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Marine Field Research Summary

Cayos Cochinos marine site.
June - September 2006

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Conservation of the Cayos Cochinos Boa constrictor (*Boa constrictor imperator*) 2006 report

Abstract

Field work was conducted between 23rd May – 5th September 2006 and work focussed mainly on Cayo Menor (Pequeño), however, a number of trips to Cayo Mayor were also made. A total of 219 boas were captured during the study period, 188 from Cayo Menor and 31 from Cayo Mayor. Of the snakes caught, 47 were recaptures, having either been marked earlier in the field-season or during one of the two previous field-seasons (2004 – 2005). Females were found to be significantly longer and heavier than males with females also having a greater mass than males of the same length.

Eight females were surgically implanted with radio-transmitters and their movements and habitat preference recorded throughout the season. A member of the HCRF patrol staff and a local Garifuna Biology graduate were trained how to continue to track the boas after we left. This has been of some success, however, greater efforts will need to be made to incorporate the local community into the conservation and management of the Cayos Cochinos Boa constrictor.

Stable isotopes were used to investigate the level of water stress boas may be experiencing during the dry season as well as calculate the FMR (Field Metabolic Rate) of the radio-tagged females. Operative Temperature Models (OTM) and humidity sensors were deployed throughout the forest and surrounding habitat. These models will gather data on the thermal profile of habitats available to boas throughout the year. This work is still in progress and the data yet to be analysed. Tissue samples were exported for future DNA analysis.

Introduction

The Hog Island Boa (*Boa constrictor imperator*), one of the most popular and sought after snakes in the pet trade, exists solely on two small islands in the Cayos Cochinos, approximately 17km north of the Honduran coast. During the 1980's these two populations were decimated to satisfy European and US markets. By the early 1990's it was reported within the trade community that Hog Island boas had gone extinct in the wild. Measures were taken to prevent further removal of boas from the area but no active population management was implemented.

In 2003, we were asked to conduct an assessment of the population and initial work began in June 2004. Fortunately, a small number of animals had persisted on both islands and the populations appeared to be recovering. However, interviews conducted within local communities revealed resentment towards current conservation management strategies, particularly in relation to fishing restrictions that have negatively impacted livelihoods. Attitudes towards boas were generally negative and they were seen as another resource that had been taken away from the community. It was clear that if long-term sustainable conservation of the boas is to be successful, in addition to an increased understanding of their population status and ecology, community involvement and increased economic incentives would be essential.

It is our view that current management plans have so far neglected to fully take into account the livelihoods of local Garifuna fishing communities. As a result, there is frequently conflict between these communities and management authorities. It is our intention to alleviate negative attitudes by providing local people with training and employment opportunities as research assistants. It is hoped that it will be possible to provide them with an income that will offset the loss of revenue caused by localised fishing restrictions and allow them to see economic incentives for conserving their boa populations. Data collected by research assistants will in return provide valuable information on the boa's ecology, which will allow the implementation of effective management strategies.

We hope skills learnt by research assistants will in the future allow them to be utilised as guides for small scale ecotourism projects planned within the community. In this way, economic incentives for conserving the boa populations will be maintained long after the initial research phase has been completed. During the 2006 Operation Wallacea field-season we hoped to initiate the first stages of this community integration phase whilst continuing data collection to enhance our understanding of this insular Boa constrictor.

Methodology

VES

Visual Encounter Surveys (VES) were performed by walking slowly through the forest and searching all surrounding habitat. Date, time, weather, location, the number of people searching and the length of time searched for were recorded for each survey. Boas were 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. Boas were measured (SVL and Tail Length, weighed, sexed and marked with a PIT (Passive Integrated Transponder) tag. Boas were given a secondary form of identification by clipping the ventral scales. A number of habitat characteristics were recorded at each capture location and UTM coordinates obtained using a hand-held GPS (Global Positioning System). External body temperature and ambient temperature were recorded with a heat-gun prior to capture and internal cloacal temperature recorded immediately after capture.

Permanent Plots (Pilot Study)

A 2 hectare permanent plot was marked out in the forest using brightly coloured string at the plot boundaries. The plot was searched in the morning on consecutive days. The number of people searching and the time the plot was searched for were kept constant. Boas captured were processed in the field and released immediately at the point of capture.

