Coral View Beach Resort

Utila Marine Science Report – 2009

Prepared by Operation Wallacea on Behalf of the Coral View Beach Resort and Research Station

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Contents

Executive Summary

Operation Wallacea operates a multidisciplined marine research program in Honduras. This comprises of research stations within the Cayos Cochinos Archipelago and the island of Utila, working in partnership with the HCRF and the Coral View Research Station respectively. In addition a mobile social science team operates within communities on the north shore of the mainland. Within these research stations six research groups operate, these groups are the Fish and Invertebrate Ecology Research Group, the Mangrove Ecology Research Group, the Social Development Group, the Urchin Ecology Research Group, the Conch Ecology Research Group and the Herpetofauna Research Group. Research conducted over the summer expedition of 2009 on Utila was run by the first three of these groups, despite this they were diverse projects and covered many elements of marine conservation. These included surveys of the reef fish and benthic cover, assessment of the impact of divers on the reefs, assessment of the mangrove system ecology and their functions and opinions in the local communities towards sustainable development, in particular ecotourism. The work can roughly be divided into two objectives for all groups, the first is to conduct a survey of the populations and densities of the species within the research remit, while the second is study the ecology, behaviour and interactions of these species with their environment and other species. These two objectives combine to provide an assessment of the current status of the marine environment on Utila and provide insights into each habitat or species that will be invaluable in their future conservation. Generally the results of the monitoring program have been analysed and reported within this report while the results and data from the more complex second objective is still being processed with the output expected to be produced in individual reports and publications in the near future.

General results of the work indicate that the marine environment is subjected to a variety of different stresses and threats, but that there are some positive results where encouragement can be taken mixed in with some larger areas of concern for the overall health of the system. Certainly the main result from the marine research groups is the variety of condtions found in the marine environment, meaning that while there are areas that are suffering there are also those that have yet to be highly impacted. This is unfortunately not true of the fish populations though where large fish are rare in all locations.

The work done in the 2009 has developed the research program established over the previous year by Operation Wallacea in Honduras and has placed the work into a framework of research and monitoring of the marine environment around Utila in addition to working in the local communities to ensure they benefit from development in the area. The ongoing monitoring of the marine environment is of paramount importance so the health of the systems can be gauged, either to protect against its destruction or to provide data to substantiate protection zones or policies.

1. Introduction

Operation Wallacea has been associated with Marine Research in Honduras since 2003. The program, which started in the Cayos Cochinos archipelago, has now developed to encompass five research groups in a number of locations in the Honduran Bay Islands and on the mainland in addition to various associations with local and national groups within Honduras.

The basis of Operation Wallacea's work is to bring academics and world leaders in research topics into the field to run small specialist research groups within the overall project framework. These groups consist of principle researchers, Ph.D. students, dissertation and thesis students and research assistant volunteers. The projects run over a 10 week period every summer. This format gives many advantages to field research such as bringing together a wide variety of multidisciplined field scientist with varied backgrounds into the same place with a central organisation coordinating the research. Funding for the research is entirely based on volunteers, this ensures that projects can be run over prolonged periods and datasets can be built up over many years, a situation often prohibited by time scales for grant funding. The research is based on collecting data on the local ecosystems that can be channelled into high quality research publications and grant applications to establish examples of best practice conservation in the local communities.

The marine research and conservation objectives of Operation Wallacea in Honduras often require a multidisciplinary approach, utilising expertise from a variety of research backgrounds or data collection from a variety of locations. To achieve this Operation Wallacea has established three independent research operations within the marine program. Two of these are based at permanent research centres and concentrate on studying the biodiversity and ecology of the local marine and terrestrial ecosystems. The first of these is run from the Marine Research Station the island of Cayo Menor within the Cayos Cochinos Marine Protected Area (CCMPA) and the other is based at the Coral View Research Centre on the island of Utila. The third operation is a mobile social development research team who travel around various villages and towns on the mainland and Islands, including both of the permanent research sites, conducting research on developing a sustainable livelihood for the local communities. This report is based on the work conducted on the island of Utila.

Projects run within the marine program can be based solely within one of the three research operations or involve two or all three of them. Separate reports have been created for each site based on the aim to deliver reports on the status of the local environment to the relevant management authorities. For Utila this is the Bay Island Conservation Association (BICA).

The following report is a summary of the research conducted by the Marine Research Program on Utila, Honduras in the summer of 2009.

1.1 Utila

Operation Wallacea started operating on Utila in 2006 and is in the process of developing a long term monitoring and research program on the Island. This is being done in collaboration with Coral View Research Centre from which all accommodation, research and diving operations are run. Data is shared with the Bay Islands Conservation Association (BICA) who are charged with managing the marine environment of Utila. The program has been built on in subsequent years since its conception. The collaboration has the following main objectives;

Ecological

- Run a yearly monitoring program of the status of the coral reefs around the Utila, to be conducted every year with the data used to produce a "Status of the reefs on Utila - annual report".

- Run a long term monitoring program of the mangrove systems on Utila and use the data to promote the conservation of these systems.

- Conducting high quality marine and terrestrial research around Utila, producing publications suitable for peer review and establish the Coral View Research Centre as an internationally recognised centre for quality research.

Interaction with local parties

- Develop the Coral View Research Centre into a high quality marine research centre, suitable for Operation Wallacea research during the summer season, University class group trips throughout the year and establish the centre as a the recognised ecotourism facility on Utila through programs such as a "reef ecology week" and promoting reef awareness.

- Develop a relationship with the Bay Island Conservation Association (BICA) through which the monitoring and research work can be disseminated through local and national bodies in order to promote the conservation and sustainable utilisation of the biodiversity of Utila.

1.2 Research Groups

Within the three operations there are currently six research groups;

- Fish and Invertebrate Ecology Research Group
- Urchin Ecology Research Group
- Conch Ecology Research Group
- Mangrove Ecology Research Group
- Herpetofauna Research Group
- Social Development Group

2. Locations of Study

Bay Islands

2.1 Utila

Utila is the smallest of the three Bay Islands off the north coast of Honduras. The island is roughly 13Km long by 4Km wide and covers an area of approximately $45Km^2$. The island is situated 27Km north of La Ceiba making it the closest of the Bay Islands to the mainland. The island is an international recognised dive tourist destination, specialising in dive training in addition to a popular tourist destination on the backpacking trail. The population centre on the island is East Harbour, although it is often just know as Utila. However, with the growing tourist industry developments are spreading around the shoreline, especially on the south coast, although inland development is limited.

Inhabitants and Culture

The Island was under British sovereignty until the mid 1800's and many influences of this are still evident, including English as the dominant language, and the island has a distinctly Caribbean atmosphere in comparison to the Central American cultures of the mainland.

The population of Utila, roughly 7000 people, comprise a variety of different groups. A few families of Caribbean origin own a large portion of the land. There is also a large population of Caucasian Caymanian Hondurans who have remained on the Island and Cayes from when the Bay Islands were a British colony. Since the rapid expansion of the dive industry Utila's population has grown to include sizable populations of Hispanic Hondurans from the mainland who have come to the island to work. In addition Utila also accommodates a large number of tourists and visiting workers who may visit the island for only a few days or stay on a semi-permanent or permanent basis for months or years.

Geography and biodiversity of the Island

The town of East Harbour spreads along the coastline in a natural bay in the south east of the island, behind which lies the only raised land, comprising of Pumpkin Hill and Stewarts Hill, the remainder of the island stretches to the west and is mostly lagoons, mangroves and wetlands. In total the island is 70% mangroves and associated wetlands. At the far west of the island are the Cayes, low lying small islands of varying size from very small to large enough to accommodate a small community.

The mangrove forests on Utila are largely comprised of the red mangrove species *Rhizophora mangle*, although inland black and white species are also found. Within the mangroves are found a wide variety of fauna commonly associated with Caribbean mangrove systems, as well as an indigenous species of iguana called the Swamper that is only found on Utila.

The north and south shores and shallow subtidal zones of Utila have very different habitats. On the sheltered south side of the island there are extensive seagrass beds, extending from the intertidal zone to the reefs. The reefs are mostly between 5 and 25 metres in depth and mostly made of reef walls. There are few shallow areas that can be classified as reef flats. The south shore is the site of most of the commercial building and large areas of the shore have been developed. The entrances to the two main lagoon systems on the island, Big Bite Pond and Oyster Bed Lagoon, are situated on the south shore. The edges of both of these lagoons are nearly entirely covered in mangroves, with most exceptions occurring where development has resulted in their destruction.

The North and Eastern shores of Utila face the prevailing wind and waves making them more exposed in nature. Reefs on the North shore are mostly steep drop offs, from 5m up to 50m+ in some cases. The shore is a mixture of sandy beaches, exposed rocks (called iron shore) and mangroves. There is small but isolated developments on the north shore. The north shore has two large semi enclosed bays, called Rock Harbour and Turtle Harbour. Turtle Harbour is a protected area, which encompasses the mangroves, seagrass and reefs out from the shore.

View of East Harbour from Chepes Beach, Utila

Economy

The island has experienced extremely rapid development of dive tourism over the previous 15 – 20 years, resulting in 11 dive schools on the island and numerous hotels, restaurants and associated developments. The dive and tourist industry comprises up to 90% of the economy of the island and its growth has resulted in a large increase in the population of the island, including mainland Hondurans coming for work and a sizeable tourist population that remain on the island on a permanent or semi-permanent basis. The remaining industry is mostly related to the fisheries on the reefs and pelagic zone. This is mostly based on the Cayes where the tourist industry is not as prevalent as it is on the main island.

