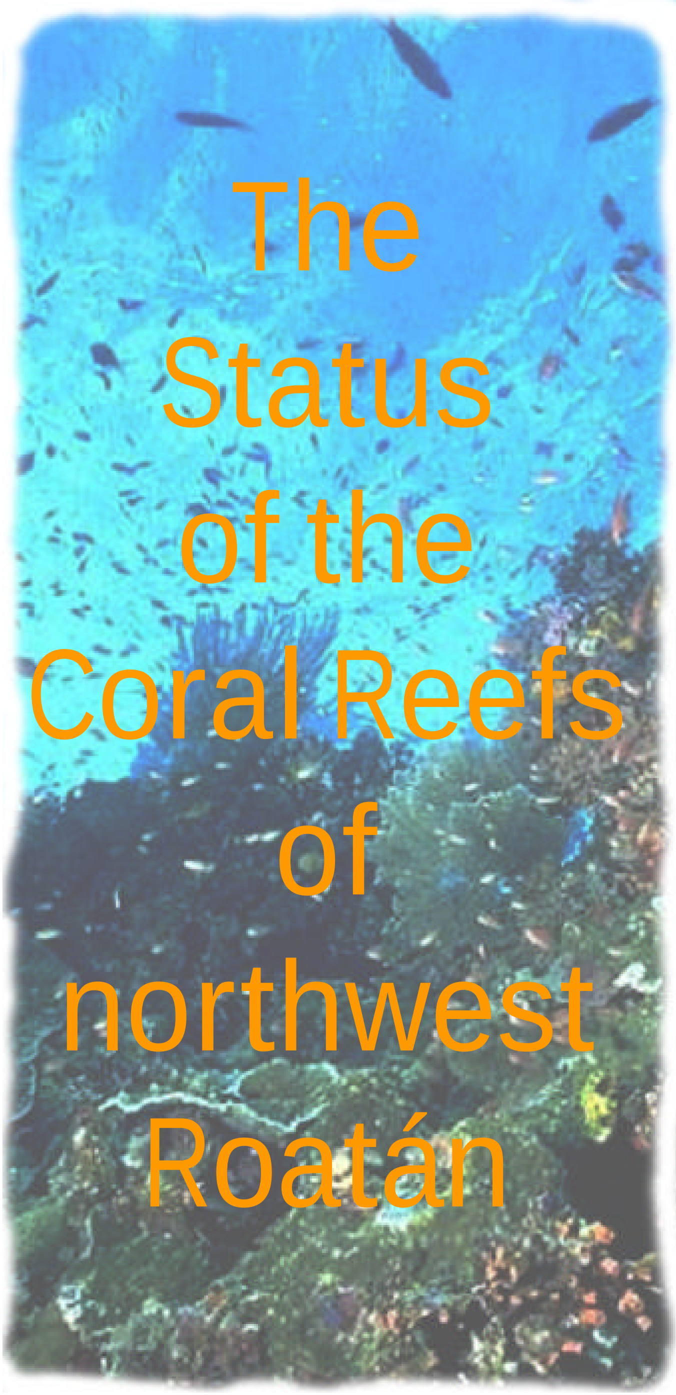
The Goose That Lays The Golden Eggs:

The Status of the Coral Reefs of northwest Roatán



Shay O'Farrell
Chief Technical Advisor
so@coralcayconservation.com

Peter S. Raines
Founder and Chairman

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Expeditions™

Coral Cay Conservation

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*'. All of our projects are operated in collaboration with governmental and non-governmental organisations within each 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.

Under the guidance of qualified and experienced project scientists, the volunteers undergo an intensive training programme in marine life identification and underwater survey techniques, 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.

Marine ecological information gathered by CCC volunteers was used in the successful bid to have the Belize Barrier Reef designated as a UNESCO World Heritage Site and in the creation of Danjugan Island Marine Reserve in The Philippines. This year so far, CCC has been instrumental in the implementation of four new community-based Marine Protected Areas in The Philippines and in the assessment of the tsunami damage to the reefs of Mu Ko Surin Marine National Park in Thailand.

CCC is associated with the Coral Cay Conservation Trust, the only British-based charity dedicated to protecting coral reefs.

