close, minimising fuel costs, and is also generally sheltered from the prevailing winds. 'Jack Neils' is particularly favoured as it has a large, shallow, sand area surrounded by coral that is ideal for training. Other popular training sites, such as 'Ted's Point', 'Moon Hole' and 'Pretty Bush' have similar attributes.

The diving schools on Utila appear to be acting in a responsible manner to protect the reefs by favouring these sandy areas until divers have gained the ability to control their buoyancy so that they will not damage corals. They also almost exclusively use the excellent system of buoys established by BICA to moor boats and this limits coral damage from anchors. However, further improvements could be made, particularly by increasing the environmental awareness briefings provided to new and experienced divers. Such programmes have been shown to be highly effective and, for example, Medio *et al*. (1996) document how briefing divers to increase their environmental awareness significantly decreased the number of contacts that they made with benthic life forms.

Pressure from recreational divers was more evenly spread around Utila. Experienced divers are known to like the north of the island since this area offers interesting reef topography and also the possibility of sighting whale sharks from the dive boats and this was reflected in the data. The marine reserve of the Turtle Harbour Wildlife Refuge appeared to be particularly popular for recreational divers and the imminent management plan for this reserve should help to mitigate any impacts. The popularity of the four dives sites within the reserve also indicates that a small fee for divers entering the area could be successful and raise vital revenue for enforcement of regulations. In contrast to Turtle Harbour, reefs further east were not used by divers as this area is very exposed and has poor reef development. The south-western reefs were also not used, presumably because of the lack of mooring buoys. However, this area has an interesting system of submerged banks and may be a potential 'new' site to reduce the pressure on other areas.

The ten most popular dive sites on the island did not appear to have altered significantly between 1997 and 2000 with, for example, Jack Neils always the most popular. This suggests that certain sites are receiving a disproportionate number of divers and may be impacted by long-term mechanical damage. There were some changes, however, and, for example, 'Black Hills' was fifth in 2000 having previously been outside the top ten and the proportion of dives increased from 3.42% in 1999 to 5.6% in 2000. Black Hills was a very popular site for CCC staff and volunteers because of the abundant fish life and it is likely that its popularity increased by word of mouth. The attractiveness of Black Hills to divers indicates that it should be considered as a potential site for a new marine protected areas. Black Hills also does not have a mooring buoy, which may lead to damage from anchors. However, placing a new buoy should be considered carefully as it may attract further dive boats and

could pinpoint its location for fisherfolk. 'Willie's Hole' also appeared to have become more popular from 1997 to 2000, possibly reflecting divers increasingly preferring it to the adjacent 'Pinnacles' which was seventh in 1997 but was outside the top ten in 2000.

It has been proposed that it is possible to determine the number of dives per site per year (the 'carrying capacity') below which impacts are not significantly harmful to the reef ecosystem (Hawkins and Roberts, 1997). Carrying capacity varies depending on a site's conditions and other factors, including the proportion of divers undertaking training. It is, therefore, necessary to have a consistent, long-term record of the numbers of divers visiting each site so that carrying capacities are not exceeded. Such data would need to be used in conjunction with research on diver related impacts to reef sites. The study documented in this report has provided a baseline estimate of the number of dives visiting each site in 2000 and shows that the annual pressure varies from less than a 1,000 at several sites to nearly 13,000 at the most popular ('Jack Neils'). However, it should be noted that these data were collected between July and September, during one of the peak tourist seasons on Utila. The data, therefore, are likely to be a slight over-estimation and subsequent surveys should collect information throughout the year.

A recent study investigating the effects of SCUBA diving to the reefs of Bonaire concluded that there was no significant damage if there were fewer than 6,000 dives per site per year and suggested this as a 'rule of thumb' carrying capacity (Hawkins *et al*., 1999). This study showed that seven of the sites around Utila were estimated to receive more than 6,000 dives per year, suggesting that these areas may be close to or exceeding their carrying capacities. Hence, diving on Utila may be better managed if dive pressure was more evenly spread across the available sites since many are under-utilised. For instance, eight sites along the popular south coast of the island were estimated to have a diving pressure of less than 1,000 dives per annum, often situated surprisingly close to popular sites. For example, 'Black Coral Wall' (the second most popular dive site between 1997 and 2000) had three sites in close proximity where less than 1000 dives occurred per year ('Big Bight Bank', 'Cactus Patch' and 'Linda's Wall'). Similarly 'Jack Neils' was estimated as receiving close to 13,000 dives per annum compared to neighbouring 'Little Bight' which had less than 3000.