Areas of research interest

The dive tourism has had a massive impact on the ecology of the island. The development has mostly occurred in the low lying land near the shore and has resulted in the removal of large areas of mangroves. All development has been performed with little consideration of environmental impact and as a result there is a large level of mangrove destruction in the developed areas.

Additionally the development has outpaced the growth of the islands infrastructure resulting in large levels of pollution entering the water. This is also true of sediment transport that has increased dramatically as a consequence of the loss in mangroves and is probably resulting in increased sedimentation on the reefs adjacent to the mangrove lagoons.

The fishing industry is having a huge impact on the reef fish populations around Utila, although evidence for this is mostly anecdotal. Many commercially important reef fish hold important positions within the reef ecosystem, usually as a predator, and their removal could have severe consequences for the health of the reef system.

3. Fish and Invertebrate Ecology Research Group

Personnel

Senior Scientist -	Dr. James Saunders - Operation Wallacea
Project supervisor -	Andrew Scott – University of St Andrews
Dissertation projects -	Louis Mullan – University of Manchester
	Priyesh Depala – University of Manchester
	Mareike Dornhege – University of Oxford
	Hannah Cox – Bristol University

3.1 Introduction to the group

The Fish and Invertebrate Ecology Research Group is based on both the Cayos Cochinos and Utila. On both systems the health of the reefs have huge ecological and economic importance to the area and therefore assessing the health of the fish and invertebrates is of considerable importance, as is developing an understanding of their ecology.

The group mostly focuses on species of fish and invertebrates that are commercially important to the systems or can be used as indicators of overall reef health. In 2008 the group conducted basic surveys of the fish populations on 4 reefs around Utila. In 2009 this project was expanded and 10 reefs were surveyed for fish, coral, invertebrate and benthic structure. The project was also expanded to include surveys of the fish in seagrass beds around Utila to assess their importance towards overall reef fish populations.

The group also included an assessment of the impact of divers on the reefs, this is covered separately in section 4, although the work was integrated with that of the Fish and Invertebrate Ecology Research Group.

3.2 Project introduction and rational

Fish and invertebrate populations are both highly important to the status of the reefs and the economy of the local area. On Utila economic importance is partly based on the fishing industry but more significantly the large dive tourist industry based on the reefs around the island. Fish and invertebrate populations provide both an income source in addition to performing vitally important roles in the ecological functioning of a healthy reef system. Therefore the importance of monitoring the fish populations is evident as a measurement of their status and the role of fishing on the ecology of the reefs.

3.3 Methods

Surveys of fish populations were done using underwater visual census (UVC) on 10 reefs each around Utila (Fig. 3.1). Ecologically and economically important species of reef fish were surveyed (Annex 1). Transects were laid over 20m and fish populations counted 2.5m either side of the tape and 5m above as divers swam along the transect at a consistent speed. This equates to a survey covering a benthic area of $100m^2$ and a volume of water of $500m^3$. The same survey protocol was used on seagrass beds to assess juvenile fish populations.

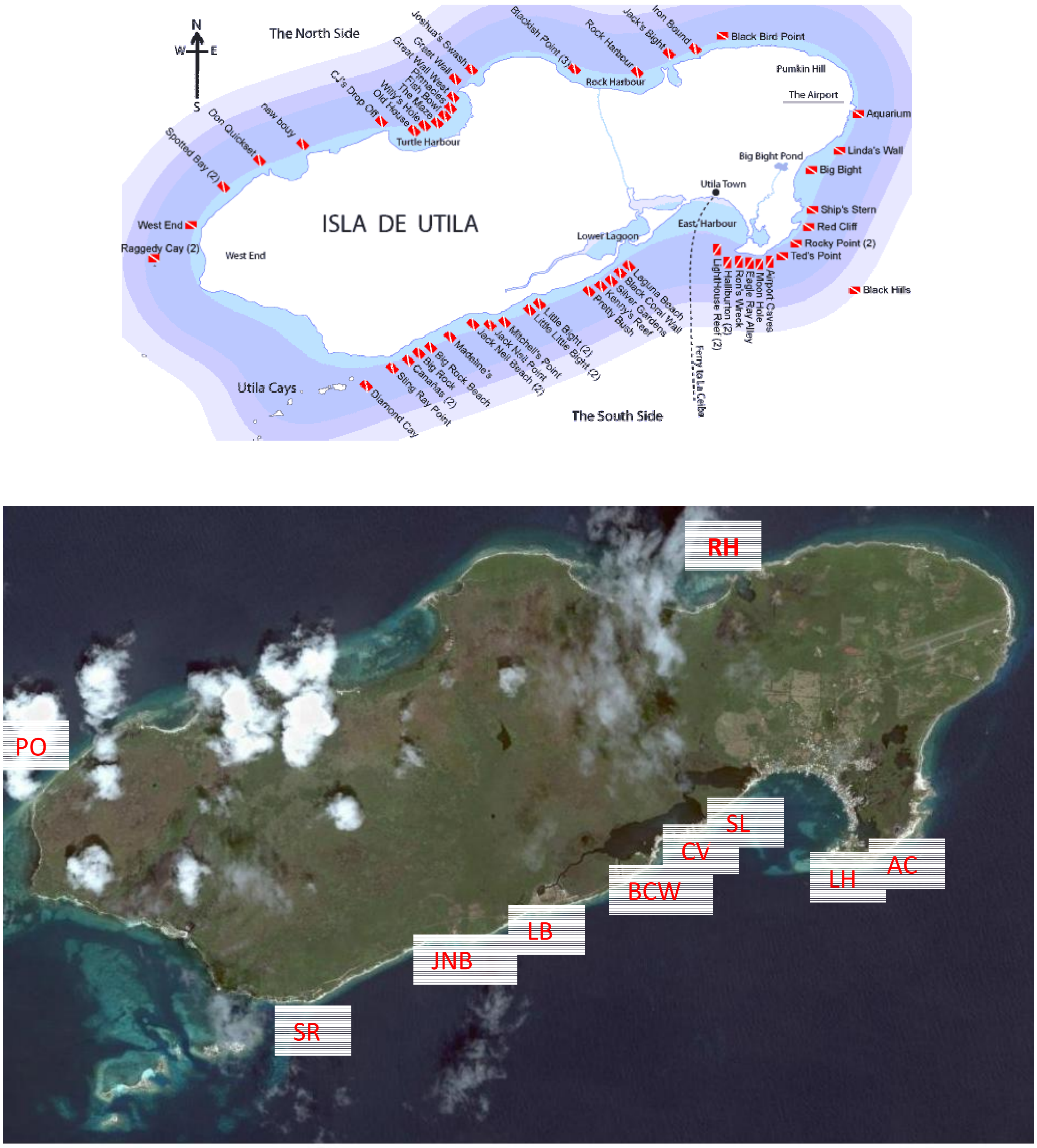

Figure 3.1 Official dive Sites on Utila (top) and map of surveyed sites including some non official sites (bottom). Clockwise from top, RH – Rock Harbour, AC – Airport Caves, LH – Light House, SL – Slumberland, CV – Coral View, BCW – Black Coral Wall, LB – Little Bight, JNB – Jack Neil's Beach, SRP – Stingray Point, PO – Parisio.

Benthic structure and coverage were measured along the same transect through a point intercept method, with the species/benthic type under the tape measure taken every 50cm, resulting in 40 different measurements from which a percentage cover can be obtained (Annex 2).

Several important species of invertebrate were also recorded, these were counted 2.5m either side of the tape measure, equalling an area of $100m^2$ (Annex 3).

Diversity (measured through the Shannon diversity index), species number and individual numbers of fish are analysed through univariate statistics, as are populations of individual species of fish. Percentage cover of hard corals and algae is compared between sites as are numbers of sea fans and plumes.

3.4 Results

Fish population properties and individual species

Both the number of species and individual fish found on the reefs of Utila increased from 2008, however the methodology used in 2009 better represented the overall fish population so direct comparisons are not possible (Table 3.1). Strangely despite recording more species of fish the diversity of the fish communities has not changed.

Table 3.1 Number of species, individuals and diversity of reef fish populations on the reefs of Utila. Standard errors (se) are given (n=8).

	2008	**2009**
Number of species	8.00	8.99
se	0.69	0.96
Number of individuals	27.54	32.01
se	5.61	3.79
Shannon Diversity	1.74	1.74
se	0.10	0.12

Reef population structure on individual reefs

There was considerable variation in fish communities around the reefs, with high numbers of fish found on three reefs, Slumberland, Black Coral Wall and Jack Neil's Beach, these are all on the south shore, however they are not adjacent to each other with Coral View and Little Bight situated between them indicating that the South Shore as a whole is not higher in fish numbers and that individual reefs have their own characteristics (Figure 3.2). Indeed while individual numbers are high on these reefs the diversity is not as high here as on other reefs (Fig. 3.3), indicating a dominance by a single species of fish, possible the presences of a large shoal of fish, again indicating the unique nature of each reef.