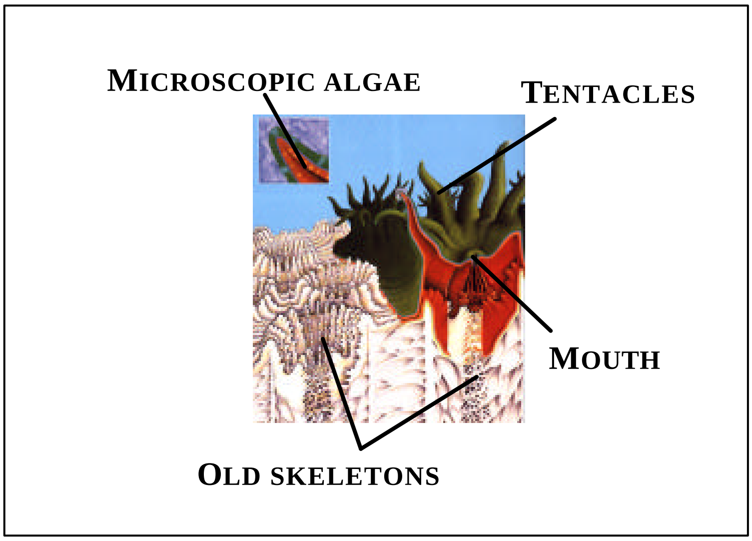
For further information, please visit us at www.coralcay.org

INTRODUCTION

Coral reefs are remarkable and unusual biological structures. Most other life in the sea relies largely on upwellings from the deep to supply essential nutrients to the microscopic algae that form the basis of the food chain. Microscopic animals, collectively known as *zooplankton*, feed on these algae, with slightly larger animals feeding on the zooplankton and so on up the chain to the 'apex animals' that have no natural predators, such as the great whales. In tropical countries, however, the sun heats the surface of the ocean, creating a warm 'cap' that suppresses the upwelling of these nutrients. In fact, most tropical seas are marine 'deserts' that support little or no life and it is this lack of plankton that makes the water so clear.

Corals however have found a solution to the problem: they bring their algae with them. Corals are animals, very closely related to jellyfish and sea anemones. In fact, you can think of a coral 'polyp' (as the individual animal is known) as an anemone with a hard skeleton. All animals excrete the nutrients and carbon dioxide that plants require in order to live, and the plants convert the energy of sunlight to use in the creation of the oxygen and starches that the animals require. Biologists refer to such a relationship, where two or more organisms benefit from each other, as *symbiosis*. A group of microscopic algae collectively known as *zooxanthellae* actually live within the coral tissue, which is translucent and colourless. Packed in at a density of around 30,000 organisms per mm^3, it is these algae that give the coral its colour.

The coral and the algae tightly recycle nutrients between them and therefore do not require the upwelling of nutrients to survive. Most reef building corals gain around 80% of their energy requirements directly from their symbiotic algae, and make up the balance by feeding with their tentacles. The coral/algae symbiosis effectively allows corals to harness the energy of the sun and it is because of the passive nature of this that they can spare energy to create the limestone skeletons of which reefs are composed. Most corals are colonial animals, with thousands or even millions of individual polyps joined together. Only the outermost layer of a coral colony is living; the bulk of the colony is composed of the skeletons of their ancestors, and these form the physical structure of coral reefs.



A close up view of the body plan of a coral polyp.
Painting by Geoff Kelly, from *Corals Of The World*, J.E.N. Veron, AIMS

All of the other life that is associated with reefs, such as the fish, lobsters, conch, seastars, urchins and so on rely on the structure of the reef to provide food, shelter and habitat. Over a million different reef species have now been identified, and some scientists suggest that the actual amount may be as much as ten times that. In fact, despite accounting for only around 1% of the ocean's area, coral reefs support 25% of all known marine fish species. Without the peculiar relationship between the corals and the microscopic algae that live inside them, there would be very little life in the tropical seas.

Reefs are obviously of enormous benefit to humans. An estimated 500 million people worldwide live within 100km of a coral reef, and derive a substantial portion of their livelihoods from them. Most small-scale tropical fisheries rely heavily on reef species for their livelihoods, with an enormous proportion of many tropical countries' high quality protein being derived from inshore fisheries. In the Caribbean alone, reef fisheries contribute over US$300 million per annum to the region's economy.

