Cayos Cochinos Marine Science Report – 2009

Prepared by Operation Wallacea on Behalf of the Honduran Coral Reef Foundation

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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 Urchin Ecology Research Group, the Conch Ecology Research Group, the Mangrove Ecology Research Group, the Herpetofauna Research Group and the Social Development Group. Research conducted over the summer expedition of 2009 by these groups within the Cayos Cochinos was performed by all but one of these groups (Mangroves) and covered many elements of marine conservation. These included surveys of the reef fish and benthic cover, urchin and conch populations, endemic reptile species and of attitudes 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 MPA 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 dominance of algae over hard corals. Given the common occurrence of phase shifts from corals to algae within the Caribbean this has to be a major cause for concern.

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 the Cayos Cochinos 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 six 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. Results from this group are considerable and are covered separately in the Honduran North Coast Science Field Report 2009.

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. A description of the three operations follows with the collaborators, main research aims and development objectives of each listed (Section 1). Descriptions of the locations in which Operation Wallacea operates are then outlined (Section 2) before the research is detailed by research group (Sections 3-6) and summarised in a final conclusion (Section 7).

The following report is a summary of the research conducted by the Marine Research Program on the Cayos Cochinos in the summer of 2009.

1.1 Cayos Cochinos

The Cayos Cochinos Islands were established as a Honduran National Monument in 1993 and given protection through the establishment of the Cayos Cochinos Marine Protected Area (CCMPA) at the same time under the management of the newly established Honduran Coral

Reef Foundation (HCRF). Operation Wallacea started working with the HCRF within the CCMPA in 2003 at the Marine Research Station situated on Cayo Menor.

The main objectives of the research within the CCMPA are;

- Yearly monitoring of the status of the reefs within the Marine Protected Area, to determine the health of the reef system and the success of the CCMPA in protecting the reef systems.

- Conducting high quality marine and terrestrial research within the MPA, producing publications suitable for peer review and establish the Cayos Cochinos MPA and Marine Research Station as an internationally recognised centre for quality marine research.

- Assess the population levels, ecology and behaviour of the native Bay Island Boa Constrictor and Ctenosaurs on the two main islands.

1.2 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. The program has been built on in subsequent years since its conception. The collaboration has the following main objectives;

Ecological

- Establish 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".

- Establish 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.

1.3 Social Development Team

The social development team undertake a variety of projects based in communities on the mainland, predominantly Rio Esteban, Neuva Armenia and La Ceiba, the two communities of West End and Chachahuate within the Cayos Cochinos MPA and East Harbour on Utila. Although the specifics of the individual projects dictate if and for how long each student spends in each community.

The social science team involves interaction with several local organisations, these include HCRF on Cayos Cochinos, and Tony Ives, Director of the Groupo Apoyo y Desarollo (GAD - *Development Support Group*), a NGO based in La Ceiba that works to promote sustainable development and scholarships to the communities on the North Shore and within the CCMPA. The Research Group also recruits students from the University in La Cieba, the Centro Universitario Regional del Litoral Atlantico (CURLA) to act as translators.

The social science group has a varied remit, assessing various elements of community development within the places they visit. These can roughly be divided into four components

- Develop an ecotourist industry within Rio Esteban
- Assess the feasibility of sustainable development on Neuva Armenia
- Assist in the commercialisation of the MPA
- Assess the attitude within the communities to the development of the MPA and other related topics

1.4 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

Islands

2.1 Cayos Cochinos

The Cayos Cochinos Islands are located about 18km off the northern Honduran shore and comprises the very southern end of the Meso-American Barrier Reef System (MBRS), the second largest barrier reef in the world. The islands and surrounding seas were designated as a National Marine Monument by the Honduran Government in 1993 and remains the only such area in Honduras. The islands have been established as a protected area by the Honduran Government under the banner of the Cayos Cochinos Marine Protected Area (CCMPA) and managed by the Honduran Coral Reef Foundation (HCRF). This agreement established specific protection for the reefs and the wildlife on the islands. These included a limit on fishing in volume and species and established protection for the indigenous reptile species on the islands.

The protection of the Cayos Cochinos islands was formed in partnership with the publication of the management plan which main objectives included the protection of the reefs and terrestrial systems and ensuring that the income lost to the fishing villages through the loss of their fishing grounds was compensated through the establishment of alternative incomes.

The Marine Protected Area

The Cayos Cochinos Marine Protected Area (CCMPA) is based around an archipelago of small islands and shallow seas. There are two main islands within the area, Cayo Mayor and Cayo Menor. Cayo Mayor with a width of 1.8km and length of 1.7km is slightly larger than Cayo Menor that has a width of 1Km and length of 1.3km. In addition to these two main islands there are 14 small Cayes within the archipelago. The CCMPA contains a wide variety of marine habitats, with reefs to depths of 30m+, extensive seagrass systems and large areas of bare sediment. These habitats are distributed around the park, often nearer the islands and cayes, although several shallow reefs are found in the open sea. Despite this diversity of habitats and islands the reserve does not have a significant mangrove system, with only a few trees found on Cayo Mayor within the MPA.

Settlements and industry

Cayo Mayor has a resident population year round, with a small artisan fishing community in East End in addition to a small hotel called the Plantation Beach Resort and several private homes. Cayo Menor has no local communities or industry and has been preserved solely for research purposes. This research is based at a small research centre that contains a dive centre, laboratory facilities, several permanent accommodation buildings and catering facilities. The only long term residents on the island are a handful of Navy guards and occasional researchers. The other settlement within the CCMPA is another fishing community on Cayo Chachahuate.

East End on Cayo Mayor

The industry of the area was largely based on artisan fisheries based in the two communities of East End and Chachahuate, these have both been heavily impacted by the restricted fishing rights dictated by CCMPA management plan. However, part of this plan established ensures that alternative income sources were established for these communities, and those on the North Honduran Coast, to compensate for the loss of revenue from fishing activity. This has involved the promotion of ecotourism and the research station in the area. The Islands are now also used as the setting for the Survivor television series in both Italy and Spain, the income of which is considerable.

Areas of research interest

The Cayos Cochinos Islands offers a wide variety of marine and terrestrial habitats for surveys and experimentation, this allows a variety of unique research opportunities within the area. Of particular interest is studying the success of the CCMPA, and the various fishing restrictions that apply to different species and areas of the park. This includes both fish and commercially and ecologically important invertebrate species.

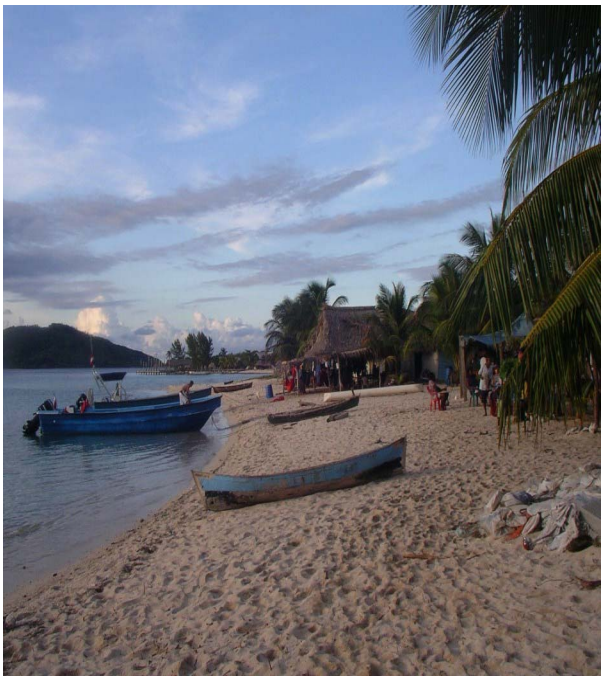
The long term arrangement between Operation Wallacea and the HCRF gives a rare opportunity to collect long term data sets over many years that may reflect the status of the CCMPA or possibly larger scale patterns such as global warming and an impact assessment should the islands be hit by a hurricane.

2.2 East End

East End is the sister community of Rio Esteban, situated on the north side of Cayo Menor. The community has an approximate population of 22 residents living in 19 houses along a single 200metre stretch of beach, peaking to a maximum population of 90 during the fishing season (April-September). The community has one primary school with two classrooms that serve all of the MPA. The area also has a Honduran Navy station where the four Navy personnel employed to patrol the MPA reside. East End has some tourism development, receiving US AID funding in 2007 to build cabanas and a restaurant. These were ready for use in summer 2008 and were used by both the Operation Wallacea social science and Herpetofauna Research Groups. The immediate marine environment consists of inner reef flats of approximately 3 metres in depth and a gently sloping wall of about 22 metres.

2.3 Chachahuate

Chachahuate is the sister community of Nueva Armenia, occupying the largest of the cayes within the CCMPA (15° 56’ 40N, 86° 28’ 43 W). There are approximately 43 households with a maximum population of 200 during the peak fishing season, and an average resident population of 90 people. The island has reduced in size following Hurricane Mitch in 1998, to about 50 metres in length because it is exposed to the prevailing north easterly trade winds. There is some tourism development with US AID and WWF sponsorship of a restaurant and cabanas, and the island is advertised in the national tourism guide ‘Honduras Tips’. Commercial sail boats, located in Roatan and Utila advertising day long trips to the Cayos Cochinos islands, use Chachahuate as the island stop off. The reef flat is approximately 1metre deep, sloping gently to a 20 metre wall and sandy bottom.



Seaside Beach and tourist restaurant on Chachahuate

Part of the recent development of the island was the construction of two environmentally friendly toilets in 2007 to replace the long drop toilets that had been used in the past and were resulting in localised organic pollution. These were not being used as successfully as desired in 2007 however their use has now become common.

Mainland

2.4 La Ceiba

The largest city on the north Honduran coast and the third largest city in the country, La Ceiba has a population of roughly 170 000 people.

La Ceiba is a frequent destination for tourists as it is the main point of access to the Bay Islands either by air or sea as well as being local to a variety of ecotourism centres in the local area, including several based in the Pico Benito National Park. It is also the transport centre for many villages on the northern Honduran coast with road access and many regular bus services.

