Coastal Ecology of The Bahamas
Earthwatch Team Data Summary, 2006

Great Guana Cay, Abaco

5-13 January 2006

Summary of Sampling Efforts:

DATE	SITE DESCRIPTION	DATA CATEGORIES	FACTORS	ACCOMPLISHMENTS
1/5/2006	Guana Seaside, Joe's Creek 1 and 2	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Deployed Sediment Traps
	Shrub Thicket, Preserve	Biotic - Land	2.1. Plant Diversity	Established Plots
	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Guana Seaside	Biotic - Sea	3.1. Fish	REEF Fish Survey
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
1/6/2006	Marina 2, RoRo dock, artificial reefs	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Deployed Sediment Traps
		Biotic - Land	2.1. Plant Diversity	Established Plots
	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
1/8/2006	Roro dock, marinas 2 and 3, artificial reefs, Guana Seaside, Joe's Creek 1 and 2	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Recovered / Deployed Sediment Traps
	Preserve	Biotic - Land	2.1. Plant Diversity	Established Plots
	Dune	Biotic - Land	2.1. Plant Diversity	Established Plots
	Preserve	Biotic - Land	2.1. Plant Diversity	Established Plots

	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Joe's Creek 1 and 2, Roro dock	Biotic - Sea	3.2. Corals (Near shore)	coral transplant monitoring
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
	marina 2	Biotic - Sea	3.2. Corals (Near shore)	coral transplant monitoring
1/9/2006	Joe's Creek 1 and 2, Marina 1	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Recovered / Deployed Sediment Traps
	Plant Plots	Biotic - Land	2.1. Plant Diversity	Established Plots
	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
	marina 1	Biotic - Sea	3.2. Corals (Near shore)	coral transplant monitoring
1/10/2006	Marina 2, artificial reefs, Roro dock	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Recovered / Deployed Sediment Traps
	Plant Plots	Biotic - Land	2.1. Plant Diversity	Established Plots
	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	2 Seine Sets
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
	artificial reefs	Biotic - Sea	3.1. Fish	REEF Fish Survey
	Joe's Creek 2	Biotic - Sea	3.2. Corals (Near shore)	Permanent Plot monitoring
1/11/2006	Joe's Creek 1 and 2	Physical and Chemical	1.1. Water - Near Shore, 1.2. Sediments	Recovered / Deployed Sediment Traps
	Plant Plots	Biotic - Land	2.1. Plant Diversity	Established Plots
	Baker's Bay Benthos	Physical and Chemical; Biotic - Sea	1.1. Water - Near Shore, 3.3. Benthos (Near Shore)	Groundtruthing, algae species list
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set

	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
	artificial reefs	Biotic - Sea	3.1. Fish	REEF Fish Survey
	Joe's Creek 2	Biotic - Sea	3.1. Fish	REEF Fish Survey
1/12/2006	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Guana Seaside	Physical and Chemical	1.1. Water - Near shore	dawn and dusk water quality monitoring
	Mouth of Joe's Creek	Biotic - Sea	3.1. Fish	Seine Set
	Joe's Creek 1	Biotic - Sea	3.1. Fish	REEF Fish Survey
	artificial reefs	Biotic - Sea	3.1. Fish	REEF Fish Survey
1/13/2006	Joe's Creek 3	Biotic - Sea	3.1. Fish	Seine Set
	artificial reefs	Biotic - Sea	3.1. Fish, 3.2. Corals (near shore), 3.3. Benthos (near shore)	REEF Fish Survey, reef module coral transplant monitoring, Epifauna survey, algae species list