Reefs also protect against storm damage, their structure providing coastlines such as that of Roatán with its first line of defence against oceanic waves. The estimated value of shoreline protection offered by the region's reefs is between $700 million and $2.2 billion per annum. As

healthy reefs are self-repairing systems, this protection is ongoing without requiring human assistance or investment.

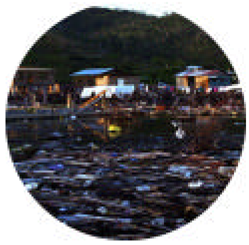
Tourism is the world's largest and fastest growing industry. Reef associated tourism is typically 'high-value', with tourists in this sector typically spending 60 – 80% more than tourists in most other sectors, with the average diver spending $2,100 per trip. Net benefits from dive tourism alone in the Caribbean region amounted to an estimated $2.1 billion in the year 2000 ($4.1 billion gross), and the sector is considered to have grown significantly since then.

The species diversity on coral reefs and the widespread use of complex toxins by reef creatures has lead to a rapidly growing interest in 'bio-prospecting' by pharmaceutical companies. As many, if not most, drugs are modelled on naturally occurring toxins, the potential economic and health benefits to be provided from well-maintained reefs are enormous. For example, the HIV treatment, AZT, was developed from the extracts of a Caribbean reef sponge, and in the Indo-Pacific region, a single family of marine 'snails' called cone shells has so far provided 50,000 different toxins for biochemists.

In addition to their unquestionable ecological value, the coral reefs of the Caribbean provided goods and services with a net economic benefit of between $3.1 and $4.6 billion in the year 2000 alone. They are one of the greatest resources of the region, and a Caribbean without coral reefs is unimaginable. Or is it?

Sadly, the coral reefs of the world are in a very poor state. 25% of reefs are either dead or dying and a further 30% of them are classified as being 'at risk'. It is likely that there are no pristine reefs left even in the remotest corners of our oceans. This spectacular degradation has happened within a single human lifetime. In the Caribbean alone, nearly two thirds of reefs are threatened by human activities, with the Bay Islands

of Honduras identified as being particularly at risk from coastal development. Over-fishing, curio trade collecting, uncontrolled development, sedimentation due to logging and land clearance, pollution, destructive tourism and mismanagement are all contributing to this loss. When these factors are added to natural stressors such as coral disease, bleaching and storm damage, the outlook is not good.



It is reasonable to assume that the economic losses to the region will continue to escalate unless action is taken to halt the decline. By the year 2015, the losses to fisheries are estimated to total between $95 and $140 million per annum; losses to tourism are estimated at $100 to $300 million per annum; losses due shoreline erosion attributable to reef decline are expected to reach $140 to $240 million per annum within 50 years. Moreover, despite the fact that Marine Protected Areas only account for a small proportion of all Caribbean reefs, half of all diving in the region occurs within these areas and it may be assumed that an increasing share of the growing market will continue to go towards well-managed reefs, with degrading reefs squabbling for the leftovers.

Economic data from: "Reefs at Risk in the Caribbean"; World Resources Institute; www.wri.org

There are, however, solutions to these problems. In many regions of the world, stakeholders at all levels from fishermen to national governments are working hand-in-hand to develop strategies to manage their marine resources in a sustainable way. Countries like the Bahamas have thriving economies based on intelligent exploitation of their reefs, whilst maintaining what are amongst the best reefs left in the Caribbean. For example, the Exuma Keys National Park supports populations of conch that are 31 times those found outside the park. With concerted effort and foresight, the decline can be halted and the reefs can return to being the self-regulating systems that they have evolved to be over hundreds of millions of years.