The city is the location of the HCRF, which has quick access to the CCMPA via the port, and the location of government agencies departmental offices that have institutional and legal responsibility for the marine environment. One such important government department, DIGEPESCA, has the duties of monitoring all fishing activity within the Department de Atlantida region; issuing commercial and artisanal fishing licences; and recording the supply of goods and their prices. La Ceiba was badly affected by Hurricane Mitch in 1998, and has frequent flooding problems during the wet season.

2.5 Rio Esteban

Rio Esteban is a small Garifuna settlement furthest from the main city of La Ceiba on the north coast of the sites studied, approximately 12 nautical miles from the CCMPA. The community has an estimated 630 inhabitants divided into several neighbourhoods (barrios), with one school up to secondary level. The coastal region is an area of estuarine discharge from the River Aguan, mangrove forests and mud flats creating an environment of relatively high deposition with a natural spit. The community has relatively little tourism with four small hotels, five restaurants (including a newly developed beachfront restaurant), and cabanas on the beachfront that are now abandoned as a result of Hurricane Mitch in 1998. It is the least accessible of all the study sites, requiring an off-road vehicle to navigate through a riverbed during the dry season. During the wet season this river bed is prone to flooding and prevents any access to or from the community. The community does have a regular daily bus service to Jutiapa and Trujillo; however, these buses cannot pass through the river when in flood. Very recently in 2007, the Municipality of Colon agreed to erect a bridge over the River Esteban, due for construction in 2008. Heavy flooding has subsequently destroyed this bridge and the community remains isolated during periods of high rainfall.

In 2008 Operation Wallacea started using Rio Esteban as the entrance point to the CCMPA. This involved volunteers being accommodated in local houses for one night. A cultural event, food and transportation to the CCMPA on fishing boats were also arranged through the village.

2.6 Neuva Armenia

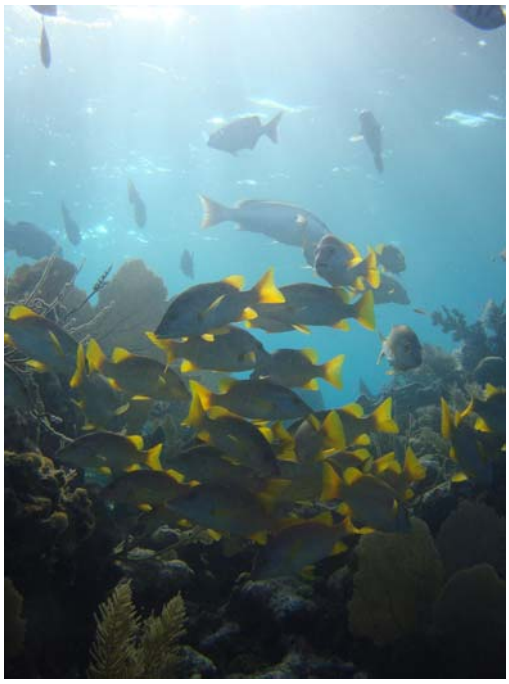
Nueva Armenia is a relatively large Garifuna settlement on the north coast mainland, approximately 40km from La Ceiba. The community has an estimated 3000 inhabitants dispersed into distinct neighbourhoods, with two schools up to secondary level, a medical centre, several churches and a fish freezing plant, although this has been un-operational since 2005. There is a relatively low level of tourism with two hotels and three restaurants, and organised boat trips out to the Cayos Cochinos. It is accessible with regular daily bus services to Jutiapa and La Ceiba, and a purpose laid gravel road. The community is now split by the River Aguan which changed its course because of the severe flooding caused by Hurricane Mitch in 1998. As a result of the hurricane, new municipal housing has been built to re-house displaced members of the community. The immediate coastal zone has a tidal sand bar, mud flats and fluvial run-off. The coastal area is used as the entering point by some tourists to the CCMPA and until last year was used by Operation Wallacea.

3. Fish and Invertebrate Ecology Research Group

Personnel

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

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 Cayos. 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 Cayos to assess their importance towards overall reef fish populations.

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

Survey methods

Surveys of fish populations were done using underwater visual census (UVC) on 11 reefs each Within the Cayos Cochinos (n=8). 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.

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).

Analysis
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 Cayos increased from 2008 dramatically, however the methodology used in 2009 better represented the overall fish population so direct comparisons are not possible (Table 3.1). Diversity has also increased from 2008, although not by a large amount which is to be expected.

Table 3.1 Number of species, individuals and diversity of reef fish populations on the reefs of the Cayos Cochinos. Standard errors (se) are given.

	2008	**2009**
Number of species	4.29	11.33
se	0.68	0.62
Number of individuals	10.50	75.50
se	2.26	4.93
Shannon Diversity	1.20	1.77
se	0.17	0.08

Reef population structure on individual reefs
The number of species and individual fish on the reefs around the Cayos was relatively consistent across all reefs with the exception of Pelican 2 + 2.5 which had very low numbers of fish (Fig. 3.1). While there is some differences in numbers (e.g. 60 individuals per transect in Timon compared to 100 at Alex's Point ad Bolanos) this is within an order of magnitude and implies a level of consistency across the whole of the Cayos Cochinos. Diversity follows a similar pattern on all the reefs, again with a very low measurement on Pelican 2 + 2.5 (Fig. 3.2).

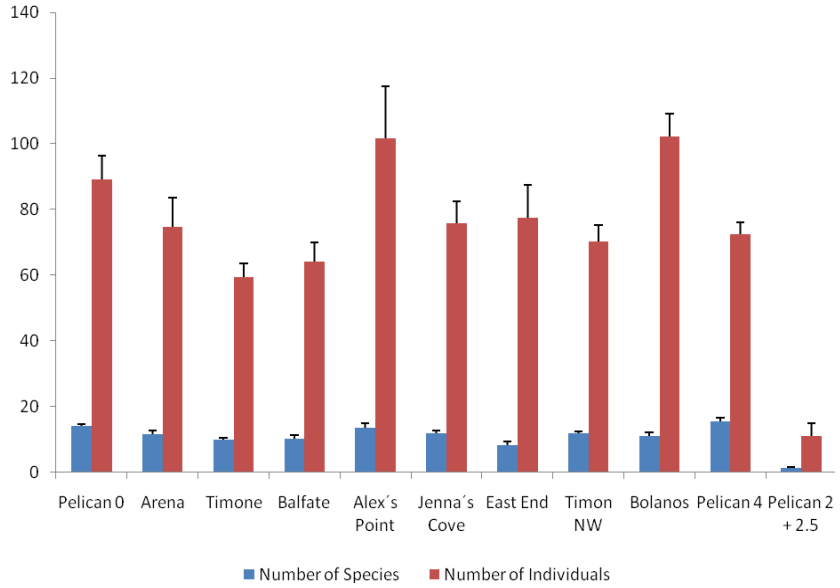


Figure 3.1 Number of species and individual fish on each reef surveyed in 2009

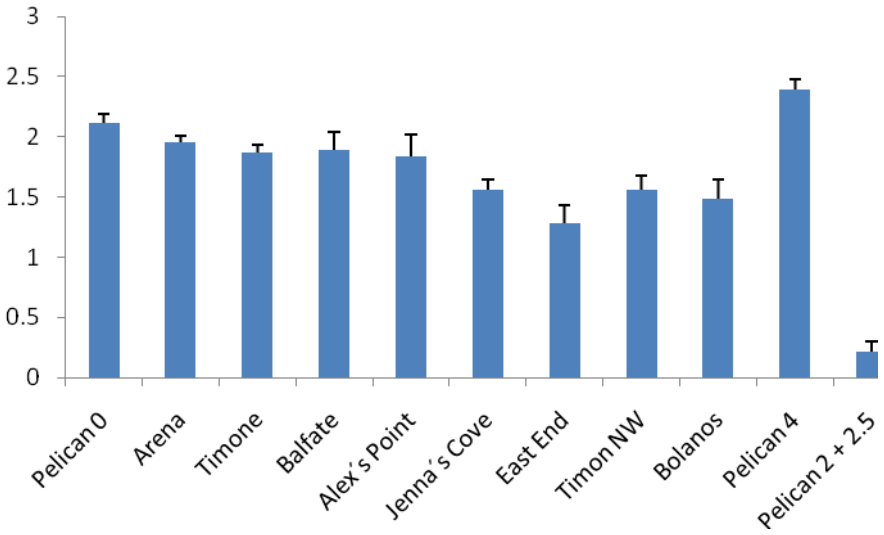


Figure 3.2 Fish community diversity as measured by the Shannon Diversity index

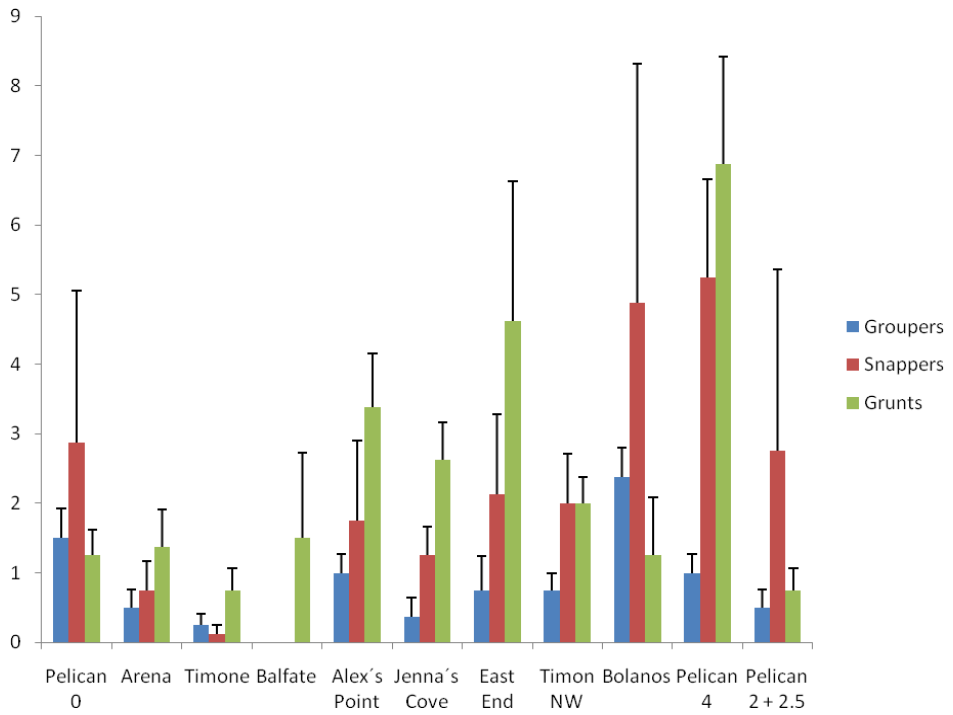


Figure 3.3 Populations of commercially important species of fish on individual reefs within the Cayos Cochinos

Populations of commercially important species of fish, including groupers, snappers and grunts are low at all reefs (Fig. 3.3). There are a few reefs that have larger populations or grunts and snappers, however these are associated with high standard error values so it is assumed that these results are due to the presence of a shoal of the species on one of the transects. These shoals give concentrated populations of fish so maybe do not represent the whole reef well, however their presence is still encoraging. Of all species Groupers are the least common, while they are generally the largest of the three families which indicats that the larger fish have not recovered from previous fishing pressure.