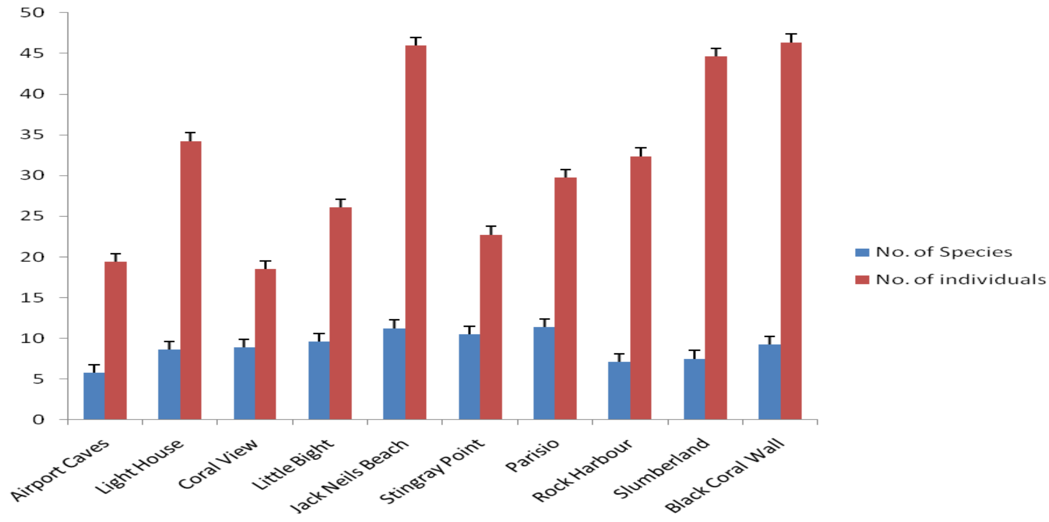

Figure 3.2 Number of species and individual fish on each reef surveyed in 2009

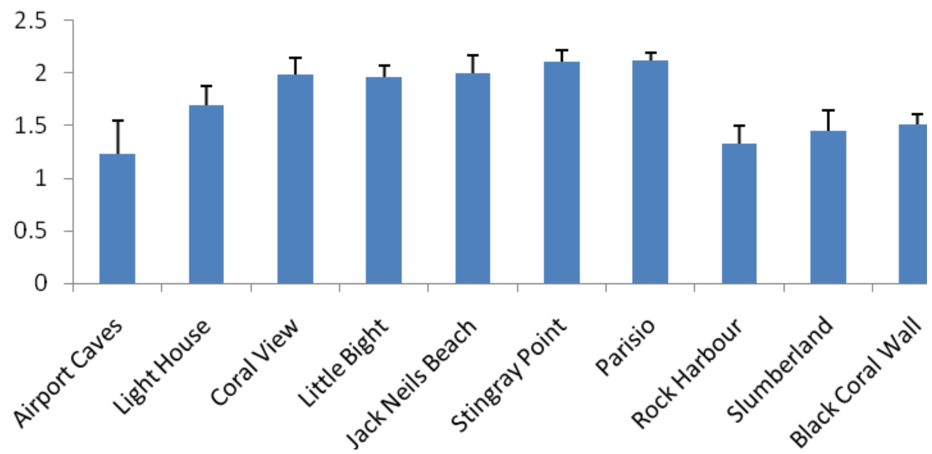

Figure 3.3 Fish community diversity as measured by the Shannon Diversity index.

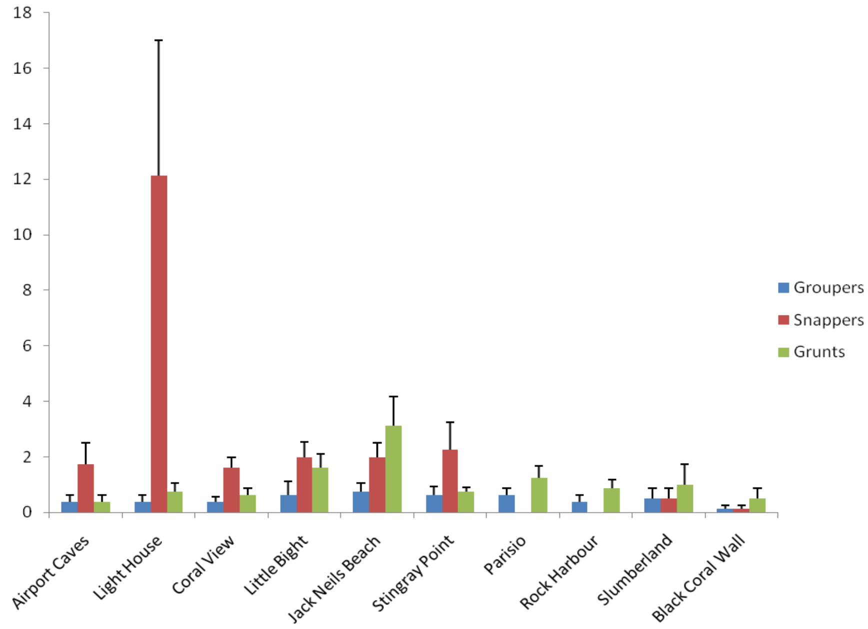

Figure 3.4 Populations of commercially important species of fish on individual reefs on Utila

Populations of commercially important species of fish, including groupers, snappers and grunts are low at all reefs with the exception of snappers at Light House reef which is a suprising result and hard to explain given the consistency of the other results (Fig 3.4). However with populations of al three families consistently below 2 individuals per transect populations are considered low on all reefs.

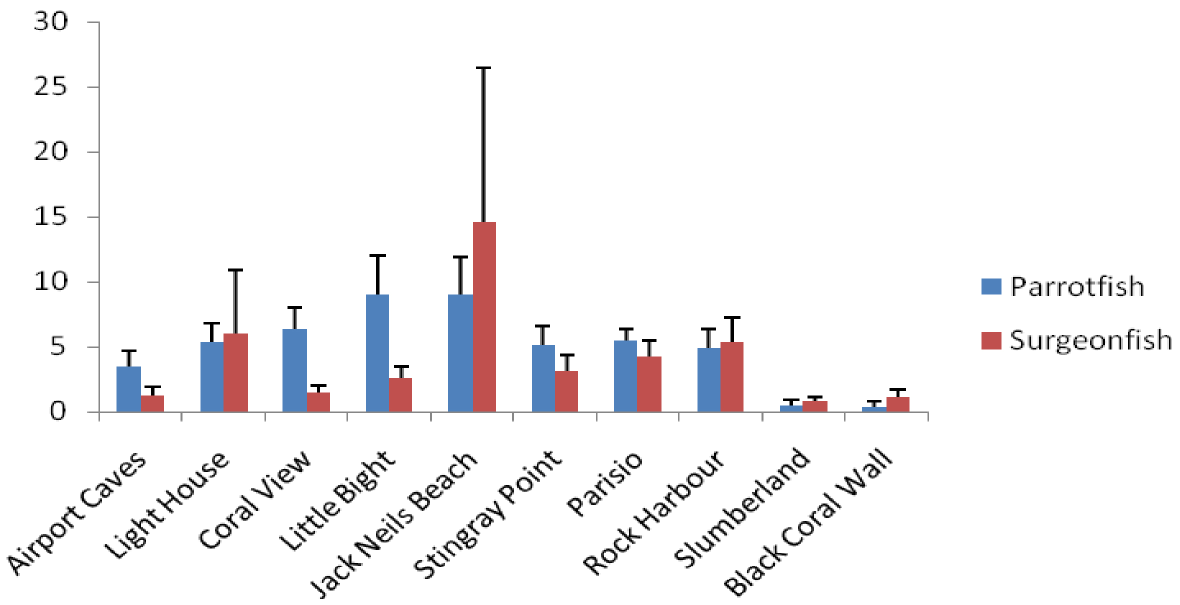

Figure 3.5 Populations of herbivorous fish families on individual reefs on Utila.

Herbivorous fish such as parrotfish and surgeonfish are more abundant than the commercially important species, however, again populatins are generally low (Fig 3.5).

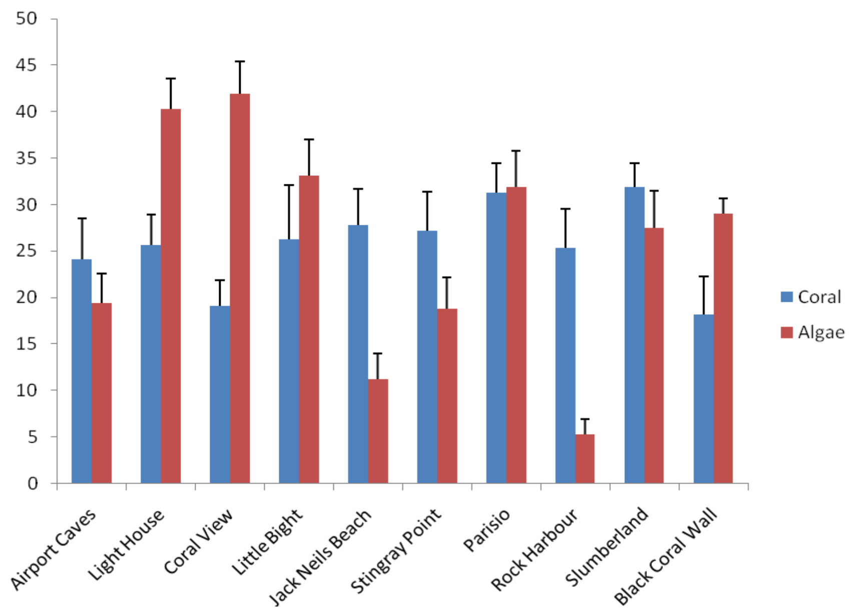

Figure 3.6 Percentage coral and algal cover at each reef – not including coraline algae.