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PROJECT BACKGROUND

Management decisions must be based on information as much as on experience. In order to supply this information to the decision makers in the Bay Islands, our project partners Proyecto Manejo Ambiental de las Islas de la Bahia (PMAIB) requested CCC to assess the status of the reefs of the region. To this end, CCC has been operating "Project Bay Islands" in Honduras since 1998, when the first phase of the project was based on Utila. In August 2000, CCC relocated its project base to the town of Oak Ridge on the south shore of the neighbouring island of Roatán. Upon the completion of the surveying in the area in 2002, the project site moved to Sandy Bay on the northwest shore, where it remained until 2004, when the base moved to its current location in Saint Helene (a.k.a. Santa Helena) at the far eastern tip of Roatán, from where the reefs around the island Barbaretta are currently being assessed.

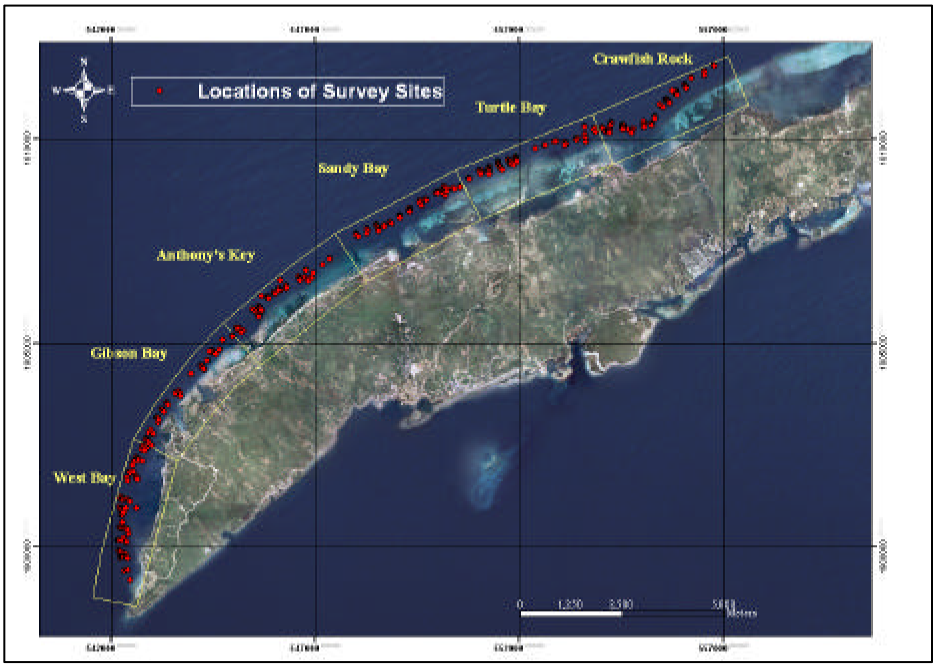
In addition to the survey work, CCC is conducting a series of community-based sustainability initiatives in Saint Helene, including:

- The creation of a self-financing garbage disposal scheme
- An adaptation of the sustainable lobster fishery of Punta Allen, Mexico (within the Sian Ka'an Biosphere Reserve, the site of a CCC monitoring project in 2002)
- The training of local divers to PADI Advanced Open Water level, in an attempt to teach basic dive safety to the fishers who continue to endure life-threatening Decompression Illnesses though lack of education and alternative livelihoods. This will also create opportunities for them within the expanding tourism sector, from which Native Bay Islands are noticeably absent
- On-going schools environmental education programs

This document is a synoptic management report, presenting the key findings of the northwest phase of the project. The complete technical report with full analysis of all of the gathered data and a more in-depth description of the methodologies used will soon be available to download from our website and from www.reefbase.org.

KEY FINDINGS

Between January 2002 and March 2004, CCC survey teams conducted a total of over 600 survey dives within the targeted region, producing 517 individual survey records. In all, 22 kilometres of reef were assessed at intervals of 250m along the shoreline, from a depth of 28m to approximately 1m (see map below).