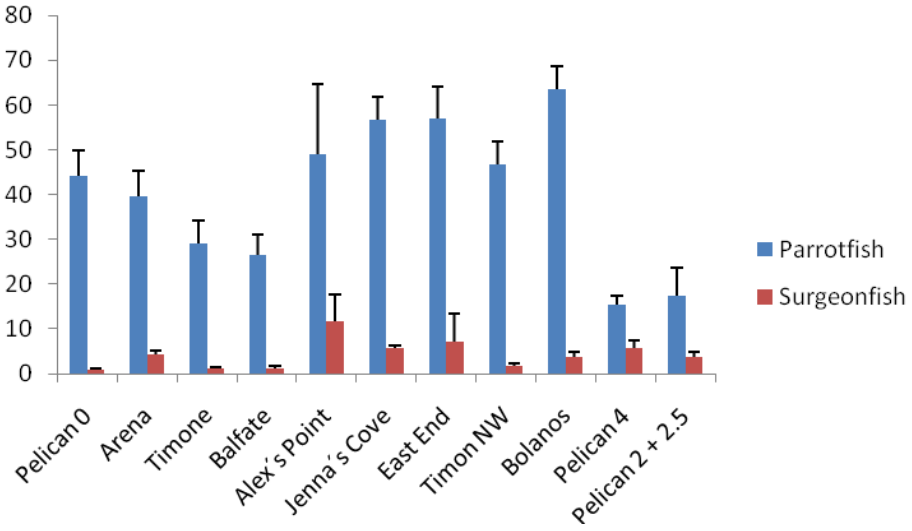


Figure 3.4 Populations of herbivorous fish families on individual reefs within the Cayos Cochinos.

Populations of parrotfish are very high which is a very encraging result, however many of these were small or juveniles while the most beneficial herbivours for the reefs are large parrotfish (Fig. 3.4). Surgeonfish populations were very low, although these fish are not as important for herbivory on the reef compared to Parrofish their low numbers is unexpected given the large number of parrotfish.

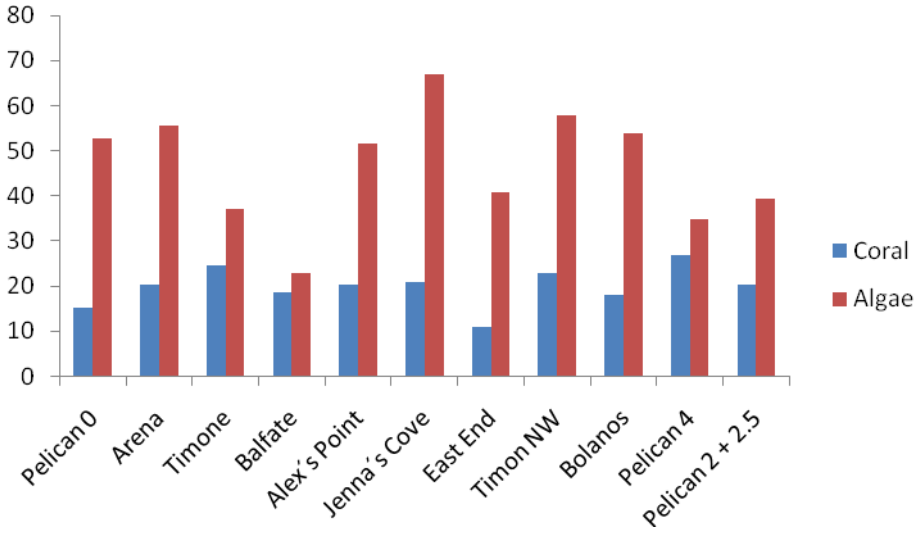


Figure 3.5 % coral and algal cover at each reef – not including coraline algae.

The comparison of algae and hard coral coverage on all the reefs within the Cayos Cochinos is not encoraging. Hard coral coverage is very low while in contrast algal coverage is very high (Fig. 3.5). Only at Balfate is algae coverage below 30% however this is not matched by an increase in hard corals which are still low. Many reefs have algae coverage 2 to 3 times higher than hard coral coverage. This pattern is suprisingly consistent across all reefs, however the pattern of sea fan and plume distribution is not so consistent with large variations within the MPA. Densities of the invertebrates are high on many reefs although the numbers are not unexpected for reefs in the Caribbean (Fig. 3.6). Low densities on Jenna's Cove and East End are very low but do not correlate with increased algae or hard coral coverage.

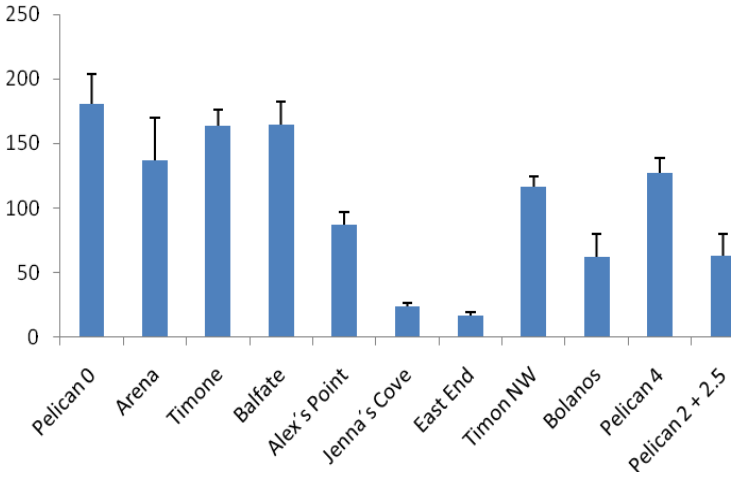


Fig 3.6 Combined counts of sea fans and sea plumes on individual reefs on the Cayos Cochinos.

3.5 Conclusions

The survey of 11 reefs within the Cayos Cochinos 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 11 reefs and repeat the surveys allowing continuously yearly monitoring. This will be the minimum requirement as it is hoped that more reefs can be added to the program, especially reefs off the mainland near Rio Esteban that will give a very interesting reference point for comparisons of reef health. As yet there have been no such surveys of these reefs and the potential outcomes are totally unknown.

The results of the reef surveys present a picture of the health of the reefs within the MPA from which a mixture of conclusions can be drawn. The fish populations are encouragingly high, especially some of the commercially important species such as snappers and grunts which is an indication that the lack of fishing may be working. Grouper populations are not as high, however this may be a result of the longer life cycle of these fish. Herbivorous fish populations are mixed, there are many parrotfish but very few surgeon fish. Given the very high algae coverage the populations of parrotfish are expected, however the low numbers of surgeons is less so. This result is mostly a result of small parrotfish populations and there was a low abundance of the larger parrotfish that are most important as herbivores. Indeed in the 88 surveys there was not one sighting of a Midnight, Rainbow or Blue parrotfish – the three largest species that would be expected to be seen. The high algae coverage is the main cause for concern from the survey. Given the underlying threat for a phase shift from hard coral to algae coverage on all Caribbean reefs this needs to be monitored closely.

It is hoped that the monitoring in future years will show an increase in larger fish, particularly parrotfish and this may then lead to a reduction in algae coverage. Given the remoteness of the Cayos Cochinos and the lack of large scale anthropogenic impacts its unlikely that the dominance in algae is caused by pollution but rather a result of the historically low fish populations and probably the diadema population crash in the 1980's.

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. Sea Urchin Ecology Research Group

Personnel

Senior Scientist -	Dr. James Saunders - Operation Wallacea
Project supervisor -	Patrick Connelly – Operation Wallacea
Dissertation projects -	David Sterling – Nottingham University
	Lucy Webb-Wilson – University of Oxford

4.1 Introduction to the group

The Sea Urchin Research Group is based on the Cayos Cochinos, conducting monitoring of population numbers and research into the ecology of the urchin species in the area. Urchins could be considered one of the most important groups of species on the reefs and as such the group is involved in a wide variety of projects.

4.2 Project introduction and rational

Sea urchins hold a very highly important role within the ecology of coral reefs, acting as one of the main grazers of algae and ensuring that a low algal density is maintained on the reefs and corals dominate. Without such grazing the potential is for algae species to grow unregulated and smother and eventually kill corals, leading to a phase shift from coral dominated to algal dominated reefs.

There are four dominant species of urchins on Caribbean reefs, the long spined, reef, rock boring and pencil. Of these the long spined urchin (*Diademia antillarum*) was the largest and most significant grazer. However, in 1983 an as yet unidentified disease decimated the populations of the long spined urchin throughout the Caribbean. Mortality rates were between 95-99%, with 99.9% recorded in some locations. Urchins live for 100+ years so regrowth of the populations has been slow and indeed absent in some areas. The consequences of this mass mortality (the largest ever recorded in the marine environment) are varied. The majority of reefs have maintained coral dominance, due in part to increased grazing by other urchins and herbivorous fish species compensating for the loss in the long spined urchin. However, many reefs have undergone a phase shift and are now dominated by algae with severe ecological and economic consequences. The main example of this being the Jamaican coral reefs that are now nearly all algal dominated and as a result both the dive tourist and fishing industries have been heavily impacted.