Hard coral coverage is relatively consistent across all reefs at around 20 – 30% coverage. While not as high as a fully healthy Caribbean reef these levels are considered high for such reefs (Fig 3.6). Algal coverage is slightly more variable and shows a very low coverage on the north shore site of Rock Harbour. Some sites do have especially high coverage such as Coral View and Lighthouse reefs and these need to be monitored in the future to ensure it does not increase. Sea fan and Sea Plume numbers were varied and inconsistent, the highest numbers being found in Rock Harbour which may be a characterisitc of the norht shore in general, however the second highest, found at Slumberland are geographically closest to Coral View with the lowest number (Fig. 3.7)

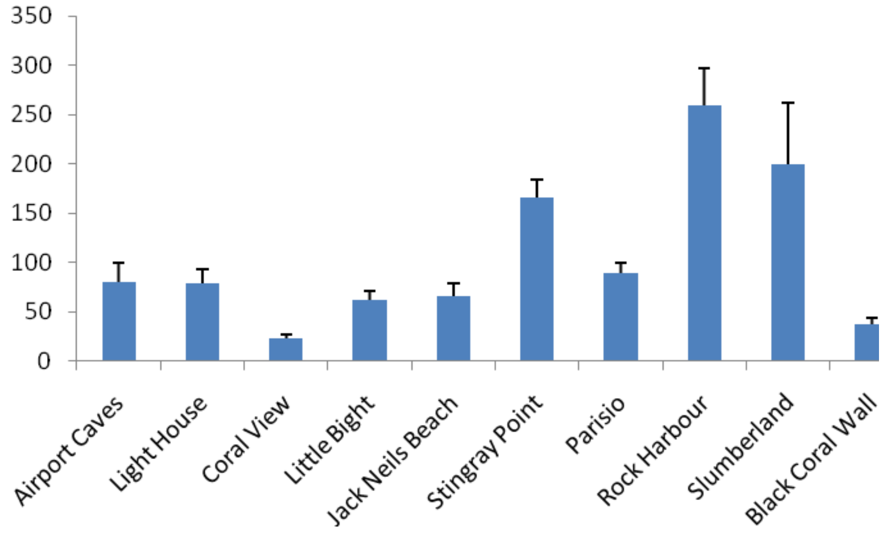

Fig 3.7 Combined counts of sea fans and sea plumes on individual reefs on Utila.

3.5 Conclusions

The survey of 10 reefs around Utila in 2009 was a vast increase on the 4 reefs surveyed in 2008. Equally the number of fish species surveyed increased improving the accuracy of the surveys. Likewise the addition of coral, algae and benthic information for 2009 has allowed a thorough survey of the reefs of the island. The intention for 2010 will be to return to these 10 reefs and repeat the surveys allowing continuously yearly monitoring, however it is evident that in some areas the north shore differs from the south shore and the number of reefs surveyed in this part of the island needs to be increased, especially around Turtle Harbour.

Generally the reefs can be said to be in moderate health, certainly reef fish populations are too low for healthy reefs, and especially the number of larger fish is very low. However, currently the benthos is considered to be in reasonable health. Given the evident impact on the fish populations though this needs to be monitored closely as the pressures on the reef fish are likely to be exerted on the benthic species soon enough. And algal coverage would be expected to increase and hard coral coverage drop.

3.6 Publications

Harm JH, Kearns E, Speight MR (submitted) Differences in coral-reef fish assemblages between mangrove-rich and mangrove-poor islands of Honduras Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008

Shrives, J.P., Cowie, G.L., Thompson, P.A., Riley, J.S. and Speight, M.R. (2008) Integrating oceanography and marine ecology: What effect does the Río Aguán have upon the benthic reef community of Los Cayos Cochinos, Honduras? Oral Presentation RCUK 2008

Shrives, J.P., Lea, J.S.E. and Speight, M.R. (2008) How Does Black Band Disease Affect The Benthic Ecology of Reefs in Los Cayos Cochinos, Honduras? Poster Presentation RCUK 2008.

Mullier, T.W. and Shrives, J.P. (2008) Ecological distribution, demography and host specificity of cleaner shrimp in the Cayos Cochinos, Honduras. Poster Presentation RCUK 2008.

Shrives, J.P. (2008) Safeguarding the Reefs of Cayos Cochinos, Honduras. ADM, Issue 29

Shrives, J.P., Lea, J.S.E. and Speight, M.R. (in prep) Faunal Associations with Black Band Disease in Cayos Cochinos Honduras. For submission to Coral Reefs

Shrives, J.P., Lea, J.S.E. and Speight, M.R. (in prep) Spatial ecology and succession dynamics of Black Band Disease in Cayos Cochinos Honduras. For submission to Marine Ecology Progress Series or Coral Reefs

4. The impact of Divers on the reefs of Utila

Personnel

Senior Scientist -	Dr. James Saunders - Operation Wallacea
Project Supervisor -	Andrew Scott – University of St Andrews
Dissertation Students -	Mhairi McCready – University of Plymouth
	Lawrence Lam – Lakeside University

4.1 Introduction to the group

The Fish and Invertebrate Ecology Research Group intends to study the many influences on the reefs and isolate what variables are effecting reef status and health. On Utila this scope of research has to include the potential impact of divers on the reefs. This research links the monitoring and biological research performed by the group with practical application and works with BICA towards assessing the diver loads and impacts on each reef,

4.2 Project introductions and rationales

Utila is the self proclaimed "cheapest place in the world to learn to dive" and while impossible to know if true it is certainly easy to believe as the small island has no less than 11 dive schools and many other hotels associated diving operations. The island is orientated towards the backpacker tourist trade and as such offers very cheap diving packages, especially as a way to learn to dive. As a result the numbers of divers on the reefs are very high and Utila as an island has now become all but totally dependent upon the diving industry and the associated businesses – 85% of the islands economy is estimated to be based on the diving industry, and therefore by extension this is based on the reefs themselves. Diving is marketed as a very environmentally friendly activity where the participant is there to experience the natural underwater world. However what is evident from watching almost any divers is that sooner or later they will in some way damage the reef on which they are diving. This will almost always be due to inadvertent contact with the reef somehow, such as banging into the reef. However in some cases it can be due to a lack of awareness of the consequences of deliberate actions such as holding onto the corals for stability. Given the numbers of divers on the reefs even small levels of contact can potentially accumulate quickly and have a significant impact on the reefs health. Therefore the group is working with BICA, who have been collecting data on the number and type of dive at each dive site over the year. Combining this data with surveys of the reefs conducted by the Fish and Invertebrate Ecology Research Group in addition to an assessment of diver practices will give a better understanding of the impacts and consequences of divers on the reefs and what possibly implications and action may be needed in order to ensure the reefs are managed and maintain their health.

4.3 Methods

Diver impact surveys

Divers were monitored during dives to assess what impacts occur and how frequently. The divers were unaware that they were being monitored to avoid bias and all divers were recorded in reference to their experience in terms of number of dives and qualifications.

Reef usage
Data was collected by BICA over the year form all the dive operations so that the total number of divers on each reef over the year was obtained. Records were also kept on the type of dive, including training and recently qualified divers. This means that in addition to overall usage the nature of the diving at each reef can be qualified.

Reef surveys
Data from the Fish and Invertebrate Ecology Research Group was used to assess the health of the reefs.

4.4 Results

Diver numbers
Number of dives on each reef varied considerable, out of the reefs selected for study numbers of divers for the year ranged from over 800 for Black Coral Wall – which was the highest on the island, to Paraiso which had less than 100 divers (Fig 4.1). As would be expected, the reefs most commonly dived are also those that have the most training dives and the high numbers of dives are probably a result of the sites being suitable for training dives (Fig 4.2).

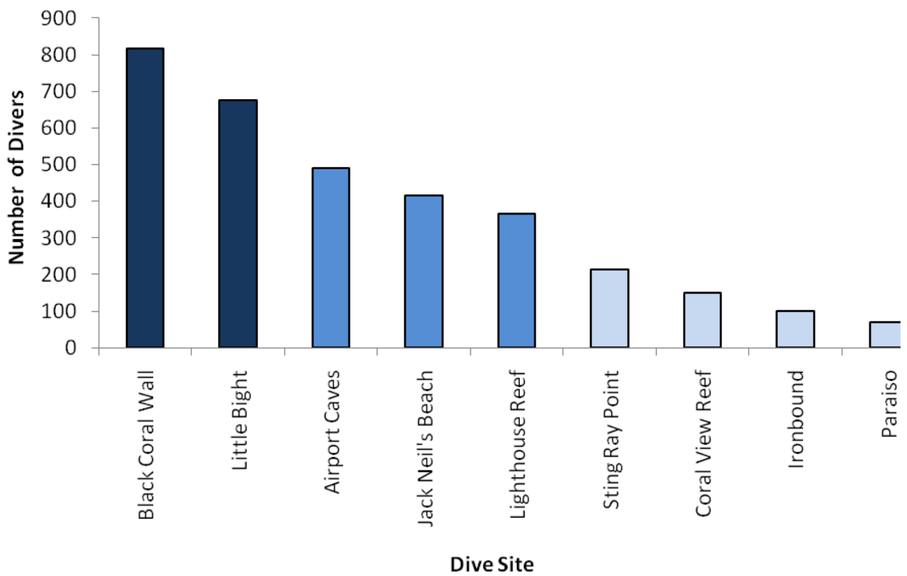

Figure 4.1 – BICA data; showing total numbers of divers during one year to each of the nine dive sites

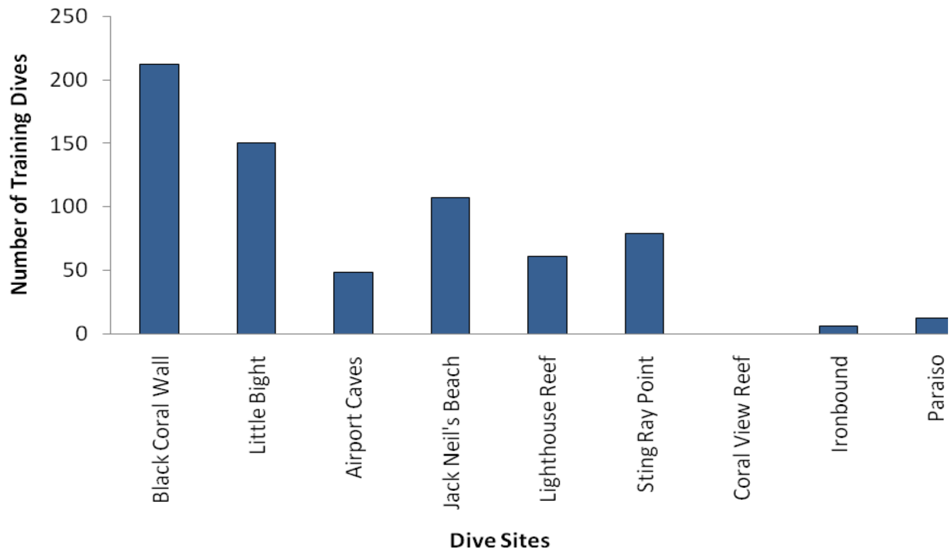

Figure 4.2 Number of training or recently qualified dives on each reef within the year.