6. RECOMMENDATIONS

This initial study of the numbers of divers on the reefs around Utila provides a baseline for further studies investigating the annual numbers of divers visiting each of the dive sites on Utila. Although further long-term data will improve the power of the data set, there are several recommendations that can already be concluded from the results.

Recommendation 1: Continue questionnaires to dive schools in order to assess diving pressure (training and recreational) but extend the research to cover the whole year. Completing daily or weekly questionnaires could be made obligatory for dive schools.

Any future study of dive pressure must be related to diver impacts on the reef itself.

Recommendation 2: Research should be conducted to investigate the impacts that divers are having on the reefs via mechanical damage.

However, it is already known from previous studies (e.g. Medio *et al*., 1996) that environmental briefings to divers reduces the mechanical damage to reefs. The system of mooring buoys has already been very effective in reducing mechanical damage from anchors.

Recommendation 3: Establish a standard environmental awareness briefing for all divers that can be used by dive schools on Utila. Such a briefing could be developed using the PADI AWARE programme.

Recommendation 4: Extend the system of mooring buoys to place them at dive sites where they are currently absent.

The data in this study clearly showed that some dive sites are close to, or exceeding, their carrying capacity but other sites are under-utilised.

Recommendation 5: Diving schools should be encouraged to distribute their diving, particularly for trainees, more evenly across all available dive sites.

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 6: 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 7: The 'Black Hills' reef (east of Utila) appears to be an excellent candidate for protection because of its growing popularity with divers.

7. REFERENCES

Barahona, G.M. and H.M. Guzmán. 1998. Encuesta socio-ecológica de las poblaciones residentes de la Reserva Biológica Cayos Cochinos, Honduras. *Revista de Biologia Tropical* **46 (Suppl. 4):** 39-55.

Clark J.R. 1996. Coastal zone management handbook. CRC Press.

Cortés, J. and Hatziolos, M.E. 1998. Status of coral reefs of Central America: Pacific and Caribbean coasts. Pages 155-163. *In:* Wilkinson, C.R. (Editor). Status of coral reefs of the world: 1998. AIMS, Australia.

Darwall, W.R.T. and N.K. Dulvy. 1996. An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania – A case study. *Biological Conservation* **78:** 223-231.

Erdhardt, N.M. 2000. The Atlantic spiny lobster resources of Central America. In: Philips, B.F. and J. Kittaka (Eds) Spiny lobsters: Fisheries and Culture, second ed. Fishing News Books, Oxford, pp. 153-168.

Erdmann, M.V., A. Mehta, H. Newman and Sukarno. 1997. Operation Wallacea: Low-cost reef assessment using volunteer divers. *Proceedings of the 8th International Coral Reef Symposium* **2:** 1515-1520.

Fenner, D.P. 1993. Some reefs and corals of Roatan (Honduras), Cayman Brac and Little Cayman. *Atoll Research Bulletin* **388:** 1-30.

Fielding, S. 2000a. Recent demographic and migration changes: impacts on natural resources of the Honduran Bay Islands. Unpublished report to the Wildlife Conservation Society and Summit Foundation.

Fielding, S. 2000b. The Caribbean cruise ship industry: environmental impacts to the Honduran Bay Islands. Unpublished report to the Wildlife Conservation Society and Summit Foundation.

Fine, J.C. 1992. Greedy for groupers. *Wildlife Conservation* **95:** 68-71.

Forest, N.B. 1998. Assesment of coastal regulations and implementation: case study of Roatán, Bay Islands, Honduras. *Coastal Management* **26**: 125-155.

Guzmán, H.M and C. Guevera. 1998. Mortalid masiva de organismos arrecifales zooxantelados durante el blanqueamienyo de 1995 en Cayos Cochinos, Bay Islands, Honduras. *Revista de Biologia de Tropical* **46 (Suppl. 4):** 165-173.

Guest, J. 1997. Project Utila, Preliminary Report. Unpublished Report.

Harborne, A. R., D. C. Afzal., M. J. Andrews. 2001. Honduras: Caribbean Coast. *Marine Pollution Bulletin* **42(12)**: 1221-1235.

Harborne, A.R., D.C. Afzal, M.J. Andrews and J.M. Ridley. In press. Beyond data: The expanded role of a volunteer programme assisting resource assessment and management in the Bay Islands, Honduras. *Proceedings of the 9th International Coral Reef Symposium*.

Hawkins, J. P. & C. M. Roberts. 1992. Effects of recreational scuba diving on fore-reef slope communities of coral reefs. *Biological Conservation* **62:** 171:178.