The reefs around the Cayos Cochinos have so far maintained coral dominance, but long spined urchin populations remain low and therefore the reefs remain highly vulnerable to a future phase shift to algal dominance. This program aims to assess if and how urchin populations are changing, determine the rate of increase of the long spined urchin population and potentially offer a warning sign if populations of any urchin species start to drop.

In addition to these surveys the ecology of the urchin species needs to be studied so we can better understand the role of urchins in reef ecosystem dynamics and use this information in management practices that will ensure against a future phase shift.

4.3 Methods

4.3.1 Urchin Surveys

18 reefs were surveyed around the CCMPA (Fig 4.1). This involves counting all urchins within a 15m x 2m transect ($30m^2$) (n=6). Reefs were surveyed by snorkelling at depths between 1-2m. One way ANOVA was used to compare the densities of urchins between and within reefs.

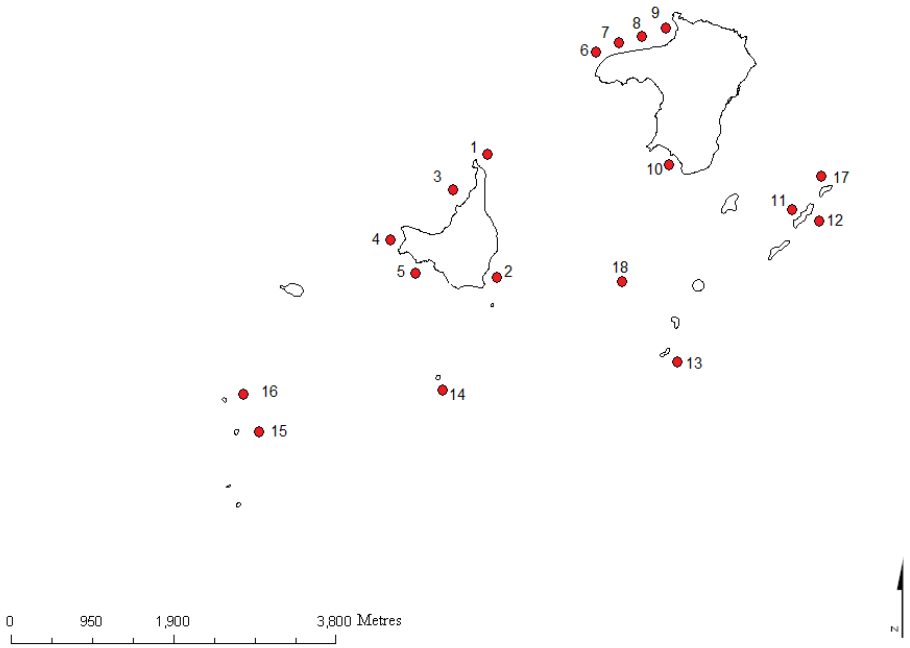


Figure 4.1 Map of the Cayos Cochinos Archipelago with reefs surveyed for urchin populations highlighted

The reefs were assessed using the Habitat Assessment Score devised by Gatwick and Speight (1995) (Table 4.1). With the assessment of the reefs variations in the populations of the urchins can be related to the structure of each reef.

4.4 Results

Urchin populations around the 18 reefs surveyed around the Cayos Cochinos varied considerably in both number and dominant species (Fig 4.2). Dominance of one species of urchin was found on many of the reefs although the species varied. On several reefs the rock boring urchin was highly dominant (reefs 1, 7, 8, 16 and 17). However, on reefs 2, 3, 5, 10, and 18 the reef urchin was most abundant. On no reef were *Diadema* urchins dominant, however there were several reefs where their population were high, including 5, 11, 14 and 18.

When compared with the habitat scores from the HAS assessment the most interesting result was that of total urchin number correlated with hard coral coverage. However this is total urchin numbers and when *Diadema* populations were compared there was no such correlation.

Table 4.1 Scoring criterion for the Habitat Assessment Score (HAS), based on Gratwicke and Speight (1995)

	HAS SCORE				
	1	2	3	4	5
Rugosity (visual topographic estimate of the substratum in each quadrat)					
Variety of growth forms (stalked/lobed/filamentous/ ribbon-like/massive/branching/ cylindrical/tube/fan/plate/ pinnate/encrusting/other)	<2	3 & 4	5 & 6	7 & 8	9–10
Height (visual estimate of average height of habitat architecture) (cm)	0–9	10–19	20–39	40–79	>80
Refuge size categories (holes or gaps in habitat architecture or substratum in the following size categories: 1–5, 6–15, 16–30, 31–50 and >50cm)	0–1	2	3	4	5
Live cover (total per cent cover of *e.g.* living corals, mangrove roots, seagrass, macroalgae and sponges)	0–19	20–39	40–59	60–79	80–100
Hard substratum (%)	0–19	20–39	40–59	60–79	80–100

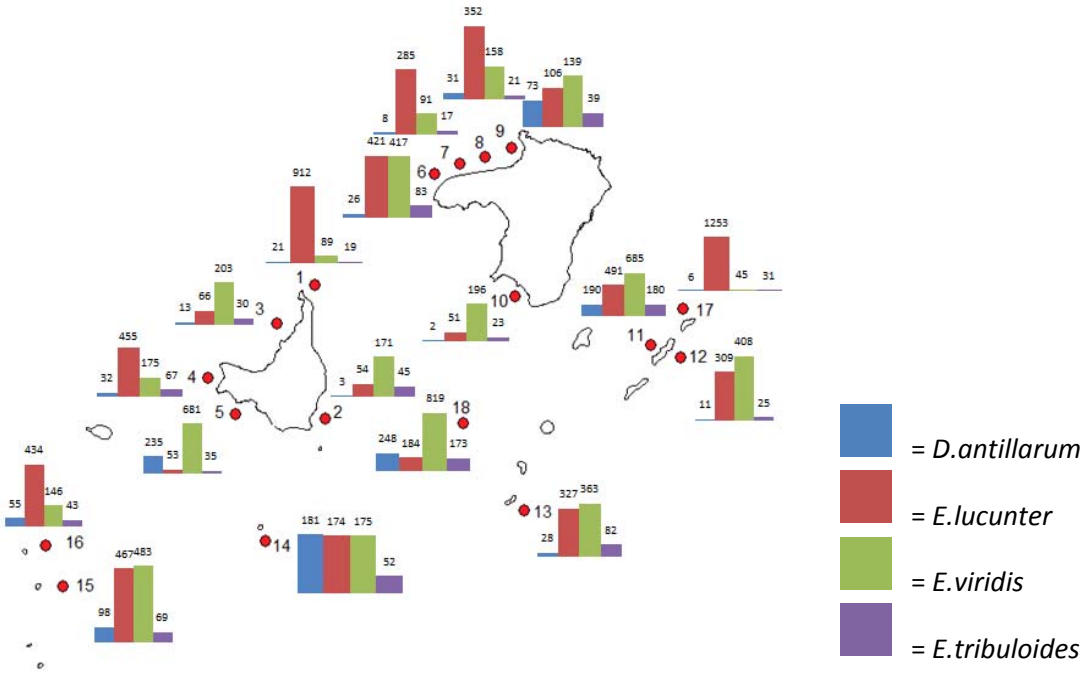


Fig 4.2 Densities of the four main species of urchins within the Cayos Cochinos MPA

4.5 Conclusion

The survey of the urchin population of 18 reefs in 2009 was by far the most comprehensive survey of the urchins within the MPA performed to date and gave the platform for a continued long term monitoring program. Indeed given the limited depth of the protocol (it has to be snorkelling) the number of reefs surveyed in unlikely to increase in the future. Results from the surveys are mixed, as would be expected for such a large survey. Certainly there are several reefs where the populations of *Diadema* are encouragingly high, likewise the density of all urchin species within the MPA is very high.

Of most interest is the correlation between urchins and total hard coral coverage, it is impossible to draw conclusions from this data but it is possible that this is a cause and effect relationship where the urchins promote the settlement of coral recruits and subsequently maintain higher coral coverage. Given the very high coverage of algae and low numbers of hard corals within the MPA (See Section 3) it is hopeful that increased urchin populations on some reefs will reverse this pattern and had coral populations may increase again. This is only true of total urchin populations though, the abundance of *Diadema* is not related to hard coral coverage and this is unexpected as they have historically been the dominant grazer on the reefs. If their populations are increasing on some reefs, as the results would imply then they may not have reached a sufficient density as yet to impact upon algae levels.

4.6 Publications

Bologna, P., Webb-Wilson, L., Connelly, P., Saunders, J.E., (In prep) Assessment of Diadema antillarum from Cayos Cochinos, Honduras.

Hall, C. M., Shrives, J.P., Speight, M.R and Saunders, J. (2008) Sea urchin ecology on the shallow reefs of Cayos Cochinos, Honduras, with particular focus on Diadema antillarum recovery. Poster Presentation RCUK 2008.

Shrives, J.P. and Speight, M.R. (in prep) Assessment of the 2007 post-Hurricane Dean stranding of sea urchins upon the beaches of Los Cayos Cochinos, Honduras. For submission to Coral Reefs

5. Conch Ecology and Research Group

Personnel

Senior Scientist -	Dr. James Saunders - Operation Wallacea
Project supervisor -	Patrick Connelly – Operation Wallacea
Dissertation projects -	Chris Knox – Swansea University

5.1 Introduction to the group

The Conch Ecology and Research Group is based solely on the Cayos Cochinos and is studying the ecology and populations of the highly important mollusc *Strombus gigas*. Research is aimed at firstly determining an accurate population estimate for conch within the MPA and developing a monitoring program that allows this to be tracked each year. Secondly the group studies elements of the ecology and life cycles of the conch, with the intention of better understanding the species and therefore instigating effective conservation.