Diver contacts on the reef
The type of dive had a large bearing on the level of contact the diver had with the reef. Training dives resulted in significantly more impacts per diver than any other type of dive, with recreational diving having the least impact (Fig 4.3).

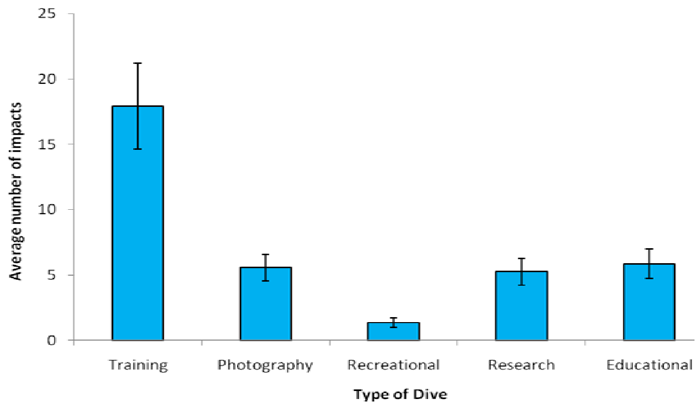

Figure 4.3 Average number of contacts per dive for different types of dive

While the type of dive influenced the number of contacts the actual qualification or experience of the diver had no influence on how many contacts they made with the reef (Fig 4.4).

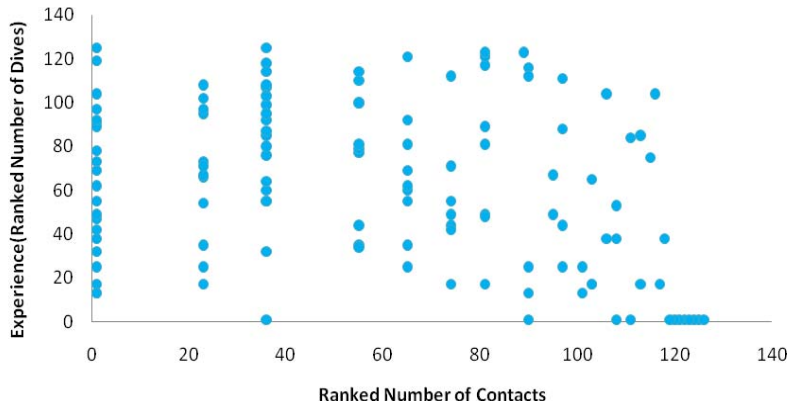

Figure 4.4 Number of contacts correlated with experience of the diver quantified through number of previous dives.

Reef health associated to diver numbers

As can be seen in section 3 the health of the reefs around the island are relatively consistent. Hard coral coverage is likely to be one of the best indicators of diver related stress due to their vulnerability being touched/broken and covered in suspended sediment. However hard coral coverage does not follow a trend similar to that of diver numbers, although the cover of hard corals at Black Coral Wall, the most dived reef, is lower than average and this may be related the lack of any other significant results leave this is only speculation.

4.5 Conclusions

The results of the groups work over the summer give a mixed message on the diver impact on the reefs of Utila. The number of divers is not evenly spread over the reefs, with some reefs experiencing nearly an order of magnitude more divers per year than others. This is also represented in the number of training dives occurring at sites as clearly some sites are used in preference for training than recreational diving. This is unavoidable as training dives require certain characteristics such as sandy sediment at specific depths. However, worryingly it is the trainee divers that have the most number of contacts per dive compared to all other types of dive. This would indicate that these reefs are being placed under increased pressure from this activity. However the measurements of the health of the reefs do not show that this increase in diver pressure is having an adverse effect on the health of the reefs. Generally this should then be an encouraging result, with the reefs of Utila being able to sustain the current levels of diver impact. Having said that it would probably be beneficial for the overall health of the islands reef to distribute the divers around the reefs more evenly, although this argument may be opposed by the counter argument that sparsely used sites interspaced with more heavily dived sites may increase the overall reef status.

5. Mangrove Ecology Research Group

Personnel

Senior Scientist -	Dr. James Saunders - Operation Wallacea
Fish Research Scientist -	Jessica Harm - Oxford University
Research Assistant	Ben Thorne - Lancaster University
Dissertation projects -	Sian Williams – Swansea University
	Catherine Taylor – Lancaster University
	Simon Culver – Birmingham University

5.1 Introduction to the group

Utila contains extensive mangrove systems that are an integral part of the functioning of the marine ecosystem. However these are under considerable threat from development on the island, especially related to the growing dive tourist industry.

The Mangrove Ecology Research Group has a variety of aims, measuring the exposure of areas of the mangrove system to pollution and disturbances, assessing how this related to the health of the mangroves themselves and also various functions of the mangrove systems, including acting as fish nurseries for juvenile reef fish and as coastal defence and sinks for waterborne sediment and pollution.

The research is divided into a monitoring program covered in the assessment of mangroves and associated habitat (Section 5.3) and research into mangrove functioning, in particular how they function as fish nurseries (Section 5.4).

5.2 Project introductions and rationales

Assessing mangrove system health

There are 4 main lagoons on Utila (Fig 5.1), two each on the north and south shores. Of the four, the two on the south shore have experienced high levels of disturbance as a result of the development of the island, and in particular the dive industry. In contrast, the two lagoons on the north shore are relatively untouched, indeed one, turtle harbour, is established as a protected area, with only researchers allowed to enter.

The two lagoons on the south shore, Big Bite Pond and Oyster Bed Lagoon, are subjected to varying types and scales of anthropogenic impact. Big Bite Pond is located on the very east of the island, near the main population centres. In particular a “slum” type area, known as Campanada, which has grown as a result of the influx of Hondurans from the mainland who work in the tourist industry. This area has grown through the extensive removal of large areas of mangroves and houses built here have little or no facilities for removing waste. The result of this is a high level of sediment erosion and an expected high level of organic pollution within Big Bite Pond. Oyster Bed Lagoon is used by a lot of the higher end hotels on Utila and as a result is not expected to suffer from the levels of organic pollution experienced in Big Bite Pond, however the hotels bring with them a high level of boat traffic disturbance and the development of the hotels and additional ongoing projects require extensive dredging of the lagoons. The result of which is a system subjected to high levels of physical disturbance. In contrast, the two lagoons on the north shore, Rock and Turtle Harbour are relatively untouched, especially Turtle harbour which is protected by local laws and access is prohibited unless for sanctioned research.

Projects being run by the mangrove research group involve assessing the pollution and disturbance levels within the lagoons and the subsequent effect this has on the health of the mangrove systems. This data will then be used as a background of system health from which other studies of mangrove system functioning related to health can be performed. Currently this involves assessing the functioning of mangroves as a nursery for juvenile reef fish species and assessing the ability of mangroves to stabilise sediment and sequester pollutants.