Great Exuma *Family Team 2006*

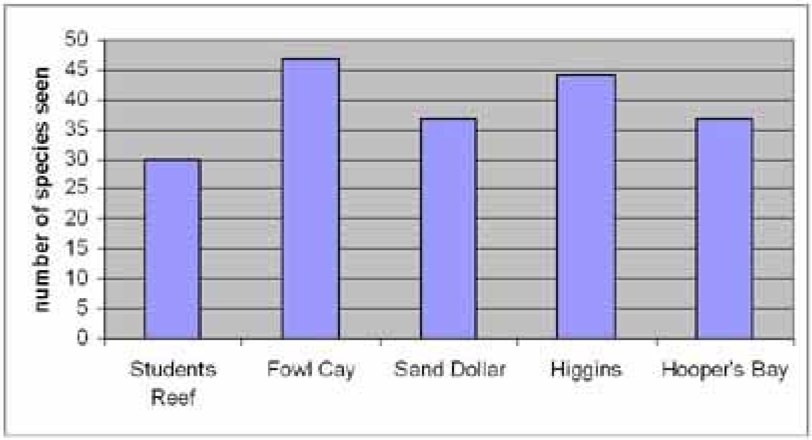
22-29 June 2006

The Coastal Ecology of The Bahamas project was pleased to welcome and include three families in our ongoing monitoring of Great Exuma island. Three parents and four fabulous, young scientists-in-training aided in data collection and water quality sampling around George Town for one week. Alan Fortescue, director of education for the Earthwatch Institute, also joined the inaugural Family Team.

A. EPIFAUNA SURVEYS

Marine invertebrates are excellent indicators of a particular location's environmental health. Sedentary filter or suspension-feeders, such as sponges and corals, are particularly sensitive to water quality conditions, and cannot survive in turbid or nutrient-rich conditions. Loss of invertebrate biodiversity over time can usually be correlated with environmental degradation.

We focused on five survey sites this year for intensive species presence and abundance surveys: Students' Reef patch reef, Fowl Cay channel reef, Higgins' patch reefs, Sand Dollar patch reefs, and Hooper's Bay hardbottom communities:

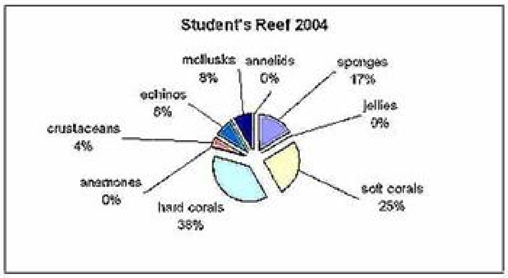


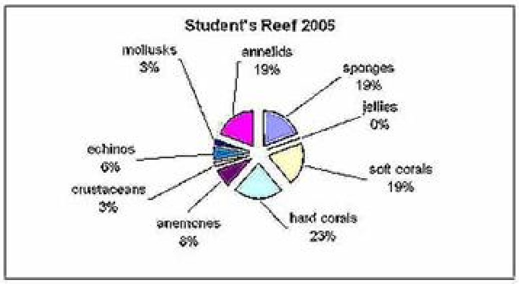
Fowl Cay, a channel reef not located near coastal development, boasted the highest number of epifauna, or macroinvertebrate species. Students' Reef, a near shore patch reef located in close proximity to a hotel under construction, exhibited the lowest number of species.

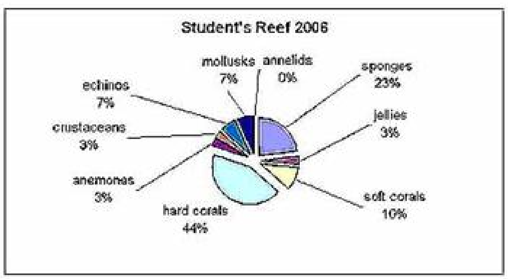
Hooper's Bay, a hardbottom / rocky shore habitat, hosted a similar number of species to a patch reef site, suggesting that low density invertebrate habitats are just as important to maintaining regional diversity as coral reefs.

We've been conducting epifauna presence and abundance surveys repeatedly at several sites since summer 2004, yielding three years of data. Multiple surveys over time at the same sites help us understand how communities change over time; our job is then to try and correlate which factors might be contributing to such change. Note how contributions of different taxonomic groups to diversity changes over time:

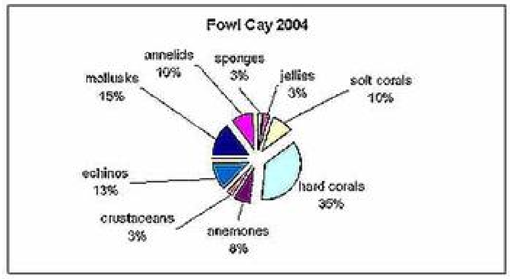
Student's Reef (Impacted)