5.2 Project introduction and rational

The Queen Conch (*Strombus gigas*) is a very large mollusc found throughout the Caribbean. It holds a highly important position with both the ecology and economy of the area. Ecologically the Conch is a deposit feeder, grazing off algae, detritus and epiphytic algae, this is coupled with a large level of sediment disruption and turnover during feeding and movement. This feeding and continued cycling of the sediment prevents it becoming stagnant and a potential source of disease and pollutants on the reef. Conch are also a major food source for some large species of fish on the reefs including sharks and eagle rays. Between these roles they hold a vital position in the functioning of a healthy and diverse reef system. Unfortunately the Conch is also highly commercially important as a food source for the local communities or more often a catch that is sold by local fishermen nationally and internationally. This means that Conch populations have become very low on many reefs and despite many areas where they are protected or populations managed their general abundance remains low.

The reefs around the Cayos Cochinos archipelago are no exception to this, with historically large fishing pressure on the Conch resulting in low numbers on the reefs. However, with the establishment of the Cayos Cochinos Marine Protected Area (CCMPA) the fishing of Conch was made illegal in the area. It is one of the few species to receive complete projection in this manner, with most other fish and invertebrate species only receiving partial spatial or temporal protection. This then provides a unique opportunity to assess the regrowth of a Conch population after the removal of fishing pressures in the area, potentially a prime indicator of the success of the CCMPA.

The project aims to tag the conch this year so that the sites can be returned to in future years and measurements of population structure, movement and growth rate can be made.

5.3 Methods

The Cayos Cochinos MPA contains many different reef, seagrass and sediment areas, all of which will be surveyed for Conch populations through both scuba and snorkelling. Each Conch found may be measured and tagged for future reference. Sites will be surveyed by three 50m transects at each with conch counted at each.

5.4 Results

Conch Density and Distribution

19 sites were surveyed for Conch, of these 10 had no conch present while 8 had some Conch (Fig.5.1). Highest densities were found at Jenna's Cove 1.5 and Arena with numbers of 9 and 8.5 conch per transect respectively, likewise, three sites only had a single conch present, these were Balomos, Pelican 2.5 and Menor West.

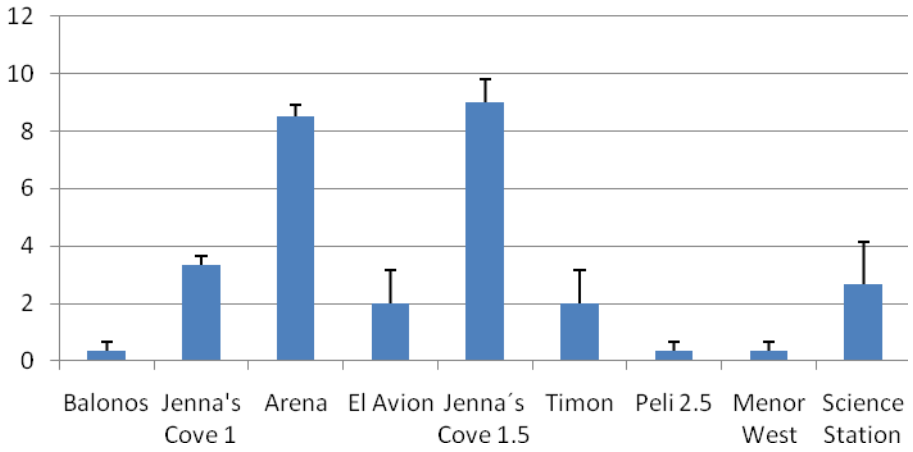


Figure 5.1 Distribution of Conch on the 8 reefs were individuals were found. Numbers are per transect.

The reefs surveyed where no conch were found were Hotel Bay, Paloma and Paloma East, Arriba East, Chachahuate, Science Station, Pelican 3, Largos Arriba West, Balfate West and Jenna's Caves.

Tagging

In total 87 conch were tagged and measured in 2008, of these 29 were in Arena, 8 in El Avion, 27 in Jenna's Cove and 11 in Timon, additionally 7 in Hotel Bay and 4 in Jenna's Caves, all of which were found outside the transects. Measurements of length, width and shell lip thickness were taken from all of these. This data will be used in future years to assess growth rate patterns if the conch can be relocated.

5.5 Conclusion

This project was the first year that a large scale monitoring and tagging program was run, although a previous study did tag some conch in 2007 the tags were temporary and did not last through the 2 year gap – this has been addressed with more durable tags.

It is clear that the conch populations is very varied within the MPA and although some sites have large populations others contain few if any conch. As yet this can not be related to potential causes, its very possible that some sites will never support Conch populations as they do not have the required characteristics, however the data from 2009 will be built on to show which these sites may be while conch populations in all sites will continue to be monitored as it is possible that conch populations will grow there and would be a very important measurement of the success of the MPA.

6. Herpetofauna Research Group

Personnel

Research Scientists -	Dr. Robert Reed - USGS Invasive Species Program
	Dr. Chad Montgomery - Truman State University
	Dr. Scott Boback - Dickinson College
	Stephen Green - University of Kent
	Julius Frazier - California Polytechnic State University
	Michael Logan – Dartmouth College
Dissertation students -	Claire Hawksworth – University of Lincoln
	Aaron Whitman – University of Maine at Machias

6.1 Group Introduction

In partnership with Operation Wallacea, the herpetofauna research group studies *Boa constrictor* and *Ctenosaura melanosterna* populations in the Cayos Cochinos (Cayo Menor and Cayo Mayor). The primary focuses of the *Boa* and *Ctenosaur* projects are to census abundance (and thus establish population viability) and to investigate the poorly know ecology of these species. The Cayos Cochinos boa displays insular dwarfism and divergent coloration from Central American boas on the mainland (*B. c. imperator*) and is thus considered to be a unique race of this species. *Ctenosaura melanosterna* is found only in the Cayos Cochinos and in the Rio Aguan Valley on mainland Honduras, and is currently listed as a critically endangered species on the IUCN red list.

Cayos Cochinos Boa (*Boa constrictor imperator*), Photo by Stephen Green

6.2 *Bay Island Boas*

6.2.1 Project Introduction and Rational

During the 1980's the Cayos Cochinos boa, or 'Hog Island Boa' as it is known in the pet trade, was subject to a period of intensive collection from the wild. This collection, driven by demand for these boas due to their small size and light 'pink' colouration, led to reports of the

Cayos Cochinos Boa being extirpated from these islands. Fortunately, a reduced population of animals persisted on both of the two largest islands in the Cayos Cochinos, and due to increased levels of protection these populations are showing promising signs of recovery. The main focus of the work to date has been to;

(i) Initiate a long term mark-recapture study that will provide estimates of survival, detectability, and population size (N_c).

(ii) Implant boas with temperature-sensitive radiotransmitters to collect data on home range size, frequency of movement, habitat preference, and thermal ecology.

(iii) Conduct genetic analysis of the Cayos Cochinos population using mitochondrial DNA to construct the first phylogeny for all boa populations in the Caribbean island system.

(iv) Determine the level of gene flow between islands and extent of the potential genetic bottleneck caused by over exploitation for the pet trade.

Other research projects being conducted include (1) thermal monitoring of habitat refugia using operative temperature models (OTM), (2) investigation of Field Metabolic Rate and Water Stress using stable isotopes, (3) comparative head morphology and body condition of boas between islands, (4) the relationship between ectoparasite load, hormone levels, and ecology, and (5) the relationship of boa posture and distribution to elements of the abiotic environment. Future research will include investigations into boa reproductive biology, growth rates, and life history traits. These data will be essential for informing current and future management strategies.

Evidence suggests that the Rio Aguan *Ctenosaura melanosterna* population is in decline, and the Cayos Cochinos population thus represents an important refuge for this species. Its protection is a conservation priority for the area. However, small insular populations are vulnerable to extinction as a consequence of stochastic events. Therefore, it is crucial that the factors influencing insular *C. melanosterna* populations are understood in order to implement appropriate management strategies.

6.2.2 Methodology

Population Surveys

Visual Encounter Surveys (VES) are performed by volunteers. Date, time, weather, location, the number of people searching, and the length of time searched is recorded for each survey. When a boa is encountered it is captured by hand and either processed in the field and released immediately or taken back to the lab for processing and released at the point of capture within 48 hours. At each capture location a number of habitat characteristics are recorded and UTM coordinates obtained using a hand-held GPS (Global Positioning System). External body temperature and ambient temperature are recorded with a heat-gun prior to capture and internal cloacal temperature is recorded immediately after capture. For each boa, the general morphological characters of

mass, snout-to-vent length (SVL), and tail length are recorded. Boas are sexed and marked with a PIT (Passive Integrated Transponder) tag. Additionally, ventral scales used as tissue samples for genetic analysis are taken from each individual. Ventral scale clips also serve as a secondary form of identification.

Radio-telemetry
In 2004 four boas were implanted with intraperitoneal, temperature sensitive radio-transmitters under general anaesthetic. These transmitters had a one-year battery life and were removed at the end of the field season. In 2005 this was repeated with another four boas. In 2006 eight large females were surgically implanted with transmitters with a three-year battery life and in 2008 another five boas were implanted with one-year transmitters. Snakes are tracked by volunteers on average once every two days. On each tracking occasion the precise location of the snake is determined to the best of the observer's ability whilst keeping disturbance to an absolute minimum. Providing the snake is visible to the observer, habitat characteristics are recorded (using the same methodology as when boas are encountered on a VES) and UTM coordinates are obtained with a GPS. Because the transmitters implanted in boas are temperature sensitive, we calculate internal body temperature by timing the pulse rate emitted by the transmitter and matching it with the manufacturer's calibration curve.

Mark-Recapture
Program MARK has been used to estimate the survival (φ) and detectability (p) of boas on Cayo Menor and these estimates used to calculate census population size (N_c) for the island. Survival and detectability of males and females have been estimated independently due to potential differences in these parameters between the sexes.