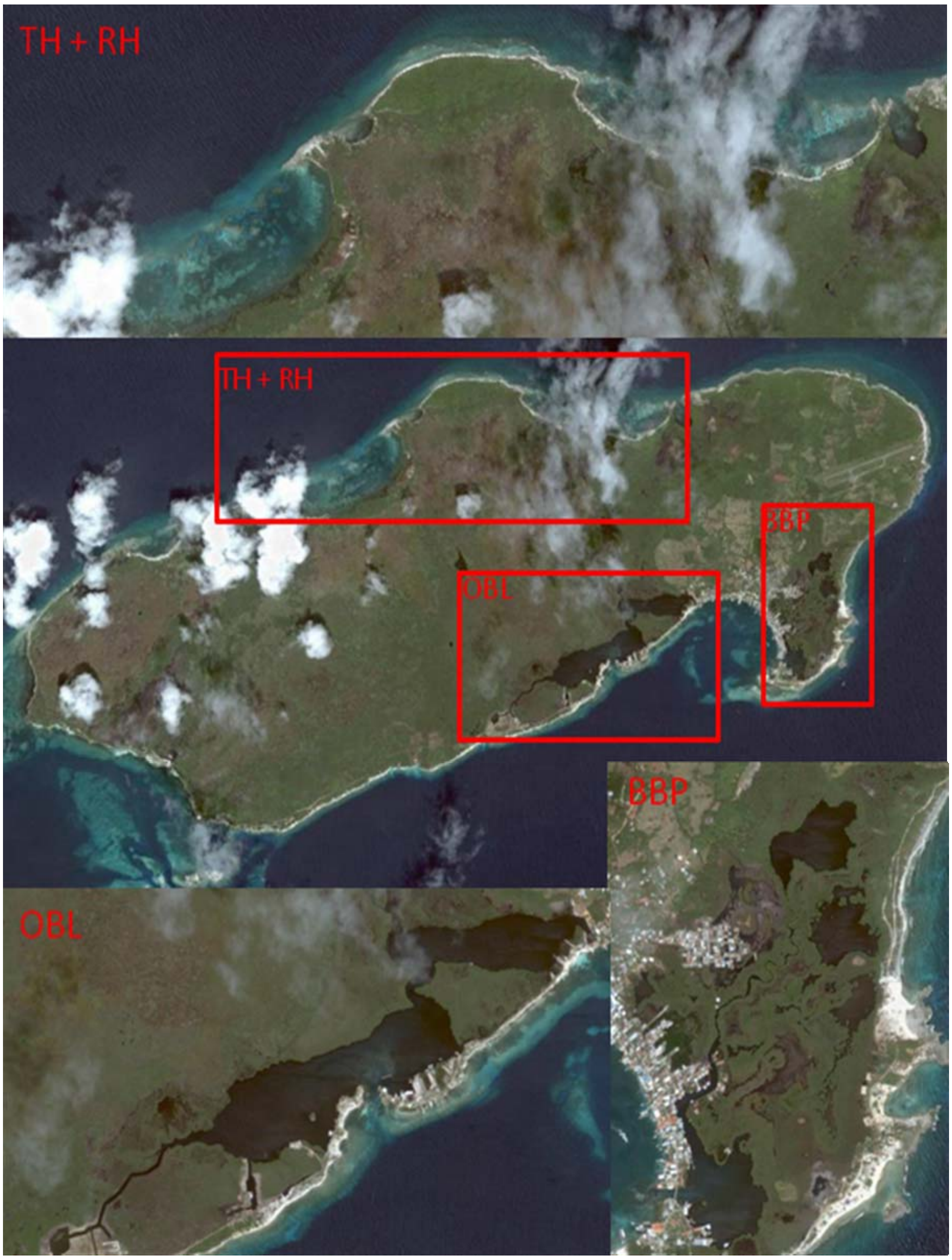

Figure 5.1 Utila with locations of the four sampled lagoons highlighted. Images taken from Google Earth.

5.3 The effects of pollution and disturbance on the health of mangrove systems

5.3.1 Introduction

Marine sediment systems provide a valuable way of measuring the long term health of a system. Deposited sediments often sequester pollutants from the water column that are adsorbed onto the sediment surfaces. This means studying the sediment allows a good measurement of long term pollution exposure within a system that may not be possible from sampling the water given its short residency time within the system. Likewise analysis of the density and resistance to erosion of sediments is a good indicator of the level of physical disturbance experienced by the system.

A project was devised to sample the sediment from the lagoons around Utila to look for indicators of system health, this was combined with a large scale survey of the mangrove trees in the lagoons to determine if sediment properties, pollution and disturbance correlated with the health of the mangrove trees.

5.3.2 Methods

Sampling strategy

Sample sites were selected every 100m around the edges of the four lagoons. Access to the lagoons was done by kayaks and hand held GPS locators were used to find the sites.

Mangrove health

The health of the mangrove trees surrounding the lagoons was measured at the sample sites through counts of primary, secondary and tertiary root number. Additionally counts were made of the number of roots that had penetrated the water surface but not reached the ground and their status (living/dead) recorded.

Survey of surface sediment properties

Approximately 70 sites were sampled around the edges of the 4 lagoons, in addition to open water sediment samples from near the mouths of the lagoons, giving a total of approximately 200 sediment samples. Sediment cores (diameter 5cm, depth 5cm, volume ≈100cm3) were pushed into the upper sediment in the shallow water (<30cm) and the base secured before removing the sediment core. Measurements of pH, salinity and temperature were taken from the sediment before the cores were transferred to sealed plastic bags for transport back to the laboratory for subsequent analysis of water content, conductivity and dissolved oxygen.

Statistical analysis

Sediment properties were compared between lagoons using a one way ANOVA after assumptions of normality were tested. A tukey post hoc test was used to identify differences between lagoons.

5.3.3 Results

Mangrove health

With all three lagoons the number of primary roots was the same while RH had more tertiary roots than both other lagoons and more secondary roots than BBP (Fig. 5.2). Rock Harbour also had the largest number of roots that had made contact with the substrate (Fig. 5.3) which is an indication of health as many roots in the other lagoons had been colonised and killed as they grew down through the water column to the benthos.

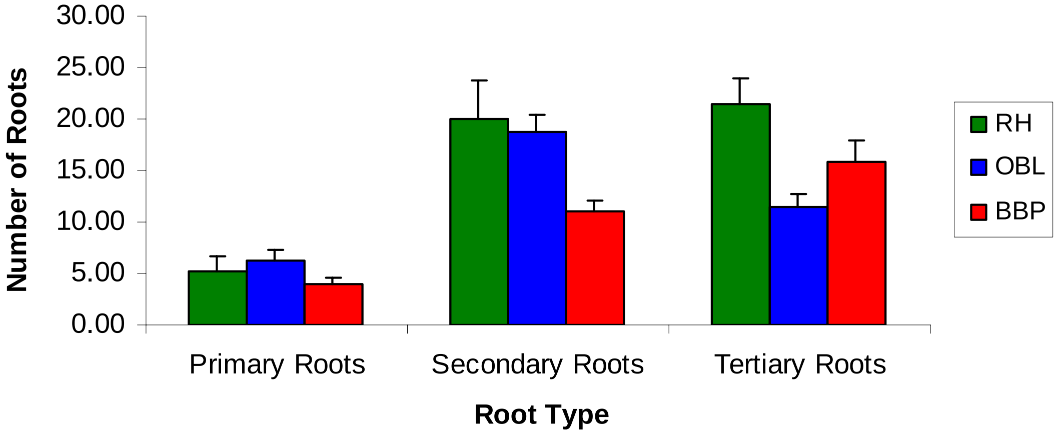

Figure 5.2 Numbers of primary, secondary and tertiary roots of mangrove trees in each lagoon

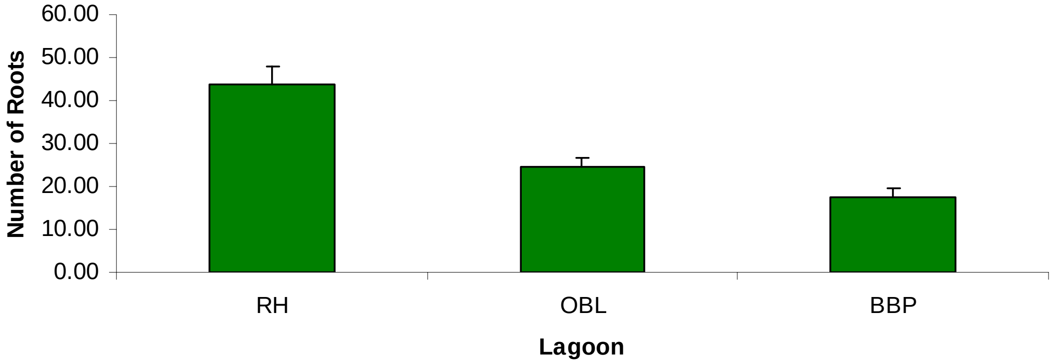

Figure 5.3 Number of grounded roots (those that have reached the benthos) from sites at each lagoon.

Tree height was similar in BBP and RH, however in OBL there were many areas where very short trees were present which lowered the average height of the lagoon (Fig. 5.4). Therefore this is less an indication of the overall height of the trees within OBL but a reflection of the presence of extremely short mangroves in some parts of the lagoon.

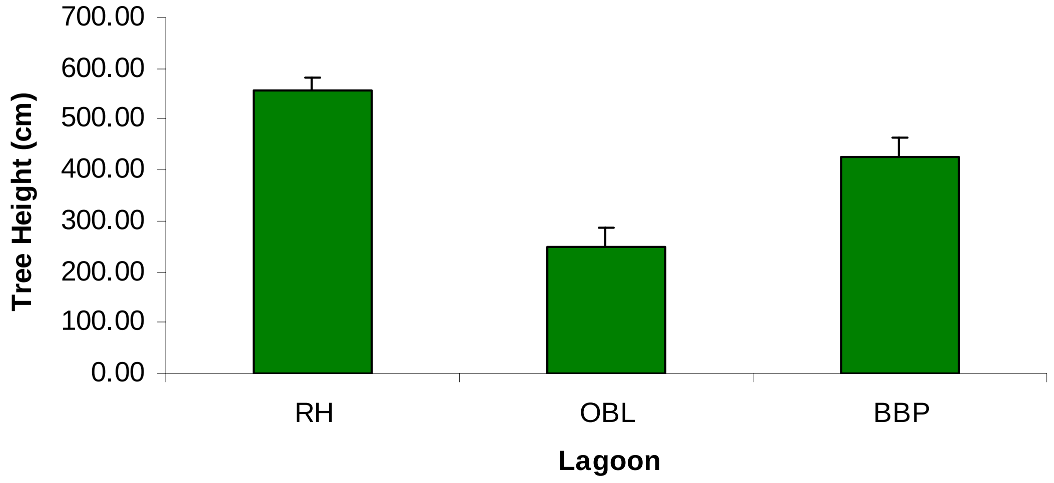

Figure 5.4 Average tree height from the tree lagoons

Sediment properties
The sediment of the lagoons was measured for pH and salinity. In both cases the pH and salinity were consistent in RH and OBL but were both lower in BBP (Figs. 5.5 and 5.6). It is very likely that these are linked and the lower salinity resulted in the lower pH although there is no indication as to why the salinity would be lower in BBP compared to OBL. RH is the exception as it has high levels of exchange with water from the sea, but if this was the determining factor then it would be expected that RH would be different from OBL.