Radio-telemetry

Eight large females were surgically implanted with intraperitoneal, temperature sensitive radio-transmitters (Holohil Systems Ltd.) under general anaesthetic. Snakes were anaesthetised using isoflurane and closely monitored after surgery until they were fully active and alert. Snakes were released at the point of capture and subsequently tracked as often as possible using a Wildlife Materials TRX-1000S (Wildlife Materials, Inc., Carbondale, Illinois) receiver and a 2-element Yagi antenna. On average snakes were tracked at least once every two days. On each tracking occasion the precise location of the snake was determined to the best of our ability whilst keeping disturbance to an absolute minimum. Providing the snake was visible, the same habitat characteristics used in the VES were recorded. UTM coordinates were obtained with a GPS.

Internal body temperature was recorded by timing the rate of pulse given out by the transmitter. The time for ten pulses was recorded using a stopwatch. This was repeated four times and an average of the four times was taken as the pulse rate. Body temperature was calculated by comparing average pulse rates with a manufacturer's calibration curve for each of the temperature sensitive transmitters.

OTM

Operative Temperature Models (OTM) were constructed from a piece of copper tubing that housed an iButton which was set to record temperature every 2.5 hours. OTMs were designed to mimic the thermal properties of boas with a diameter that of the average boa and a length equal to the average width of a boa when coiled during rest. OTMs were placed in various locations and habitat types around the island in order to cover as much of the potential habitat as possible. OTMs ranged from ground level to >7m in the canopy and were attached to the substrate using plastic cable ties. Humidity sensors were deployed at a number of the OTM 'stations' and set to record humidity levels at similar intervals.

Genetics

Ventral scales, clipped during marking, were stored in eppendorf tubes containing 95% ethanol. Samples were exported at the end of the season and will be analysed for levels of genetic diversity within the populations and degree of relatedness to other boa populations including the Bay Islands, Mainland Honduras, Belize and Belize island boas. Trials are currently underway to cross-amplify a number of microsatellite markers in Boa constrictor using primers developed for other species at the University of Kent.

Water-Stress

Only males were used during this study due to possible differences in metabolism and hydration between the sexes. Males were weighed and then a background (BKG) blood sample was taken. We

aimed to take samples between 0.2-0.3ml. Boas were restrained by placing them inside a clear plastic tube, then a 'cardiac-stick' was performed and blood was drawn from the heart. Boas were then injected with a dose of deuterium (^2H) relative to their mass and estimated body-water content (70%) using the following equation:

$$\text{Dose} = \text{Mass (kg)} \times 0.7 \times 0.12$$

The dose was administered into the muscle tissue towards the posterior of the snake. Approximately 3hrs 15 minutes after the dose had been administered a second blood sample (S1) was taken. All blood samples were frozen on site at the time of extraction. Blood will be analysed for the level of increase in deuterium concentration between the BKG and S1 samples, giving a measure of the dilution space available within the blood and hence a measure of hydration. Boas were released at the site of capture.

Field Metabolic Rate (FMR)

At the end of the field season, radio-tagged females were captured and reweighed. A background (BKG) blood sample was taken (see above for method) and a dose of doubly labelled water (^2H and ^{18}O) was administered relative to the mass of the snake. Doubly labelled water was made up using the solution ratio 0.704 : 2.099 (gD/g : gO-18/g) and snakes were injected with a target dosage of 0.4699g/Kg Body Mass. Approximately 24 hours later a second blood sample (S1) was taken. Boas were released at the site of capture. Boas were recaptured during a later trip to Cayos Cochinos during Dec 2006 and a third blood sample (S2) taken.

Blood samples will be compared for relative levels of the stable isotopes ^2H and ^{18}O . It would be expected that the concentration of both isotopes will fall between samples and eventually return to background levels as they are removed from the body as waste products of metabolism. However, because ^{18}O is removed from the body in the form of CO_2 and H_2O , whereas ^2H is only removed as H_2O , any difference observed between the S1 and S2 concentrations is a direct measure of CO_2 production and hence an indirect measure of metabolism. All blood samples were frozen upon extraction.