CCC survey sectors and locations in northwest Roatán

On each dive, surveyors gathered data on almost 300 variables, including 170 species of fish, 56 species of algae and 42 species of hard corals as well as recording oceanographic data and the presence of negative impacts, such as anchor damage and sewage. Because the location of each survey site was recorded with a Global Positioning System (GPS) unit, the data could then be overlaid onto maps and analysed spatially as well as semi-quantitatively. The resultant data have been analysed in a number of ways, namely:

1. **the presence and abundance of live hard coral and of other key indicator species**
2. **the definition of distinct marine habitats**
3. **the rating of each survey site relative to others that have been classified in the same habitat (*Conservation Management Value*)**

INDICATOR SPECIES

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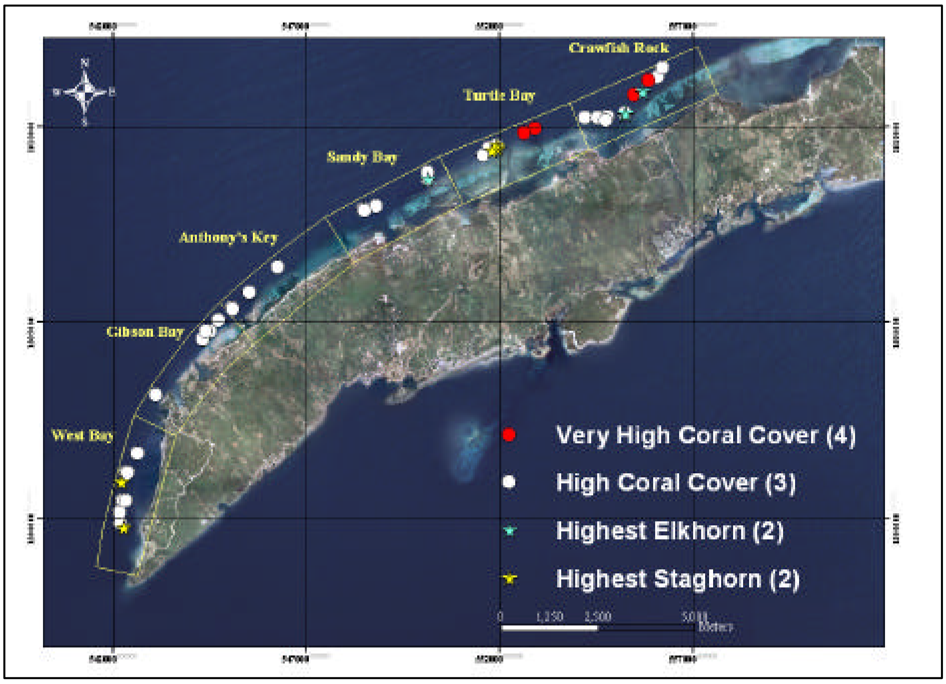
Certain species have been shown to be effective indicators of overall reef health. Depending on the particular species, they can highlight histories of overfishing, nutrient pollution, destructive fishing practices and the removal of organisms for sale within the tourism industry (curio collection) or aquarium trade. Using live hard coral cover in addition to the indicator species defined by the Reef Check Foundation[1], a synoptic portrait of the health of Roatán's reefs is presented here. For a full analysis of all indicators, please refer to the complete technical report.

[1] www.reefcheck.org



Key live hard coral cover locations
Figures in parentheses indicate DAFOR abundance ratings

In many places on the northwest reefs, the coral cover is moderate to good, with a small number of exceptional sites, as illustrated above. Staghorn coral (*Acropora cervicornis*) and Elkhorn coral (*Acropora palmata*) were once amongst the major reef building corals in the Caribbean, but most colonies were killed off in the 1980s by White Band Disease. There has been some recovery of Elkhorn coral since that time, but Staghorn coral has not faired so well. Moderate stands of both species were recorded during the survey programme.

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Lobster

Indicator of Overfishing

Panulirus species

The maximum value in any sector was DAFOR 2 (6 - 20 lobsters) but this recorded at only 1 survey site in West Bay.
Average in all sectors: Zero

Conch

Indicator of Overfishing and Curio Collecting

Strombus gigas

The maximum value in any sector was DAFOR 1 (<6 conch).