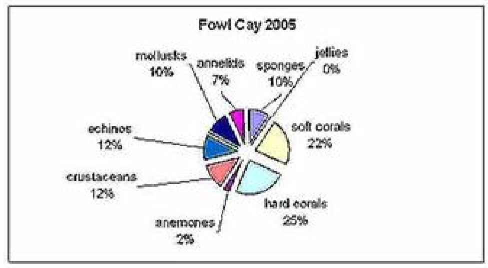


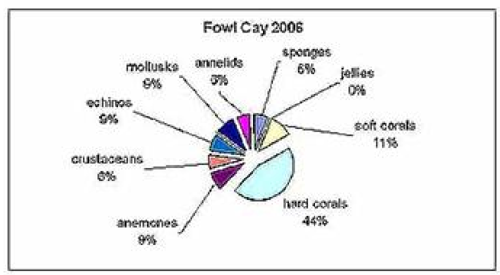




Fowl Cay (Unimpacted)







B. FISH POPULATION SURVEYS

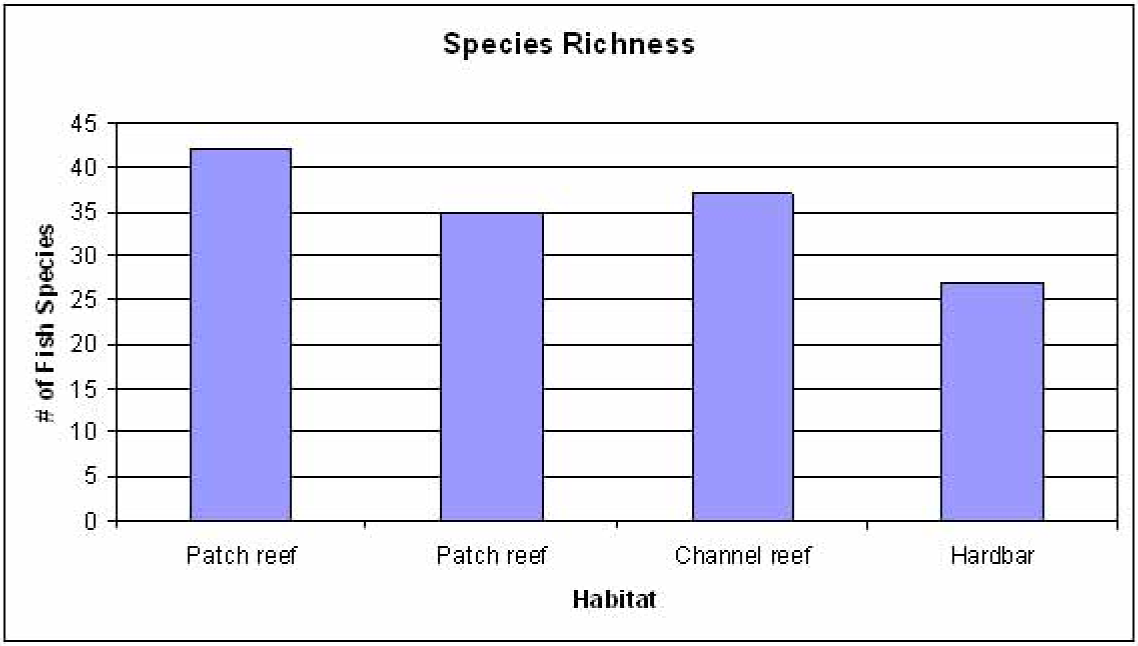
Roving Diver Surveys

Methodology: The roving diver surveys that were conducted on this expedition are based on the methods developed by other marine biologists and prior experiences that this team has had on previous expeditions. Basically, they consisted of a group of staff members, usually two or more, and Earthwatch volunteers snorkeling (less than three meters) over various monitoring site for a specified time frame. These surveys help to asses the biodiversity of fish species and their abundance at different sites around the island. The staff members would survey and record the data on underwater papers or slates while the volunteers aided in fish identification and population estimates. Data consisted of identifying fish species and a population estimate for each species indicated by the following categories: single (1), few (2-10), many (11-99), and abundant (100+). Once the survey was complete, the staff would lead a debriefing and help clear up any problems or questions in identification techniques for individual fish species. The conclusion of the survey would be the transcription of the raw data along with other data (i.e. survey time, habitat, temperature, visibility determined by secci disk, and current) onto REEF® Fish Survey Forms to be input later.