Training of Local Staff

We trained one park ranger employed by the HCRF and a local biology graduate from the Garifuna community in radio-tracking techniques and the recording of habitat and behavioural data. Talks were held to discuss the possibility of beginning an education programme, about the Cayos Cochinos Boa constrictor and its conservation, within local schools.

Results

VES

A total of 219 boas were captured during the study period, 188 from Cayo Menor and 31 from Cayo Mayor. Of the snakes caught, 47 were recaptures, having either been marked earlier in the field-season or during one of the two previous field-seasons (2004 – 2005). In total three hundred and thirty nine individual snakes have been captured and marked on Cayo Menor with an observed sex of 1.29:1 (Males:Females) ($P > 0.05$). Thirty six individuals have been captured and marked on Cayo Mayor, but sex ratio was not found to be significantly different from 1:1 ($P < 0.05$).

SVL ranged from 41cm – 205cm and mass from 31g – 5,500g. Mean SVL was $108.5 \pm 27.9\text{cm}$ for females and $94.8 \pm 13.0\text{cm}$ for males with females being significantly longer than males (Wilcoxon two-sample test, $p < 0.01$). Mean mass was $761 \pm 768\text{g}$ for females and $397 \pm 132\text{g}$ for males with females being significantly heavier than males (Wilcoxon two-sample test, $p < 0.01$). Females are heavier than males of the same body length: ANCOVA on log₁₀-transformed data, ($p < 0.01$).

Permanent Plots

Despite our efforts only one boa was captured in the permanent plot during five morning sampling periods. The study was suspended.

Continuing Analysis

Due to the long term goals of our work much of the data analysis has not yet been completed. However, data from 2004-2005 is currently in press and will be published later this year.

Reed, R.N., S.M. Boback, C.E. Montgomery, S. Green, Z. Stephens, and D. Watson.
Ecology and conservation of an exploited insular-endemic population of *Boa constrictor* (Squamata: Boidae) in the Cayos Cochinos, Honduras. In: Biology of the Boas and Pythons. R.W. Henderson, R. Powell, G.W. Schuett, and M.E. Douglas eds., Eagle Mountain Publishing. *In Press*.

Discussion

2006 was our most ambitious and successful season to date. The number of boas radio-tracked was double that of previous years, increasing from 4 to 8. Our number of captures was also higher than previous years. Numbers of snakes being recaptured increased, however, more data will need to be gathered before a reliable population estimate can be obtained.

With funding from Operation Wallacea and the Durrell Institute of Conservation and Ecology, University of Kent, it has been possible for Steve Green to develop current research goals into a PhD research project. It will now be possible to devote more time to refining population estimates and expanding current research interests. In 2007 a combination of permanent plots and transects will be established to monitor how detectability of boas changes between seasons. Knowledge of detectability will help identify when boas are most vulnerable to poachers.

In 2006 the boa project expanded its research with the help of two dissertation students, Tony Frazier and Phil Gillis. Tony's work with OTMs will determine how different habitats vary with respect to temperature and humidity throughout the year. This data will be combined with data from our ongoing radio-telemetry study, allowing us to identify which habitats will best suit the thermal requirements of boas at different times of the year. Phil's work will investigate the level of water-stress experienced by boas during the dry season. It is likely that boas are forced to retreat to humid microhabitats to avoid desiccation during the dry season which results in fewer encounters during VES.

With three successful field seasons completed, the boa project has matured into an exciting and firmly established conservation project within the Operation Wallacea program. However, it is our belief that a greater degree of integration and cooperation between management authorities, the local communities and Operation Wallacea is vital to ensure long term sustainability of the Cayos Cochinos Boa constrictor and local Garifuna communities.

In 2007 we hope to increase our focus on community involvement and education as a means of conserving the Cayos Cochinos Boa. A Disney Grant, secured in 2006, will provide funds for the production of educational materials for use in the school at East End Village and for the 'Cabana Project' where materials will be provided for the new tourist information centre.

Efforts will continue to be made to train local people as research assistants and increase their role in data collection throughout our study and during future monitoring periods.