Average in all sectors: Zero

Coral Shrimp

Indicator of Aquarium Trade Collecting

Stenopus hispidus

The maximum value in any sector was DAFOR 1 (<5 individuals).
Zero banded shrimp were recorded in 2 out of the 6 sectors.
Average in all sectors: Zero

Pencil Urchin

Indicator of Curio Collecting

Eucidaris species

The maximum value in any sector was DAFOR 1 (<5 individuals).
Zero pencil urchins were recorded in 2 out of the 6 sectors.
Average in all sectors: Zero

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Flamingo Tongue

Indicator of Curio Collecting

Cyphoma gibbosum

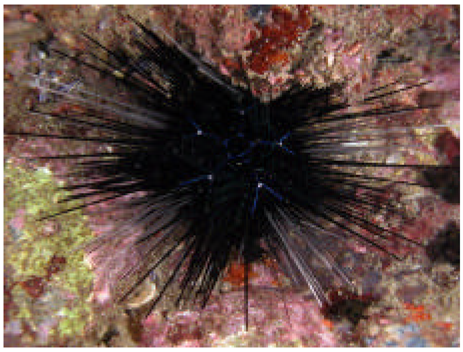
The maximum value in any sector was DAFOR 1 (<5 individuals).

Zero flamingo tongue were recorded in 2 out of the 6 sectors.

Average in all sectors: Zero

Long Spined Urchin

Indicator of Overfishing & Nutrient Pollution



Diadema species

The maximum value in any sector was DAFOR 3 (6 - 20 urchins) but this recorded at only 2 survey sites.

Small populations (<6 urchins) were recorded in all other sectors.

Average in all sectors: Zero

Staghorn Coral

Acropora cervicornis

The maximum value in any sector was DAFOR 2 in West Bay (5-20% of seabed). This sector also had the highest median (average) value of DAFOR 1 (1 – 5% of seabed).

Live Hard Coral

Various taxa

The maximum values of DAFOR 4 (50 – 70% of seabed) were recorded in Turtle Bay and Crawfish Rock. Average values were DAFOR 2 (5- 20%) in 4 of the 6 sectors, and DAFOR 1 in the remaining 2 sectors.

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Grouper

Indicator of Overfishing

Serranidae

The maximum value in any sector was DAFOR 3 (21 –50 fish) but this was recorded at only 2 of 517 survey sites.
Zero Grouper of any species were observed at 17% of survey sites.
Average in all sectors: Zero

Snapper

Indicator of Overfishing

Lutjanidae

The maximum value in any sector was DAFOR 4 (51-250 fish) but this was recorded at only 1 of 517 survey sites.
Zero Snapper of any species were observed at 29% of survey sites.
Average in all sectors: Zero

Butterflyfish

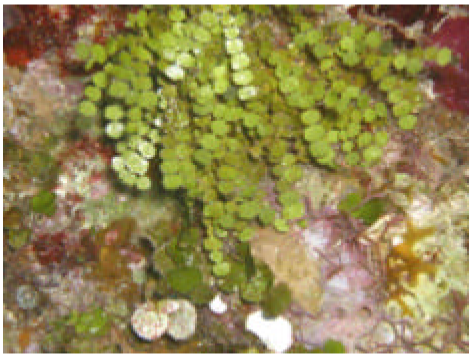
Indicator of Aquarium Trade Collecting

Chaetodontidae

The maximum value in any sector was DAFOR 3 (21 –50 fish) but this was recorded at only 4 of 517 survey sites.
Zero Butterflyfish of any species were observed on 18% of transects.
Average in all sectors: Zero

Macro Algae

Indicator of Overfishing & Nutrient Pollution



Various taxa

The highest Macroalgal cover was recorded in Turtle Bay (42% seabed coverage at 20 metres depth; 36% at 10 metres).
Coverage is inversely proportionate to distance from Mud Hole

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In order to allow for comparison of survey sites, they must first be classified into distinct ecological units, or habitats. Each variable in each survey record (the data from each site) is compared statistically against the same variable in every other survey record and the similarity between any two records is calculated using the Bray-Curtis Similarity Coefficient. This similarity is expressed as a percent. Using the ecological analysis package, PRIMER (Plymouth Routines In Multivariate Ecological Research), the survey records are then ranked by these similarities to produce natural groupings or 'clusters' from the data. The SIMPER routine in MiniTab statistical software is then used to define the key characteristics of each cluster.