Genetics
Despite the popularity of *Boa constrictor* in the pet trade, little work has been done on the genetics of the species and as a consequence no microsatellite library existed for *Boa constrictor* at the start of this investigation. Microsatellite markers developed for the closely related Jamaican boa (*Epicrates subflavus*) were identified and assessed for their suitability for use in *Boa constrictor*. In addition to these attempts, the first microsatellite library is now being developed for the species in collaboration with Dr Warren Booth at North Carolina State University. A phylogeny is also being constructed across the island system using sequence data obtained from two mitochondrial DNA genes, ND4 and cytochrome-b.

6.2.3 Results
Population Surveys
A total of 566 boas have been captured and marked on Cayo Menor and 85 on Cayo Mayor. Of the boas caught on Cayo Menor, 260 were female and 306 male, and of those caught on Cayo Mayor, 36 were female and 49 male. A Chi squared goodness of fit test proved the number of boas captured did not significantly differ from a 1:1 sex ratio on either of the two islands ($P \leq 0.01$). The numbers of boas captured on Cayo Menor was variable between years (figure 6.1). This is mainly due to variability in numbers of volunteers available for visual encounter surveys. However, the percentage of recaptures has steadily increased each year (figure 6.2). Too few boas were caught in 2009 to reliably include in the results presented here.

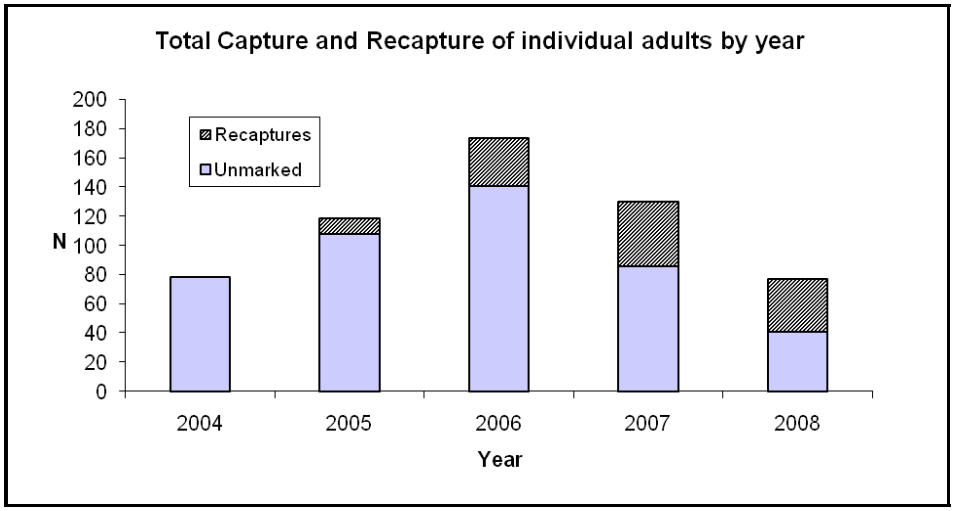


Figure 6.1. Number of boas caught in each year showing variability in the number of boas caught, but an overall increase in the percentage of recaptures in each sampling period (grey portion of bars).

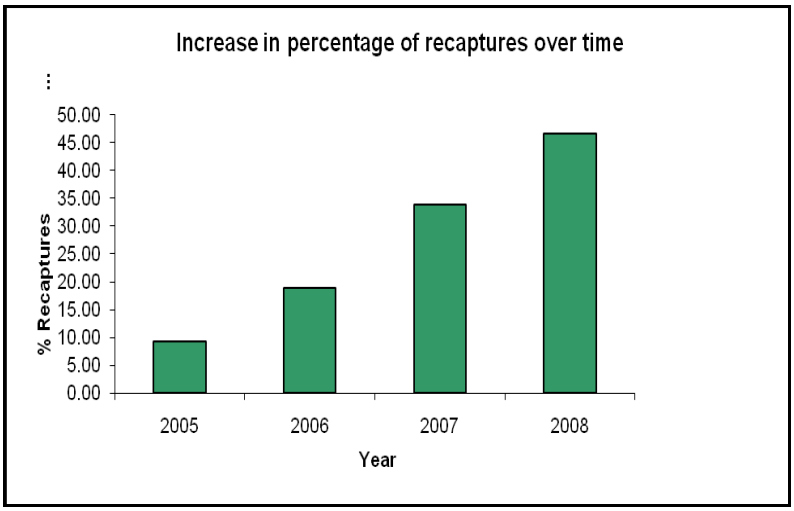


Figure 6.2. Graph showing the steady increase in percentage of recaptures each year

Program MARK

Analysis of the mark-recapture statistics using program MARK revealed that under the most parsimonious model survival is likely to be constant between the sexes ($\varphi = 0.54$) but detectability differs, with females being easier to detect than males ($p = 0.45$, $p = 0.23$). Population estimates were then generated using the detection probabilities for each sex (Figure 6.3) using the following equation:

$$N = 1/p \times \text{Number of individuals caught in the sampling period}$$

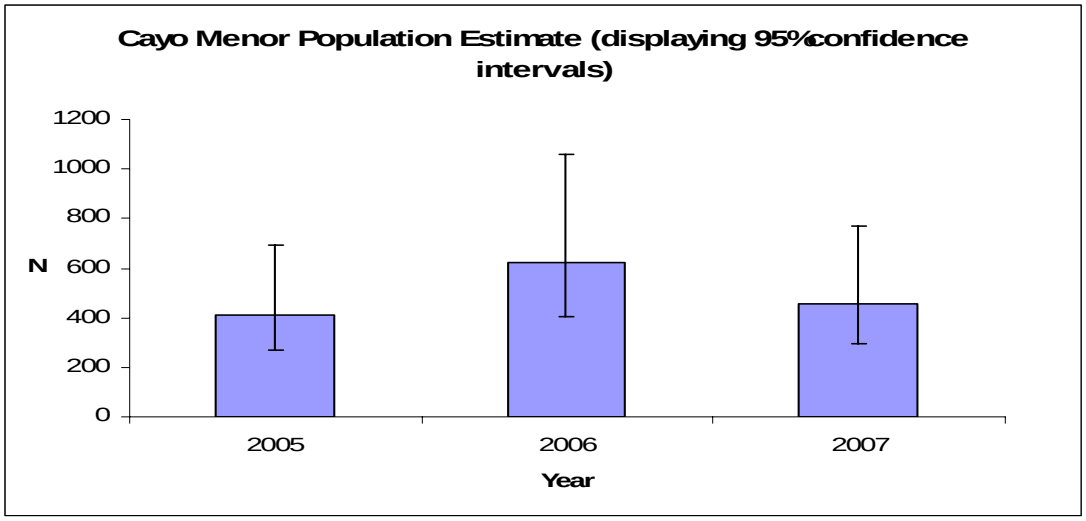


Figure 6.3. Cayo Menor population estimates by sampling period based on male and female detection probabilities displaying 95% confidence intervals.

Genetics

Ten out of thirty five microsatellite markers designed for *Epicrates subflavus* amplified successfully in *Boa constrictor*. Of these ten successful markers, three were found to be polymorphic in Honduran boas. Five species specific polymorphic markers have also been identified for *B. constrictor*. All boas captured between 2004 – 2008 have now been genotyped for the eight polymorphic loci and the population genetic analysis is now underway.

Results from the phylogenetic analysis using sequence data from the mtDNA genes ND4 and Cyt-b suggest the level of protection currently afforded to the Cayos Cochinos boa is appropriate. However, the data also suggest that a similar degree of protection should be considered for the relatively unprotected Bay Island populations.

Ectoparasite Loads

In 2009, we studied the relationship between ectoparasite (tick) load, sex, and body condition for boas on Cayo Menor. Due to a wealth of research on this topic for other species of reptiles in combination with what we know about boa behaviour and immune function, we predicted that ectoparasite load would be negatively correlated with body condition, and that males would carry higher loads than females. Contrary to our predictions, we found that ectoparasite load was not correlated with body condition (Figure 6.4; N=142, Pearson Correlation Coefficient = -0.102, P = 0.227) and that females carried more ectoparasites than males (Figure 6.5; ANOVA, N = 142, $F_{1,140}$ = 10.295, P = 0.002). However, we found that ectoparasite load was significantly positively correlated with SVL (Figure 6.6; ANOVA, N = 142, $F_{1,140}$ = 33.149, P= <0.001) and since females are on average larger than males, they may provide a larger surface area by which ectoparasites can attach. To correct for this bias, we re-performed the analysis with the effect of body length (SVL) removed, and the difference in ectoparasite load among sexes became non-significant (Figure 6.7; ANOVA , N=142, $F_{1,140}$ = 2.528, P = 0.114).

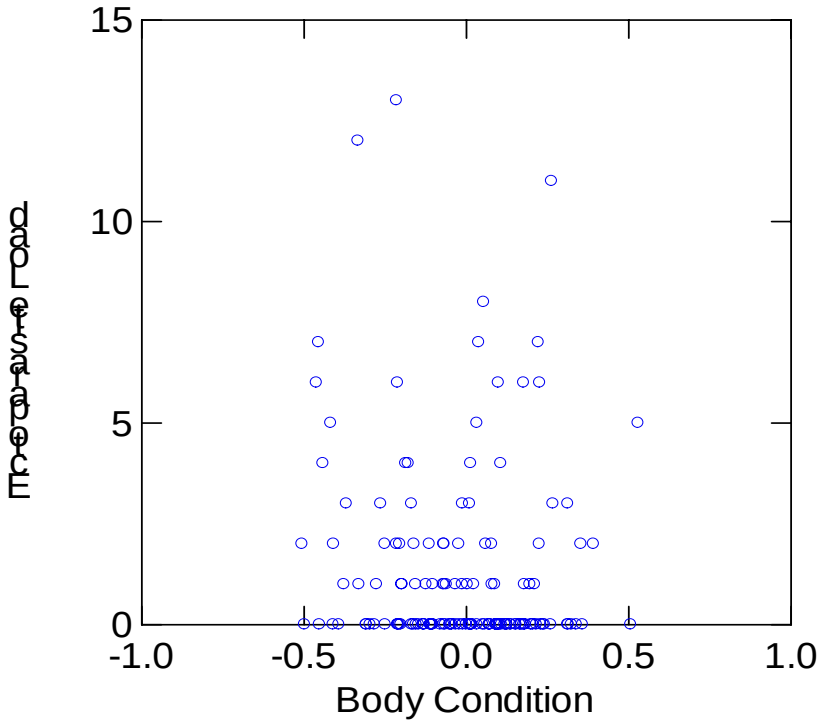


Figure 6.4. Ectoparasite load as a function of body condition.