Reef Fish Pilot Study: 2006

In the summer of 2006 Operation Wallacea initiated a pilot study of reef fish movement on the island of Cayos Menor in the Cayos Cochinos Marine Protected Area, Honduras. It is well known that the life histories of the majority of reef fish species begin with long distance (up to thousands of kilometres) dispersal during the larval stage followed by settlement, juvenile establishment and a prolonged territorial adult stage. Much less is known about the rates and distances of juvenile and adult movement during and after the establishment of territories. The long term goal of the project is to combine snorkelling with a 'mark-recapture' approach to quantify the movement of juvenile and adult reef fish at a smaller spatial scale than is traditionally considered in the design and management of marine reserves. The aim of the pilot study was to test different methods of capturing fish and select a logistically and ecologically appropriate, and socioeconomically relevant group of species for long term study. The project will help answer basic questions about the life history ecology of reef fish and provide insights into the ecological appropriateness of establishing small scale harvest areas for local fisherman within the Cayos Cochinos preserve.

Three methods for capturing fish were tested: baited funnel traps (1 × 0.6 × 1.7m), line and hook fishing from boats, and line and hook fishing while snorkelling. While the first two methods consistently captured fish, the species composition of the catch was largely uncontrollable. Sight fishing was equally efficient and allowed us to visually target individual fish from a range of carnivorous species. Of the fish consistently captured using sight fishing we chose grunts (Haemulidae, represented by 18 species in the Caribbean) as the study group for four reasons: six species are common on the reefs around Cayos Menor (French-*Haemulon flavolineatum*, Bluestriped-*H. sciurus*, White-*H. plumieri*, Caesar-*H. carbonarium*, Striped- *H. striatum*, Tomtate - *H. aurolineatum*); their size, behaviour and colour make them easily to locate and identify while snorkelling; while they spend the day cruising shallow reefs in mixed-age schools, they spend nights foraging over large areas in the sea grass beds that separate different reefs around the island, making them an ideal group for a study of small scale movement patterns; they are historically and presently an important component of the local subsistence fishery.

The pilot study took place at the southern tip of a long (1 km) windward shore reef that runs up the east side of the island. To the west of the 200 m long study sight, a 1 km long bed of sea grass separates the study reef from the next closest reef. This location thus provides the opportunity to compare movement along a continuous reef and across a sea grass bed to the adjacent reef. Between July 17th and August 1st nine Opwall volunteers were trained in grunt identification and sight fishing techniques. During that period 21 grunts (7 *H. flavolineatum*, 14 *H. plumieri*) were marked with small 'spaghetti tags' through the tissue of the caudal peduncle (tail muscle). During each sampling effort (7 days) volunteers looked for marked fish and recorded the number observed. Over the study period 37 marked fish were observed in the study area. As part of other studies being conducted during and after the marking effort the patch reef on the other side of the grass bed was searched for marked fish 13 times and the remaining 800m of the shore reef 5 times. No marked fish were observed outside the study area.

In the summer of 2007 we will increase our sampling effort and expand the spatial scale of the study to better determine rates and distances and grunt migration on the island of Cayos Menor.

Operation Wallacea Social Science Field Report 2006

by

Keri Brondo and Laura Woods¹

Introduction

This report is a brief summary of the research undertaken by the social science research team in the Cayos Cochinos Marine Protected Area, Honduras during the 2006 field season. There are four sections to this report. The first section provides an overview of the Cayos Cochinos Marine Protected Area and its management plan, the effects of which on the local population form the basis of our inquiries. Next, the social science research agenda is summarized, including our overall objectives, data and methods. Data analysis is still underway, and therefore no findings are reported. The final section of the report is a brief summary of some of the economic input Operation Wallacea has had on the local population. This section was developed in coordination with Laura Woods, a field research team member during the 2005 season. Finally, two forthcoming articles are abstracted: these manuscripts will provide a deeper analysis of the data collected from our research team.

Research team members included Natalie Bown (Newcastle University), Ria Harding (University of Birmingham), Caroline Morgan (University of Birmingham), Tara Sabi (University of Nottingham), and Keri Brondo (Michigan State University).