In summary, the habitats are:

1. Shallow seagrass-dominated lagoon area
2. Lower reef slope with bedrock and sand patches and mixed hard coral, sponge and algal assemblages
3. Mid reef slope with diverse hard coral, especially massive corals and brown algae
4. Shallow upper reef slope dominated by bedrock with patches of sand and mixed hard coral and algal assemblages
5. Upper reef slope with significant hard coral cover dominated by *Montastrea, Porites and Agaricia* species and mixed algal communities
6. Shallow upper reef slope and reef crest dominated by massive and encrusting corals with abundant algal cover

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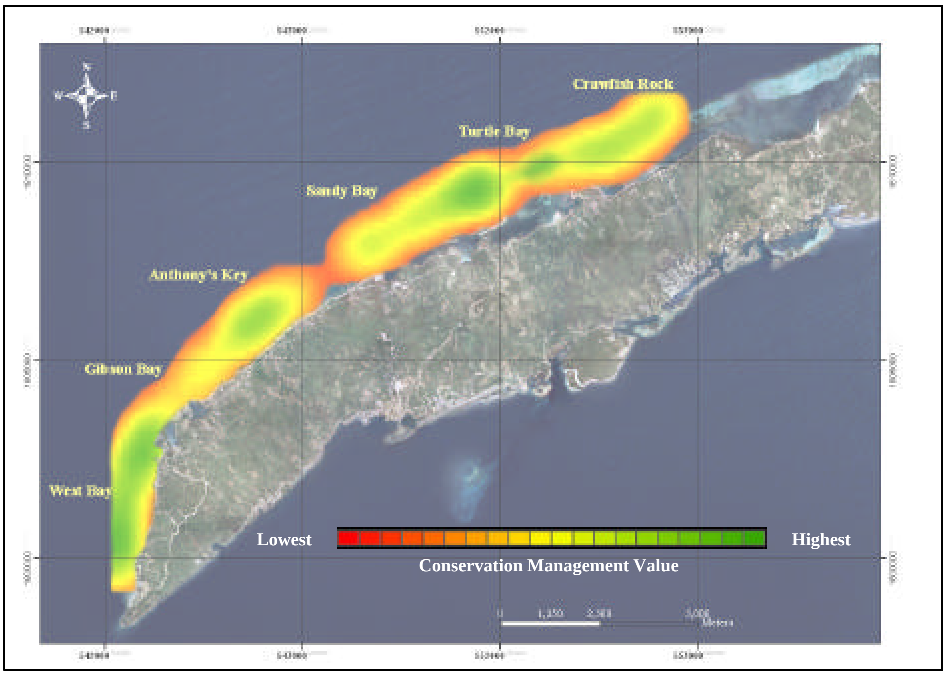
Using five ecological indices, comparisons between survey records can now be made in order to highlight key areas of ecological importance. The indices used are live hard coral cover at each site, the number of benthic species recorded (not including algae), the number of fish species recorded, the Shannon-Weiner Biodiversity Index for benthic species (not including algae) and the Shannon-Weiner Biodiversity Index for fish species.

The average of each of these indices is calculated and then each individual survey record is then compared against the average to determine whether it is above or below average. A survey record that was below average in all five indices would score a Conservation Management Value (CMV) of 0; a survey record that was above average in one index would score a CMV of 1 and so on up to a maximum CMV of 5. Because the location of each survey has been recorded with a GPS unit, this allows the CMVs to be imported to a Geographic Information System (GIS) to allow for spatial analysis. The density function in the Spatial Analyst of ArcMap (ESRI software) can then be used to highlight areas displaying a particularly high or low density of the various CMVs. These values can be represented on a colour ramp to facilitate visual interpretation. In the GIS output below, the colour red represents areas where lower CMVs are dominant; the colour green represents areas where higher CMVs are dominant.



CONCLUSIONS

With the exceptions of live hard coral cover and macroalgae, the abundances of all of the key indicator species are extremely low, with a number of species such as flamingo tongue and pencil urchins being entirely absent from the site records in two of the six survey sectors. The average value recorded for grouper, snapper, lobster and conch in every sector was zero, indicating a very high level of overfishing. For example, the Nassau Grouper (*Epinephelus striatus*) was once one of the prevalent grouper species throughout the Caribbean; zero of these fish were recorded on 494 out of 517 survey sites. Zero grouper or snapper of any species were recorded on 17% and 29% of all surveys respectively.