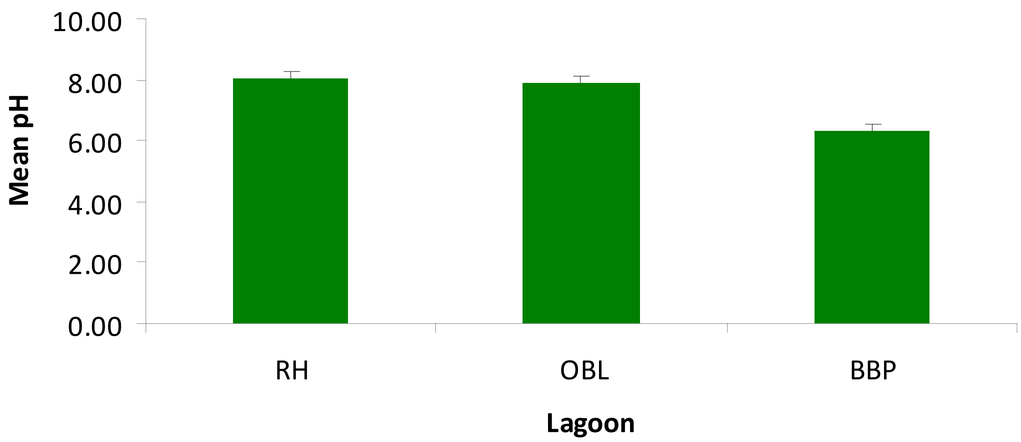

Figure 5.5 pH values taken from sediments in the 4 sampled lagoons and open water

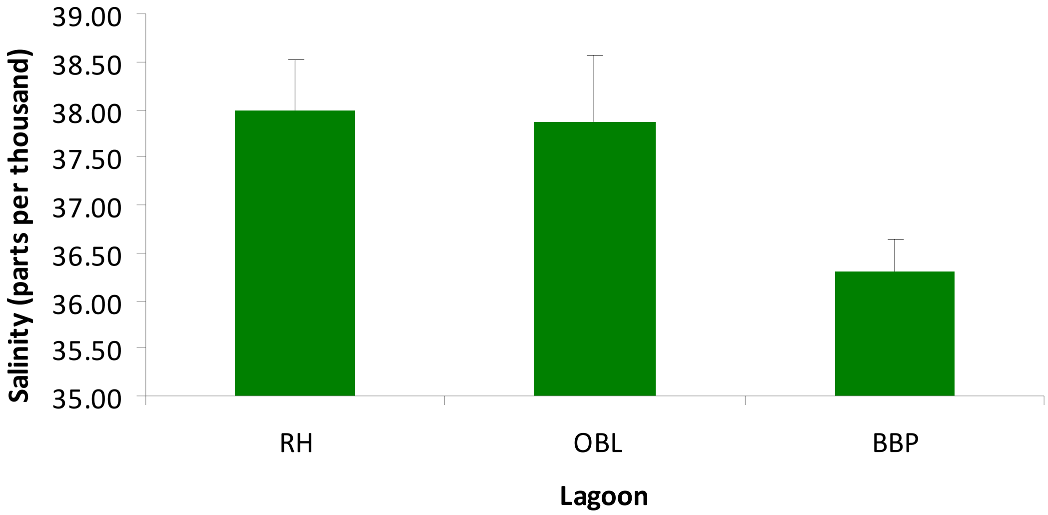

Figure 5.6 Sediment salinity values taken from sediments in the 4 sampled lagoons on Utila

5.3.4 Discussion

The health of the mangroves on Utila is very varied and is a clear indication of the range of pressures the systems and lagoons are being subjected to. There are many mangroves that could be considered very healthy, especially those on the north shore in Rock Harbour. However there are many areas where the trees are not in a healthy status, especially in Big Bite Pond where the trees are subjected to very high levels of disturbance and pollution.

This project is overall in its infancy, however the work done in 2009 has established the basis for a long term monitoring program of the mangroves that will allow their health to be recorded accurately and consistently in future years. Equally interesting is the scope this would give to measurements of the mangroves functioning and the use of these functions to the health of the marine environment. This included fish nurseries but also the potential for sediment stabilisation and pollution sequestering.

5.4 Relationship between mangrove system health and function as a reef fish nursery

Figure 5.7 Deploying a minnow trap at the mangrove edge

5.4.1 Introduction

Mangrove systems are well recognised as a vital component of the life cycle of many reef fish, including many commercially and ecologically important species. There is a large supply of suitable food in addition to the complex three-dimensional root system and shade providing a good refuge from predation for juvenile fish that then migrate to the reefs once large enough.

Previous studies have shown that mangrove physical characteristics, such as proproot density, can have a direct correlation to fish densities. In 2008, a study of Oyster Bed Lagoon was performed assessing the populations of juvenile fish in various parts of the lagoon with different physical characteristics. The strong negative correlation found between fish abundance and percent substrate algal cover suggests that fish may be negatively affected by algae. Although increased heterogeneity of proproots from epibionts such as algae have been shown to increase fish abundance, it was hypothesized that thick mats of algae reduce foraging efficiency of carnivorous fish. The aim of this study is to test the foraging efficiency hypothesis with algal removal and prey tethering experiments.

5.4.2 Methods

Algae removal.

Three sites were selected within the lagoon; both the east and west sides of the lower lagoon and one site in the upper lagoon (Fig 5.1). Substrate algae was removed from four $3m^2$ plots at these three sites. Visual fish surveys were performed 8 hours before removal, five hours after algae removal, and then 2, 4, 12, and 30 days after removal.

Foraging efficiency

The experiment was performed in the upper site due to its dominance of one genus of algal species, *Caulerpa sertularoides* (green feather algae), which reduces variability of habitat differences affecting foraging efficiency. Minnow traps were used to catch the xanthid crab, Pilumnoides hassleri, (carapace width 2-3cm). Tethering technique was based off a widely used and tested method in brachyuran predation experiments. In quadrats with algae and without algae, PVC pipes were pushed into the sediment exposing only the top 3cm in. Each crab was attached (via cable ties) to the drilled hole located at the top end of the PVC pipe for a total of nine crabs per day. A total of 45 crabs were tethered five times in three sites with three distances from mangroves. Presence of crabs was checked after 24 hours.

5.4.3 Results

Mean fish abundance before and after algal removal was not significantly different. However, there is a trend towards more fish after removal (Fig. 5.8). Tethered *Pilumnoides* crabs had higher survival rates in algae (92%) than in silt (50%) (Fig. 5.9).

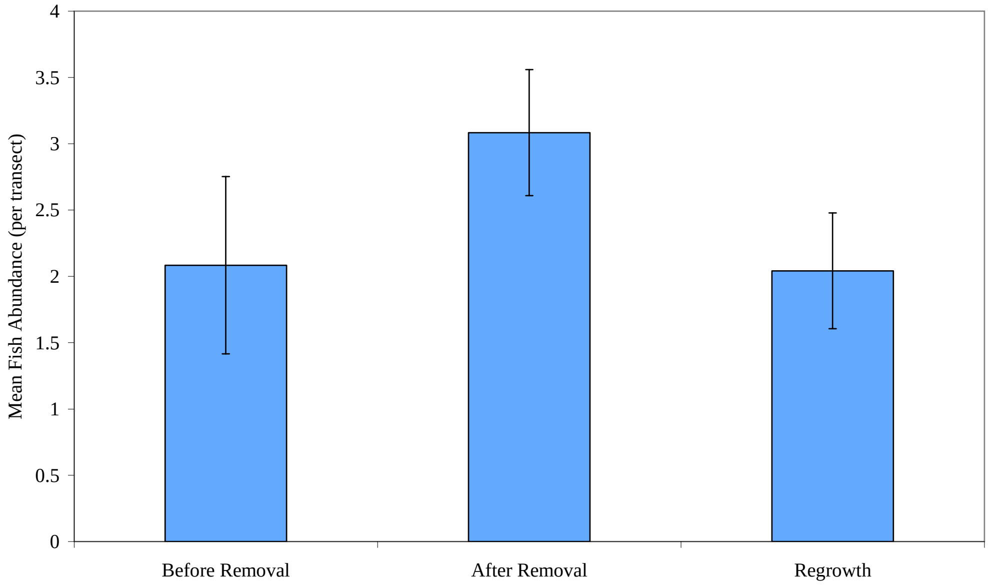

Figure 5.8 Mean fish abundance (±SE) per transect in quadrats before removal algae, immediate after removal, and more than 12 days after removal (when algae begin to re-enter quadrat).