Background: Ecotourism Levels in the Cayos Cochinos

The Cayos Cochinos are located 19 miles northeast of La Ceiba on the northern Honduran coast, and at the southern most point of the Meso-American Barrier Reef. The Cayos Cochinos was declared a Marine Protected Area (MPA) in 1993 and the management of the area's resources is overseen by the Honduran Coral Reef Foundation (HCRF), an organization formed by Honduran business leaders, and funded by international conservation groups (e.g., AVINA, WWF) and research organizations. In 2003, Legislative decree 114-2003 designated the Cayos Cochinos as a Marine Natural Monument and the HCRF as the managing agency responsible for the conservation of the islands for the subsequent 10 years (2004-2014). In 2004, the HCRF and the World Wildlife Fund (WWF) developed a five-year management plan for the MPA. The 2004 Cayos Cochinos Marine Protected Area management plan established restrictions on fishing and development activities in effort to conserve the southern end of the Meso-American Barrier Reef. Ecotourism has been suggested in the management plan as a means to replace lost income from fishing.

The Afro-indigenous Garifuna are the earliest occupants of the Cayos Cochinos. The MPA's waters are home to a rich variety of fish, lobster, and conch and have served as the site for Garifuna subsistence fishing since the early 1900s. The Garifuna are descendants of Africans and Amerindians (i.e., Carib and Arawak Indians) who settled along the Central American coastline more than 208 years ago, after being forcibly exiled by the British from the island of St. Vincent to Roatan, Honduras in 1797 (Gonzalez 1988; Palacio, 2000). From there, they established settlements along Central America's North Coast from Nicaragua to Belize, and have since extended their communities to major cities in the United States. Honduras has the largest Garifuna population, with settlements stretching along its north coast and islands. The Garifuna inherited the livelihood strategies of their African and Amerindian ancestors, and despite their work as transnational wage labourers, many who remain along the coast still continue to practice subsistence fishing and cassava farming. There are two Garifuna settlements within the MPA: Chachauate, an island without water, sanitation, or electricity; and, East End, a small settlement on Cayo Mayor. Mainland Garifuna communities have temporary dwellings on other cays

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for fishermen to overnight and thus are also dependent on the Cayos Cochinos for their livelihood. These communities are Nueva Armenia, Rio Esteban, Sambo Creek, and Corozal. Nueva Armenia (and its Cayos Cochinos sister settlement, East End) and Rio Esteban (and its Cayos Cochinos settlement, Chachahuate) are particularly affected by MPA regulations because many residents rely on fishing for subsistence and sale.

While the Cayos Cochinos are being promoted (at least in the management plan) as a ecotourism destination, there is a wide range of tourist 'types' who currently visit the Cayos Cochinos, but the degree to which these tourists are engaged in geotourism to date (or even ecotourism) is debatable. The majority of visitors to the MPA are research tourists and day tourists, most of who are snorkelling or diving the protected reefs. Scientific or research tourists, such as those associated with Opwall, stay on Cayo Menor, the smaller of the two islands and home to the HCRF scientific research station. Only scientific researchers are cleared to visit Cayo Menor, and the HCRF manages the clearance. Dive resort tourists travel to Cayo Mayor and stay at the all-inclusive Plantation Beach Resort. Wealthier regional tourists also occasionally rent the privately-owned homes on the smaller cays. A range of tourists take day trips from coastal hotels through tour operators based on the mainland to either dive with the Plantation Beach Resort dive staff, snorkel in the area, and visit Chachahuate, one of Honduras' postcard Garifuna communities (because of its idyllic "close-to-nature" character). But all in all, relatively few visitors overnight on Chachahuate; and even less so in East End. Those who do stay in the Garifuna settlements are typically backpackers or "adventure tourists" or tourists. These tourists come to experience "Garifuna culture:" they stay with a family, eat traditional Garifuna dishes, buy locally made jewellery, and interact with community members.

Research Agenda and Methods

The 2006 Opwall social science agenda included three main objectives. These were:

1. To assess levels of participation in development and implementation of the 2004-2009 MPA management plan.
2. To assess current levels, community expectations, and potential for ecotourism.
3. To pilot a household survey (see Appendix for pilot survey) intended to serve as the basis for the development of a standardized socioeconomic monitoring program assessing the effects of MPA regulations on Garifuna community residents.