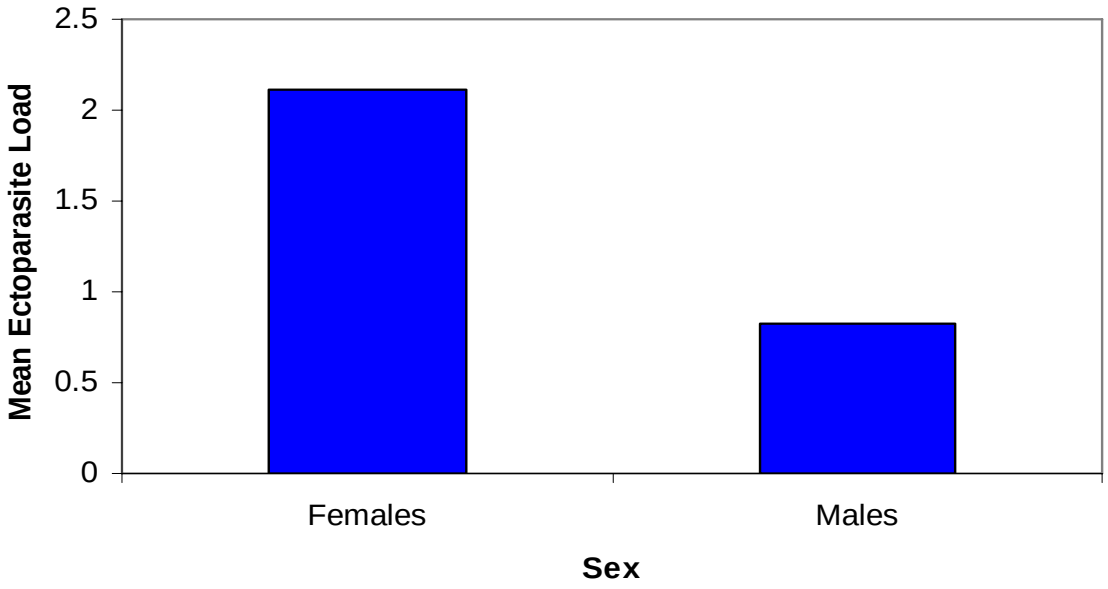


Figure 6.5. Mean ectoparasite load for females and males.

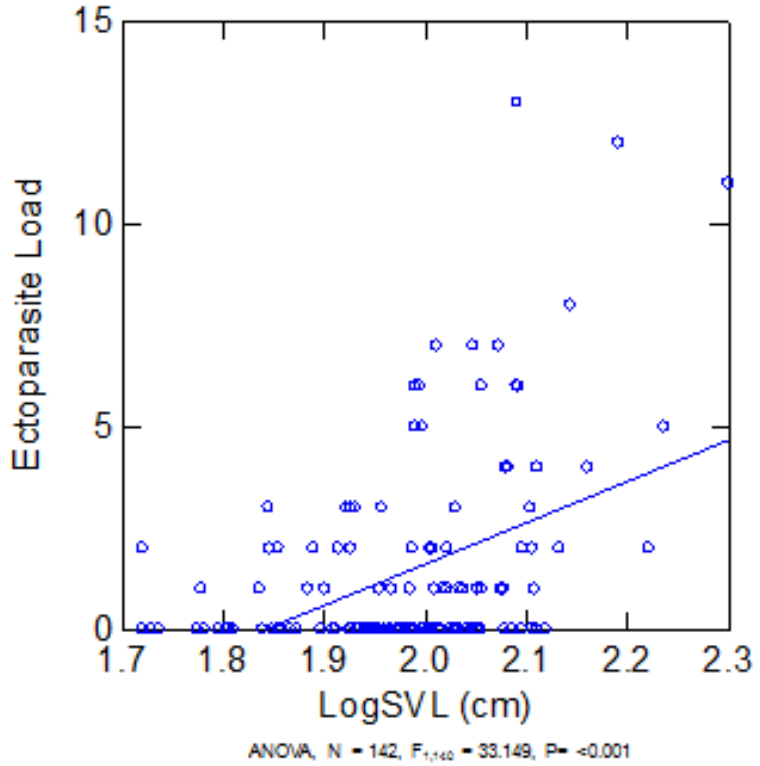


Figure 6.6. Ectoparasite load as a function of body length (LogSVL).

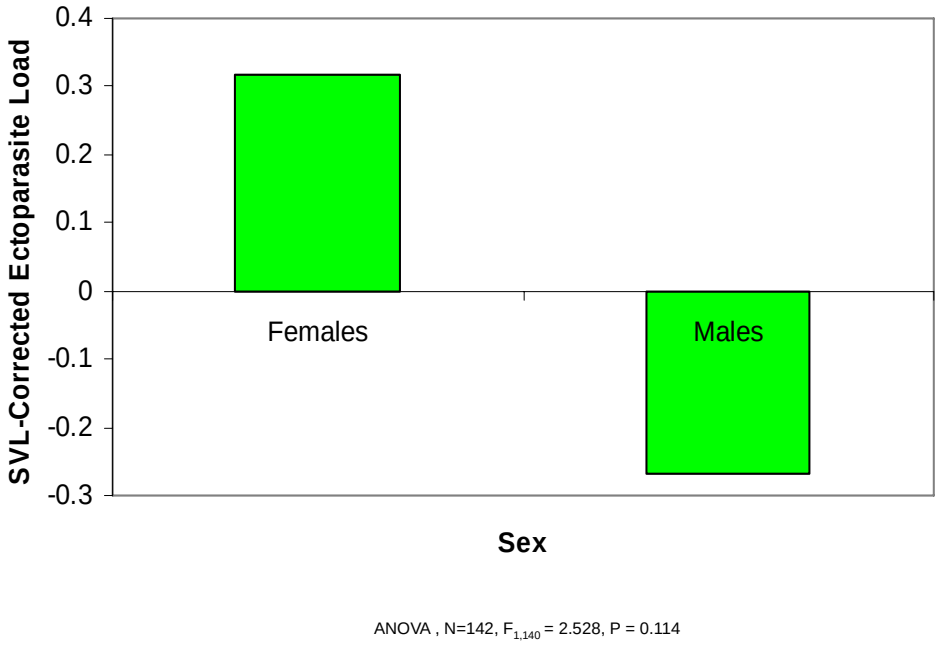


Figure 6.7. Ectoparasite load for males and females with the effect of SVL removed.

The Influence of the Abiotic Environment on Distribution and Posture

In 2009, we placed 13 HOBO data loggers across Cayo Mayor to record humidity at 15 minute intervals. Data loggers were separated into 3 "humidity zones" representing low, medium, and high humidity (Figure 6.9). The zones were determined a *priori*, although after the data from the loggers was uploaded it was determined that our "low" and "medium" zones did not significantly differ in humidity. Both, however, differed from the "high" zone. Over the course of 2009, we also recorded a variety of abiotic variables and posture data, to establish whether boas minimize physiological stress associated with certain suites of variables by altering the percentage of their surface area exposed to the environment. For example, we predicted that in low humidity areas boas would be more tightly coiled to avoid evaporative water loss. The results presented in Figure 6.8 show the expected trends, although none of the differences were significant (probably due to small sample sizes). Nevertheless, significantly more boas were found in high humidity areas, whether we corrected for search effort or not (Figure 6.9).

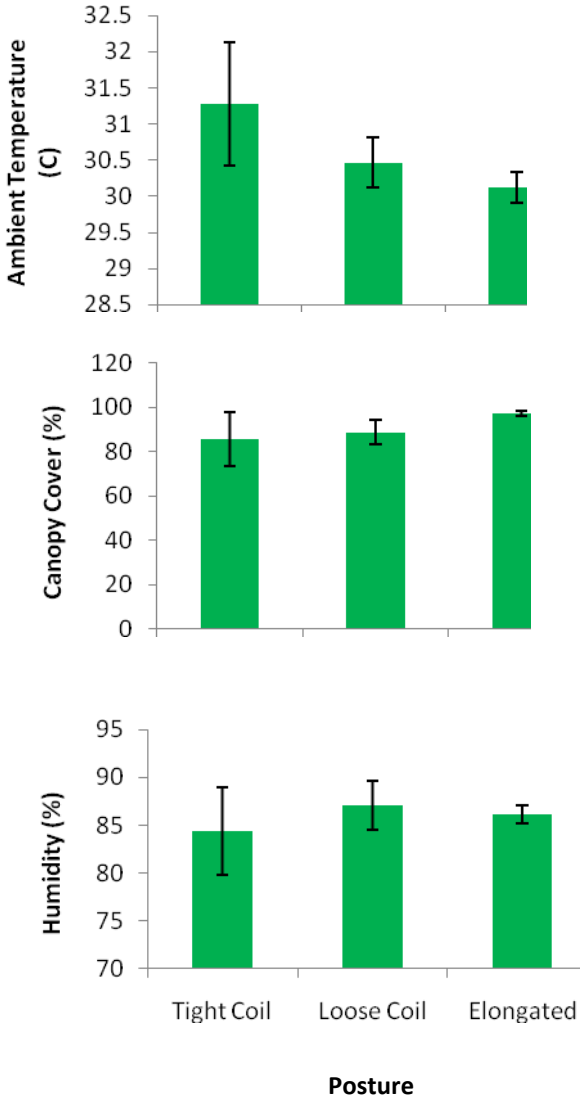


Figure 6.8. Boa posture in relation to several environmental variables.