Hawkins, J. P. & C. M. Roberts. 1997. Estimating the carrying capacity of coral reefs for scuba diving. *Proceedings of the 8th International Coral Reef Symposium* **2:** 1923-1926.

Hawkins, J. P., C. M. Roberts, T. Van't Hoff, K. De Meyer, J. Tratalos & C. Aldam. 1999. Effects of recreational scuba diving on Caribbean coral and fish communities. *Conservation Biology* **13:** 888-897.

Heyman, W. D. and B Kjerfve. 1999. Hydrological and oceanographic considerations for Integrated Coastal Zone Management in Southern Belize. *Environmental Management* **24(2):** 229-245.

Heyman, W. D. and B Kjerfve. 2001. The Gulf of Honduras. In: Seeliger, U., Kjerfe, B. (Eds), Coastal Marine Ecosystems of Latin America. Ecological Studies, vol.144. Springer, Berlin.

Hodges, L.L. 1997. Protected natural areas of Honduras. *Mesoamericana* **2:** 5-6.

Hunter, C. and J. Maragos. 1992. Methodology for involving recreational divers in long-term monitoring of coral reefs. *Pacific Science* **46:** 381-382.

Keith, D.E. 1992. Shallow-water gorgonians (Octocorallia) of Roatan, Honduras. *Bulletin of Marine Science* **50:** 212-226.

Kramer, P.A. and P.R Kramer. 2000. Ecological Status of the Meso-American Barrier Reef System. Impacts of Hurricane Mitch and 1998 coral bleaching. Final Report to the World Bank.

Kramer, P.A., P.R. Kramer, E. Arias-Gonzalez, M.D McField. 2000. Status of the coral reefs of northern central America: Mexico, Belize, Guatemala, Honduras, Nicaragua and El Salvador. In: Wilkinson, C. (Ed.), Status of Coral Reefs of the World: 2000. Australian Institute of Marine Sciences, Townsville, pp. 287-313.

MacKenzie Jr., C.L. and L.L. Stehlik. 1996. The crustacean and molluscan fisheries of Honduras. *Marine Fisheries Review* **58:** 33-44.

Medio, D., R. Ormond & M. Pearson. 1996. Effects on the rates of damage to corals by scuba divers. *Biological Conservation* **79:** 91-95.

Merrill, T.L. (Ed) 1995. Honduras: A country study, third ed. Area Handbook Series, Prepared by the Library of Congress, Federal Research Division Defence Department, Army.

Mumby, P.J., A.R. Harborne, P.S. Raines and J.M. Ridley. 1995. A critical assessment of data derived from Coral Cay Conservation volunteers. *Bulletin of Marine Science* **56:** 737-751.

Ogden, J.C. and N.B. Ogden. 1998. Reconnaissance survey of the coral reefs and associated ecosystems of Cayos Cochinos, Honduras. *Revista de Biologia Tropical* **46 (Suppl. 4):** 67-74.

Peters, E.C, J.J Oprandy and P.P. Yevich. 1983. Possible causal agent of white band disease in Caribbean Acroporid corals. *Journal of Invertebrate Pathology* **41(3)**: 394-396.

Richards, M. 1996. Protected areas, people and incentives in the search for sustainable forest conservation in Honduras. *Environmental Conservation* **23:** 207-217.

Rijsberman, F. (Ed.) 1999. Conflict management and concesus building for integrated coastal management in Latin America and the Caribbean. Working paper to the inter-American Development Bank. Environmental Division of the Sustainable Development Department, ENV-132, E.

Rogers, C.S. 1990. Responses of coral reefs and reef organisms to sedimentation. *Marine Ecological Progress Series* **62:** 185-202.

Sullivan Sealey, K., G. Bustamante. 1999. Setting geographic priorities for marine conservation in Latin America and the Caribbean. The Nature Conservancy, Arlington, Virginaia.

Tewfik, S., H.M. Guzmán and G. Jácome. 1998. Distribution and abundance of the spiny lobster popuations (Panulirus argus and P. guttatus) in Cayos Cochinos, Honduras. *Revista de Biologia Tropical* **46:** 125-150.

Wells, S.M. 1995. Reef assessment and monitoring using volunteers and non-professionals. University of Miami.

Westmacott, S, K.A. Teleki, S.M. Wells and J.M. West. 2000. Management of bleached and severely damaged reefs. IUCN, Gland and Cambridge.

UNEP/IUCN. 1988. Coral reefs of the world. Volume 1: Atlantic and Eastern Pacific. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, UK / UNEP, Nairobi, Kenya.