To accomplish these objectives, our team engaged in a myriad of data collection activities, including surveying households in and around the MPA, interviews with key informants, archival research, participatory mapping activities, and participant observation and direct observation.

Research sites within the MPA included Chachahuate, East End and the Plantation Beach Resort (both located on Cayo Mayor), and Cayo Menor, where the HCRF and Opwall staff are based. Our mainland field sites included Nueva Armenia (Chachahuate's sister community), Rio Esteban (East End's sister community), Sambo Creek, Guadalupe, and La Ceiba. Guadalupe was selected as a comparative case study for our team to assess distinctions between communities traditionally reliant on the MPA resources (i.e., Chachahuate, Nueva Armenia, East End, Rio Esteban, and Sambo Creek) and a community that has never relied on the area's resources (i.e., Guadalupe).

Over the course of the field season, the research team conducted a total of 152 household surveys, 10 focus groups with residents of each community, and 43 in-depth interviews with key informants in communities and organizations. Household surveys were tailored to collect basic demographic and shifts in income, as well as support for the MPA and its management plan; 100% of occupied households were surveyed within the MPA communities; and 35 households (i.e., every 5th household) were surveyed in each of the mainland communities. In-depth interviews were conducted with community leaders including members of the Patronato (i.e., local governing system), individuals listed as participants in the development of the management plan, members of local fishing cooperatives, independent fishermen (i.e., not part of the cooperatives), tourism workers (e.g., boat operators, heads of dance troupes, hotel owners and workers, women who board ecotourists). We also

interviewed and received archival data from staff at the HCRF, Opwall, Digepesca (the Fisheries Department), the Ministry of Tourism, the Garifuna Chamber of Tourism, and several local independent tour operators. The types of secondary data that we collected for review included meeting minutes and legislation regarding the management plan, licensing procedures, tourism impact assessments, Garifuna mobilization press releases, census data, and so on.

Participant and direct observation were essential to our data collection process. Our team travelled between each of the impacted communities, staying in homestays with families and participating in local events (ranging from observing *casabe* production and attending the local *feria*, to casually conversing with our host families).

Data analysis is in process and we are using both SPSS and Atlas-ti to manage the data. The data is being coded inductively and deductively. Because our analysis is not complete, we are unable to report any findings at this time. We can, however, outline a selection of the topical areas that we are exploring:

1. Shifts in time of household income – i.e., have households become *less* reliant on fishing since the implementation of the management plan, and *more* dependant on tourism activity? Are there other factors that contribute to shifts in household income in addition to the management plan (e.g., weather patterns, the growth of a remittance economy)?
2. Levels of involvement in the participation and implementation of the management plan. Examples of the types of questions we are interested in are: Who was involved in the development of the regulations from the local communities? Were there some communities that featured more prominently in the management plan's development? Do some communities or families support the management plan more than others? If so, why?
3. Stakeholder understandings of "ecotourism" and its development. The kinds of questions we are interested in here are: how are various stakeholder groups (e.g., the HCRF, Opwall, Garifuna organizations, tour operators, residents of Garifuna communities, etc.) conceptualising "ecotourism"? What types of activities are associated with ecotourism? Who is responsible for funding its development?
4. The impact of fishing regulations on the Garifuna diet (as most traditional dishes are fish-based).

Each of the above topics will be explored comparatively by community, as each community has distinct past and present primarily livelihood strategies and differing levels of tourism.

Research Tourist Community Inputs from Field Season 2005

There were a number of initiatives implemented by Opwall volunteers meant to provide economic benefit to the local population in the summer of 2005. Opwall staff initiated a series of regular events in which the student research tourists participated that enabled direct income flow into the Garifuna communities located within the MPA, bypassing the HCRF. The three primary income-generating activities included regular Tuesday barbeques, direct school donations, and day trips to Chachahuate.