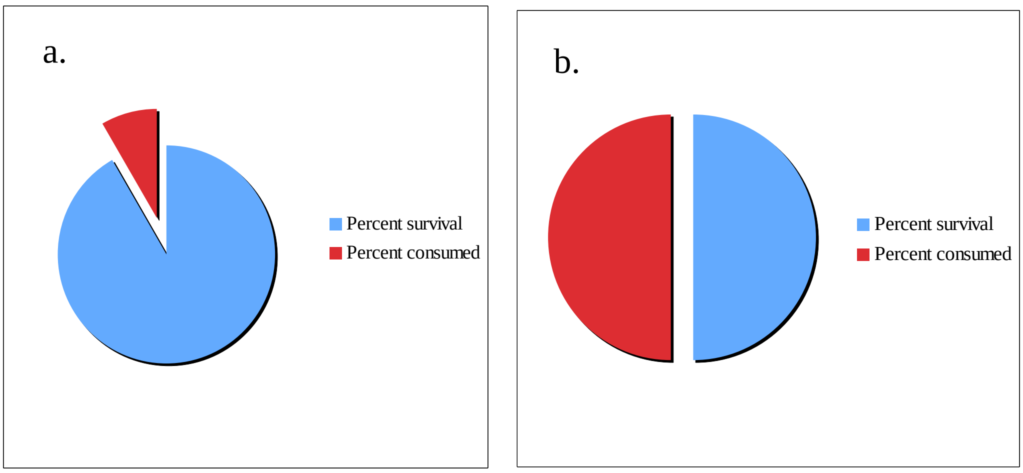

Figure 5.9 Percent survival of Pilumnoides crabs tethered in (a) algae and (b) silt.

5.4.4 Discussion

Results from surveys in 2008 show fish negatively correlated to substrate algae cover, yet fish abundances did not change after algae was removed from experimental plots. However, fish abundances did increase, although insignificant, after algae removal which suggests that perhaps plot size was insufficient. Most likely, the quadrat was not large enough (i.e. not enough algae removed) to affect fish. During the surveys, fish were observed entering and leaving the quadrat, which suggests high mobility. A tagging study performed by Verweij (2007) found that L. apodus moves approximately 5m within a day and 34m between days. A simpler, alternative method would be placing a dark tarp (10m x 2m) on the substrate and securing with long (1meter) spikes. Although more natural, removal of algae was difficult and increasing quadrat size would be not time-efficient.

More importantly,tethering experiments show that survival of decapod prey is higher when algae is present, suggesting algae reduces foraging efficiency. During the experiment, both *Sphoeroides testudineus* (checkered pufferfish) and *Lutjanus griseus* (grey snapper) were observed preying on *Pilumnoides* crabs tethered on silt. In addition, tethered crabs immediate reaction was to burrow in algae, which indicates that algae provides an ideal refugia from carnivorous fish.

7. Overall Conclusions

The reefs around the Cayos Cochinos are protected from a variety of fishing pressures through the CCMPA, monitoring of the status of the fish populations with the area is therefore essential to gauge how successful the CCMPA is being in developing the fish populations within the park. The reefs around Utila are the basis for the islands economy, either from the diving or fishing industry. For this reason the understanding and protection of the reefs has to be given paramount importance. In 2009 the first large scale monitoring of many reefs and mangrove systems were conducted, assessing the fish, coral, algae and invertebrate populations around the island. This was a very important step towards a continuous monitoring program. Although it is hoped that the number and variety of reefs and habitats surveyed will increase in following years the basis of 10 reefs for full surveys, assessment of diver impact on reefs and 23 different mangrove sites surveyed is a very strong output of research and monitoring for an eight week research program. The full results and analysis of this work are not covered in this report as it will require extensive analysis to extract the full story of the ecology marine ecosystem in Utila in 2009, however the initial findings presented within this report give an overview of the findings.

Generally the findings of the seasons research indicate that Utila has an extensive and diverse marine ecosystem incorporating a variety of reef systems and mangrove lagoons. The health of these systems is varied. Some of the results are encouraging, such as the relatively low abundance of algae on the reefs and the small impact of divers on the reefs while these are in contrast to the relatively low populations of fish and hard coral coverage. Similar results can be drawn from the mangroves where healthy systems are found in some parts of the island while others are clearly suffering from the impact of human development and disturbance.

Overall the work conducted in 2009 has to be considered a significant success and most importantly the basis of a real long term program. In particular there have been many improvements in data management and retention with the creation of the Utila Database into which all data gathered from the season has been entered and will be freely available in future years to allow easy and direct comparisons of a huge number of variables within the monitoring program.

Appendix 1 – Reef fish species and families surveyed by the Fish and Invertebrate Ecology Group

Family	Common name	Latin name
Grouper	Tiger Grouper	*Mycteroperca tigris*
	Nassau Grouper	*Epinephelus striatus*
	Graysby Grouper	*Cephalopholis cruentatus*
	Coney	*Cephalopholis fulva*
	Red Hind	*Epinephelus guttatus*
	Black Grouper	*Mycteroperca bonaci*
	Goliath Grouper	*Epinephelus itajara*
Snapper	Red Snapper	*Lutjanus campechanus*
	Yellowtail Snapper	*Ocyurus chrysurus*
	School master	*Lutjanus apodus*
	Mutton Snapper	*Lutjanus analis*
	Dog Snapper	*Lutjanus jocu*
	Mahogany Snapper	*Lutjanus mahogoni*
	Lane Snapper	*Lutjanus synagris*
	Cubera Snapper	*Lutjanus cyanopterus*
Grunt	White Grunt	*Haemulon plumieri*
	French Grunt	*Haemulon flavolineatum*
	Blue Stripped Grunt	*Haemulon sciurus*
	Spanish Grunt	*Haemulon macrostomum*
	Caesar Grunt	*Haemulon carbonarium*
	Black Margate	*Anistremus surinamensis*
	Porkfish	*Anistremus virginicus*
Parrotfish	Stoplight Parrotfish	*Sparisoma viride*
	Queen Parrotfish	*Scarus vetula*
	Midnight Parrotfish	*Scarus coelestinus*
	Blue Parrotfish	*Scarus coeruleus*
	Rainbow Parrotfish	*Scarus guacamaia*
	Princess Parrotfish	*Scarus taeniopterus*
	Striped Parrotfish	*Scarus iserti*
	Redband Parrotfish	*Sparisoma aurofrenatum*
	Redtail Parrotfish	*Sparisoma chrysopterum*
	Small Parrotfish	*NA*
Angelfish	Queen Angelfish	*Holacanthus ciliaris*
	French Angelfish	*Pomacanthus paru*
	Grey Angelfish	*Pomacanthus arcuatus*
	Rock Beauty	*Holacanthus tricolor*
Damselfish	Dusky Damsel	*Stegastes adustus*
	Sergeant Major	*Abudefduf saxatilis*
	Beaugregory Damsel	*Stegastes leucostictus*
	Bicolour Damsel	*Stegastes partitus*

	Yellowtail Damsel	*Microspathodon chrysurus*
	Longfin Damsel	*Stegastes diencaeus*
Butterfly fish	Foureye butterflyfish	*Chaetodon capistratus*
	Banded butterflyfish	*Chaetodon striatus*
	Spotfin butterflyfish	*Chaetodon ocellatus*
Surgeonfish	Blue Tang	*Acanthurus coeruleus*
	Ocean Surgeonfish	*Acanthurus bahianus*
Jack	Bar Jack	*Caranx lugubris*
	Horse-eye Jack	*Caranx latus*
Others	Barracuda	*Sphyraena barracuda*
	Hawksbill Turtle	*Eretmochelys imbricata*
	Morey Eel	*Gymnothorax funebris*
	Stingray	*Dasyatis americana*
	Eagle Ray	*Aetobatus narinari*

Appendix 2 – Classicisation of benthic coverage and substrate types for reef surveys

Benthic Cover Type	Name	Code
Corals	Acropora cervicornis	CAC
	Acropora palmate	CAP
	Agaricia agaricites	CAA
	Agaricia lamarcki	CAL
	Agaricia tenufolia	CAT
	Colpophyllia natans	CCN
	Diploria labyrinthiformis	CDL
	Diploria strigosa	CDSt
	Eusmilia fagistiana	CEF
	Favia fragrum	CFF
	Madracis mirablis	CMM
	Meandrina meandrites	CMeM
	Millepora sp.	CFIRE
	Montastrea annularis	CMA
	Montastrea cavernosa	CMC
	Montastrea faveolata	CMFv
	Montastrea franksi	CMFr
	Mycetophyllia sp	Cmy
	Porites asteroides	CPA
	Porites porites	CPP
	Sidastrea sidereal	CSS
	Stephanocoenia intersepta	CSI
Algae	Amphiroa	AA
	Caulerpa	ACL
	Corraline crustose algae	ACR
	Cyanophyta (fuzzball)	AFC
	Dictyota	AD
	Halimeda	AH
	Lobophora	AL
	Padina	AP
	Sargassum	AS
	Udotea	AU
	Valonia	AV
Sponges	Ball Sponge	SB
	Barrel Sponge	Sba
	Fire Sponge	SF
	Rope Sponge	SR
	Vase Sponge	SV
Invertebrates	Anemones	IA
	Gorgonians	IG
	Hydroids	IH
	Polychaete	IP

	Zooanthids	IZ
Benthos	Rock	BR
	Recently killed coral	RK
	Rubble	Ru
	Silt	RSt
	Sand	Rsa

Appendix 3 – Species list of common Invertebrates surveyed during reef surveys

Family	Common Name
Sponge	Barrel Sponge
	Ball Sponge
	Encrusting Sponge
	Fire Sponge
	Rope Sponge
	Vase Sponge
Anemone	Giant Anemone
	Corkscrew Anemone
	Branching Anemone
Zooanthid	Zooanthid
Gorgonian	Encrusting Gorgonian
	Sea Whip
	Sea Plume
	Sea Fan
	Black Coral
Mollusc	Triton
	Conch
	Flamingo Tongue
	Nudibranch
	Bivalve
	Squid
	Cuttlefish
	Octopus
Crustacean	Pedison Shrimp
	Banded Shrimp
	Arrow Crab
	Spiney Lobster
Enchinoderm	Diadema Urchin
	Pencil Urchin
	Sea Cucumber