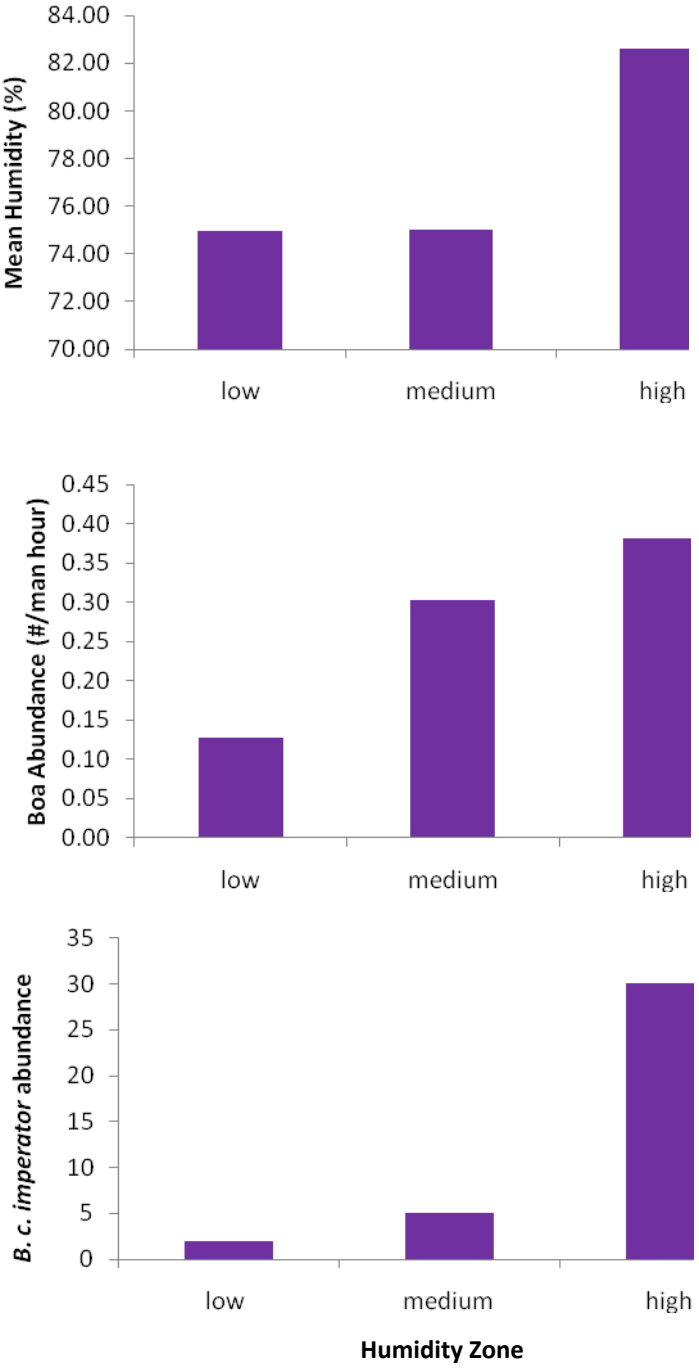


Figure 6.9. Differences in abundance and humidity among *a priori* specified humidity zones on Cayo Menor.

6.2.4 Discussion

Since the initiation of the boa project in the Cayos Cochinos in 2004 an enormous wealth of data has been obtained and is currently being analysed, not all of which has been reported here. The long term nature of mark-recapture studies has called for a degree of patience in order to ensure a large enough proportion of the population had been marked. Happily we have now reached a stage where we can have a reasonable level of confidence in our models. Current population estimates suggest a population of <1000 boas on Cayo Menor and

probably closer to 600 individuals. This estimate is considerably lower than a previous estimate based on just one season of data in 2004 and highlights the danger of overestimating population size when using limited data from a single sampling event. This estimate also demonstrates the importance of vigilance by management authorities in combating illegal off take of boas for the pet trade.

In 2007, the most parsimonious survival and detectability model was identified as constant survival but variable detectability between sexes. If this is the case then the lower detectability of males may in fact suggest an excess of males in the population. In a population with an equal sex ratio but a lower detectability of one sex you would expect to encounter that sex less frequently, however, the actual number of males being encountered is not significantly different from females encountered. It must be noted, however, that the second most parsimonious model also had a high level of support and in this model survival was found to be variable and detection constant between sexes. Too few boas were collected in 2009 to help resolve this issue.

The genetic analysis is ongoing but good progress is being made and due for completion by early 2010. The work being conducted will not only be essential for informing management strategies in the Cayos Cochinos and Bay Islands, but the development of a functioning microsatellite library will pave the way for scientists and conservationists alike to conduct research into this poorly understood species that has previously simply not been possible. It is also possible that there will be a case for increased protection of the Bay Island boas based on this research.

In 2009, too few boas were collected to establish an accurate population census. However, advances were made in understanding how boas interact with their abiotic (posture differences based on humidity, temperature, and canopy cover) and biotic (ectoparasite load) environment. Boas appear to be most abundance in high humidity areas and to reduce physiological stress in those areas by altering their posture. Contrary to what was expected, female boas appear to have more ectoparasites than male boas, and ectoparasite load is not correlated with body condition. This result might be related to the amount of effort female boas put into reproduction relative to males, but further work is needed to tease apart this pattern.

6.3 Black-Chested Ctenosaur (*Ctenosaura melanosterna*)

6.3.1 Introduction

The Black-Chested Ctenosaur (*Ctenosaura melanosterna*) is listed as critically endangered by the IUCN red list with its distribution restricted to the Rio Aguan Valley in northern Honduras and the Cayos Cochinos. The Rio Aguan Valley population is in decline and its future uncertain. The Cayos Cochinos population, therefore, represents an important refuge for this species and its protection is a conservation priority for the area. However, small insular populations are vulnerable to extinction as a consequence of stochastic events. Therefore, it is crucial that the parameters acting on this population are understood in order to implement appropriate management strategies.

6.3.2 Methods
Individual Ctenosaurs are captured using a noose and pole method or using traps. Ctenosaurs are measured (SVL and TL), weighed, sexed and marked with a PIT tag before being released at the point of capture.

6.3.3 Results
Currently results of this project are being processed and are not ready for analysis.

6.3.4 Discussion
Due to the critically endangered status of this highly fragmented species, the initiation of this study was an important objective of our research in the Cayos Cochinos.

6.4 Publications

Montgomery, C.E., R.N. Reed, H.J. Shaw, S.M. Boback, and J.M. Walker. 2007. Distribution, habitat, size, and color pattern of *Cnemidophorus lemniscatus* (Sauria: Teiidae) on Cayo Cochino Pequéno, Honduras. *Southwestern Naturalist* 52(1):38-45.

Frazier, J.A., C.E. Montgomery, S.M. Boback, and R.N. Reed. 2007. *Coniophanes imperialis* (Black–striped Snake) Diet. *Herpetological Review* 38(1):86.

Reed, R.N., S. Green, S.M. Boback, and C.E. Montgomery. 2006. *Ctenosaura melanosterna* (Black-chested Ctenosaur). Predation. *Herpetologcial Review* 37(1):84.

Frazier, J.A., C.E. Montgomery, S.M. Boback, and R.N. Reed. In Press. *Leptophis mexicanus* (Mexican Vinesnake). *Herpetological Review*.

Boback, S.M., C.E. Montgomery, R.N. Reed, and S. Green. 2006. *Oxybelis aeneus* (Brown Vinesnake). *Herpetological Review* 37(2):242.

Boback, S.M., C.E. Montgomery, R.N. Reed, and S. Green. 2006. *Kinosternon leucostomum* (Mud Turtle). *Herpetological Review* 37(2):239.

Presentations:
Logan, M.L.*, C.E. Montgomery, S.M. Boback, R.N. Reed, and J.A. Campbell. 2009. The ecology of *Anolis lemurinus* (Sauria; Polychrotidae) in the Cayos Cochinos Archipelago of Honduras. Society of Integrative and Comparative Biology. Boston, MA.

Green, S.*, R.A. Griffiths, C. Montgomery, R. Reed, and S. Boback. 2008. The Hog Island Boa – On the Road to Recovery? The Herpetology World Congress. Manaus, Brazil.

Montgomery, C.E.* 2008. *Ctenosaura melanosterna* in the Cayos Cochinos, Honduras. IUCN Iguana Specialist Group, Utila, Honduras.

Montgomery, C.E.*, S.M. Boback, R.N. Reed, S.M. Green, J.M. Walker, and M.A. Paulissen. 2007. The raindbow whiptail lizard, *Cnemidophorus lemniscatus*, on Cayos Cochinos Pequeńo, Honduras. Joint Meeting of Ichthyologists and Herpetologists. St. Louis, MO.

Montgomery, C.E.*, H. Shaw, S.M. Boback, and R.N. Reed. 2006. The reptiles and amphibian of Cayos Cochinos Pequeno, Honduras. Southeastern Ecology and Evolution Conference. Tuscaloosa, AL.

7. Overall Conclusions

7.1 The Cayos Cochinos

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. In 2009 the first large scale monitoring of many reefs was conducted, assessing the fish, coral, algae and invertebrate populations within the MPA. 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 11 reefs for full surveys, 18 reefs for urchin surveys, 19 reefs surveyed for conch populations and the continued research program on the herpetofauna 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 of the MPA in 2009, however the initial findings presented within this report give an overview of the findings.

Each research group has found a mixture of results that probably reflect the actual status of the MPA. There are certain elements of each study such as the high fish populations from the reefs surveys, increases in *Diadema* populations from the urchin group, high numbers of conch at some sites and the increase in confidence in population estimates of the boa populations that indicate the results are encouraging. However for each group there are contrasting results like the dominance of small fish and algae on the reefs, many reefs without significant *Diadema* or conch populations and the reduction in the estimated number of Boas on Cayo Menor. What can be taken from such results is the importance of the monitoring program within the MPA and the channelling of the results into management decisions that can ensure that decisions based on managing the MPA are based on counteracting the worrying results and developing upon the more encouraging results.

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 Cayos Cochinos 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