Moderate levels of live hard coral were recorded in all sectors, with high levels being found in two sectors, Turtle Bay and Crawfish Rock. As these two sectors also had the highest abundances of staghorn and elkhorn corals (which are now rare in the Caribbean), these 'health' of these sectors can be considered to be of critical importance to the reefs of Roatán and other down current reef systems which will import the larvae of these corals. However, these sectors also had the highest levels of macroalgal growth, which may be linked to nutrient runoff from the adjacent garbage dump at Mud Hole. Despite their current abundances of live hard corals, these sectors can be considered to be severely at risk of imminent degradation. Although currently outside the boundaries of the West End Sandy Bay Marine Reserve, these sectors lie within the boundaries of the proposed extension. However, without the removal of the causative agents of degradation, the incorporation of these sectors to the marine reserve is unlikely to have any significant effect on halting a decline in reef health.

In the absence of immediate and decisive management action, there is no reason to suspect that the reefs of northwest Roatán will not continue to degrade. Apart from losses to the ecological value of the reefs, the associated economic losses will also be great to the artisinal fishing and fledgling tourism industries of the island. In the space of a few short years, Roatán is in severe danger of progressing rapidly from being an up-and-coming Caribbean tourism destination to becoming catastrophically degraded. This latter situation is the case in much of the Caribbean today.

Although Roatán can boast some very impressive tourism resorts, these are not unusual in the Caribbean. Beaches are another major tourist attraction, but again the beaches of the island are far from being exceptional within the region. Furthermore, these beaches rely on the coral reefs to provide their sand and to protect the shoreline from erosion by waves. What is potentially exceptional about Roatán is its coral reefs, and preliminary analysis of recent Coral Cay Conservation survey data indicate that the reefs around the east end of the island (as well as the island of Barbaretta) may be some of the best remaining reefs of their type in the Caribbean. This creates an enormous opportunity for managers.

The oceanographic data recorded by CCC throughout the surveying program around Roatán indicate that the prevailing currents in inshore waters move from the east to the west. As most reefal organisms such as corals and fishes reproduce by spawning in the water, downcurrent areas will obtain much of the benefit of the ecological health in upcurrent ones. The eastern reefs can be considered to be the source of much of the historical biological richness of Roatán's reefs and their immediate protection and management can be considered to be pivotal to the economic and ecological future of the whole island.

Many of the world's leading coral researchers have concluded that if the stressors that have been causative in reef degradation are effectively removed, reef systems that have not been 'fatally' damaged have a high chance of recovery over relatively short timescales. The removal of these stressors, however, requires the political will to do so.

The coral reef system of Roatán is the goose that lays the golden eggs, and this research indicates that urgent and decisive management action is required if the goose is not to be cooked for the sake of a quick meal.

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RECOMMENDATIONS

- **The urgent implementation and enforcement of management plans to safe guard the reef resources of the east end of Roatán and the island of Barbaretta. This region is currently undeveloped compared to the rest of the island, although it is likely that the degradation of the northwest reefs will cause an increased influx of tourism pressure and economic migration of Hondurans. If the stressors to the reefs of the northwest can be removed, the upcurrent reefs at the east end will be the source of much of the larval stocks required for the reef to 'repair' itself.**

- **The regulation of tourism-associated sources of degradation, such as curio collecting and sport fishing, the continuation of the latter being on a 'catch-and-release' basis only.**

- **The education of Bay Islanders and diving professionals in basic reef ecology, mechanisms and outcomes of reef degradation and solutions. CCC proposes to run such a workshop for the diving professionals of the West End in September of this year.**

- **The location and protection of key spawning sites for depleted fish stocks, such as those of grouper and snapper. Anecdotal evidence suggests that many of these sites may be located around the island of Barbaretta. The CCC project scientist is currently working with the fishing communities of the East End to locate these sites geographically and seasonally.**

- **The building of capacity amongst the Native Bay Islanders of the East End who are the custodians of the reef resources in the area. Inclusion of local communities in the decision making processes regarding their future is generally considered to be central to the success of Marine Protected Areas in remote regions that are difficult to effectively 'police' from the outside.**

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