Every Tuesday for a period of seven weeks during the high season of Opwall's research program community members from Chachahuate and East End were employed to cook barbeque-style lunches for the Opwall research tourists. Over the course of the season, the community members earned approximately \$4,200 (prior to deducting costs). This money was raised to benefit the local primary school. During these BBQs, Opwall provided a collection box alongside the buffet to encourage visitors to make additional, direct donations to the school. The sum varied each week, dependent upon the number of visitors present, their personal money allowances, their generosity, and the longevity of their stay in the Cayos Cochinos (i.e. whether or how much they had donated in previous weeks). According to Opwall staff, approximately \$700 was collected and donated directly to the school.

Student groups also went on weekly visits to the island communities of Chachahuate and East End.

During these visits, community members sold locally made jewellery, food and beverages, and braided hair. Unfortunately, the amount generated during these trips was not systematically recorded. The first trip of 45 volunteers to Chachauate was observed and following the trip, our research team interviewed community members who sold products or services to the community in order to discern how income was spread amongst resident families. Thirteen community members earned money during the two-hour trip. Three women braided hair, and ten women and one man sold jewellery. The gendered distribution of earned income was quite drastic: the women earned between \$6 and \$30; the one man earned US \$70. The continued documentation of how income is distributed by gender would be an interesting study.

Nevertheless, it must be noted that, combined, these direct contributions by the research tourists into the communities were only twice per week at most, and did not generate income even close to the potential. The majority of the time these student researchers were present in the marine research was spent getting open water scuba certification and then participating in 'research' dives. The diving offered virtually no benefit to the Garifuna communities, and arguably even caused long-term harm through damage to the barrier reef ecosystem. Given the total number of visitors to the MPA during the Opwall season, there is great scope for the communities to become better integrated into the organization of research tourism activities and thus gain a greater (and well-deserved) share of the profits.

Following consultation between volunteer researchers, students, teachers and representatives of the communities, suggestions have been made to develop the communities, both short-term and long-term. The aforementioned activities were scheduled to continue as part of a more integrated program due for the 2006 season. However, unfortunately, in 2006, the student visits to Chachauate stopped altogether and there were only two BBQs held, much to the dissatisfaction of the communities located within the MPA. One significant achievement for 2006 was that all food, accommodations, and transport to and from the MPA had been negotiated directly with community members. Yet these were largely negotiated through Nueva Armenia, leading to upset in the other Garifuna communities impacted by the MPA management plan.

Based on the exchanges between Opwall volunteers and the local population, a scholarship program was established at the start of 2006 to assist the area's youth in obtaining education past primary school and provide them with the necessary tools to engage directly in the management of local resources and community development initiatives. Through donations made by overseas donors, the Opwall Cayos Cochinos Scholarship Fund has made awards to eight Garifuna youth, between the ages of 14 and 18 years; the scholarship program will continue to award local youth into the future.

Forthcoming Papers

Brondo, Keri and Laura Woods. (forthcoming, Feb. 2007). Working Title: "Conservation as Development in the Cayos Cochinos Marine Protected Area." *Ecological and Environmental Anthropology*.

Brondo, Keri and Natalie Bown. "Conceptualizing Garifuna "Community" in the Cayos Cochinos Marine Protected Area." Paper presented in session entitled "Marine Resources and Local Perceptions" at the Society for Applied Anthropology Annual Meetings. March 30, 2007.

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Reef fish and edge effects, Cayos Cochinos - Summary of undergraduate thesis

Jessica Stephenson, Oxford University

It is intuitive that as an animal grows it will be subjected to different pressures in its environment, and require different resources from different habitats. Tropical fish communities are constantly changing; not only do many species change habitat as they grow, but they also migrate daily along the seagrass-reef gradient. Although both ontogenetic habitat shifts and diel migrations are well studied, they have previously only been studied separately or in one species; this study is unique in that it looks at both acting across whole communities. In studying two examples of the seagrass-reef gradient, this study is also able to show the importance of habitat structure on fish community structure.

On Cayo Menor, Honduras, quadrats and a 10minute observation time were used to sample the populations across the two different reef-seagrass ecotones. In total 9253 fish were counted, representing 102 species. Fish were present in different areas of the habitat at different times of day. There was variation in species diversity at different times of day and in different locations around each reef. Analysis of 12 key species found that the factors explaining the fish distribution varied considerably between the different age classes.

Summary

1. Many fish species migrate between habitats along the seagrass-reef gradient at different life stages.
2. Fish migrate along the gradient daily, and the timing and route of these migrations depends upon their age.
3. There was a considerable difference between the two reef types studied in terms of community structure at different locations along the gradient.

Sea urchin ecology, Cayos Cochinos - Summary of undergraduate thesis

Maya Goldstein, Oxford University

The herbivorous sea urchin *Diadema antillarum* suffered a Caribbean-wide mass mortality in 1983-1984 that reduced its population by 95-99%. Following this, a phase-shift from coral to macroalgal dominated reefs was observed throughout the Caribbean. Recovery has generally been slow, although promising population increases have recently been observed accompanied by phase-shift reversals (from macroalgae back to coral). In Honduras, *Diadema's* ability to reduce macroalgae and increase coral cover has been further documented, although its recovery here appears slow. Its prevalence here in shallow habitats where coral reefs are extremely diverse provides further evidence for its importance in structuring reefs. *Diadema* can also determine coral reef community structure through its interactions with other reef species. While this study has revealed relatively noisy interactions between *Diadema* and three other urchins, *E. lucunter*, *E. viridis* and *E. tribuloides*, it has however uncovered potential competition between *Diadema* and adult dusky damselfish, *Stegastes adustus*, and facilitation between *Diadema* and juvenile *S. adustus*. Altogether, this study provides further evidence that a recovery of this urchin is of major importance for the maintenance and health of Caribbean coral reefs.

Clustering behaviour in intertidal hermit crabs - Summary of undergraduate thesis

Helen Leonard, Oxford University

An investigation was performed to determine the influence of wave exposure on the clustering behaviour of intertidal hermit crabs. There are numerous speculations with regard to the function of this aggregative behaviour; however none of these can adequately explain the restricted occurrence and size-dependent structures of these clusters. Thus, I hypothesised that wave exposure induces crabs to aggregate, clustered individuals benefiting from decreased wave stress achieved through this adaptive behaviour. I further proposed that solitary crabs would carry relatively large shells, whilst smaller individuals would inhabit comparatively lighter shells and be found confined to assemblages. Wave experiments determined if solitary individuals were more adept than their aggregate conspecifics at remaining on the substrate, providing evidence that wave exposure determines clustering behaviour and shell usage.

The results of the observations and experiments are presented and statistically analysed. It is concluded that the significant difference found in shell usage between aggregate and solitary individuals alters across beaches of varying wave exposure.

Wave experiments suggest that individuals on exposed shores have a higher tenacity to cling to the substrate, but that they are restricted to carrying smaller shells than their conspecifics on more sheltered beaches. Consequently, these results provide insight into the relationship between wave stress and clustering behaviour of hermit crabs on Cayos Cochinos. Limitations of the experiments and further work are also suggested.

The main aims were to determine:

If crab and shell size differed between aggregated and solitary individuals.

If there was a threshold crab size at which most individuals on a beach became solitary.

Whether this threshold was correlated to the exposure of a shore, with sheltered beaches permitting individuals to inhabit bigger shells and become solitary at a smaller crab size, in relation to a larger transition point on a wave swept shore.

Provide evidence to support these hypotheses using wave experiments within the laboratory

5. Summary

It can be hypothesised that wave exposure may instigate clustering behaviour in intertidal hermit crabs on Cayos Menor.

The degree of exposure on a shore may affect the size of shell an individual can inhabit. Individuals on sheltered beaches may be capable of becoming solitary at smaller crab sizes whilst inhabiting larger shells.

On a wave swept beach, shell size limit is proposed to be a function of wave stress. As an individual grows, it is suggested that it will gain morphological features adept at withstand increased wave energies, coupled with the ability to hold a larger shell. At this point it is projected that an individual will become solitary.

This transition from a clustered to solitary state is proposed to be beneficial in reducing energy expenditure and in finding enhanced food resources.

Consequently, wave exposure and its magnitude may govern clustering and solitary behaviour in both *Clibanarius tricolor* and *Clibanarius antillensis* on Cayos Menor. However, other benefits may also be accrued from the formation of aggregations, resulting in clustering behaviour incorporating a multi-functional purpose.