Analysis: During the summer 2006 expedition to Exuma a total of 7 roving diver surveys, lasting 502 minutes, were conducted at four different sites around the island. These sites are representative of three unique marine ecosystems present around Exuma. The above graph is a good guide for comparing the type of marine ecosystem found at the site and its correlation to fish species abundance. By analyzing the chart we can surmise that the patch reefs had the higher variety of fish species, possibly due to more coverage for fish. The hardbar habitat had the least fish biodiversity of the sites we studied, with less than 30 species sighted, and the channel reef averaged around 37 species sighted.

Data Collection Summary:

- 7 surveys completed
- 8 hr 36 min of surveys
- 71 min per survey average
- 29 species per survey average



Most Abundant Fish: Beaugregory, Sergeant Major, White Grunt, Bluehead Wrasse, Slippery Dick, Stoplight Parrotfish, Squirrelfish

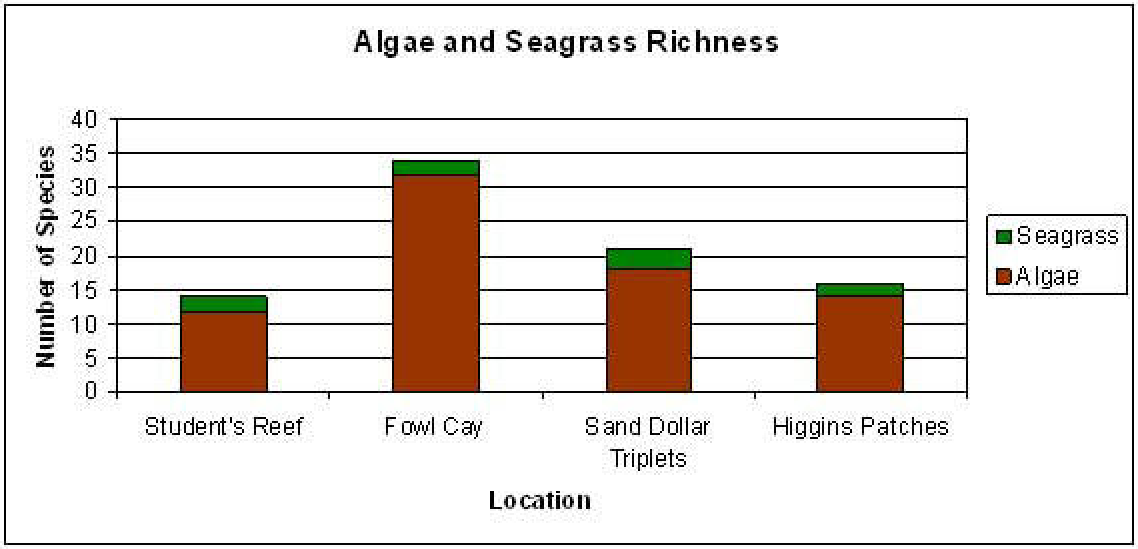
C. ALGAE COMMUNITY SURVEYS

Algae are one of the four main groups of organisms the Earthwatch teams collect data on. They are an integral part of the Bahamian ocean environment as a food source for fish and epifauna and as resource and space competitors with corals. By studying the types and abundance of algae, along with the other four groups of organisms, we can start to see how one affects the other and what the trends mean for the future of the undersea environment.

Our method of data collection for the algae and seagrass surveys was the roving diver technique. This involves one or two staff members, along with several volunteers, swimming around the area of interest and identifying all the species of algae present while noting their abundance. They carry plastic baggies so that the unidentifiable species can be collected and sorted out later with a reference book. The data can then be analyzed for species richness and abundance at each site.

Results:

The Earthwatch Family Team completed four algae and seagrass surveys this summer off the coast of Georgetown, Exuma and the surrounding cays. Out of these four, the survey off of Fowl Cay had the most species richness, as shown in our graph below:



These results are probably due to the amount of living space for the algae. The Fowl Cay habitat was a channel reef with the largest coral surface area than all of the other survey sites combined; so it makes sense that many more species be identified there.

D. WATER QUALITY SURVEYS

Water quality was monitored by volunteers and staff at four sites around Georgetown on a daily basis. Water quality monitoring sites were pre-determined based on the past year's sampling sites, in order to survey seasonal changes. Water quality data was also collected at each survey site where coral, epifauna and fish surveys were performed during the expedition.

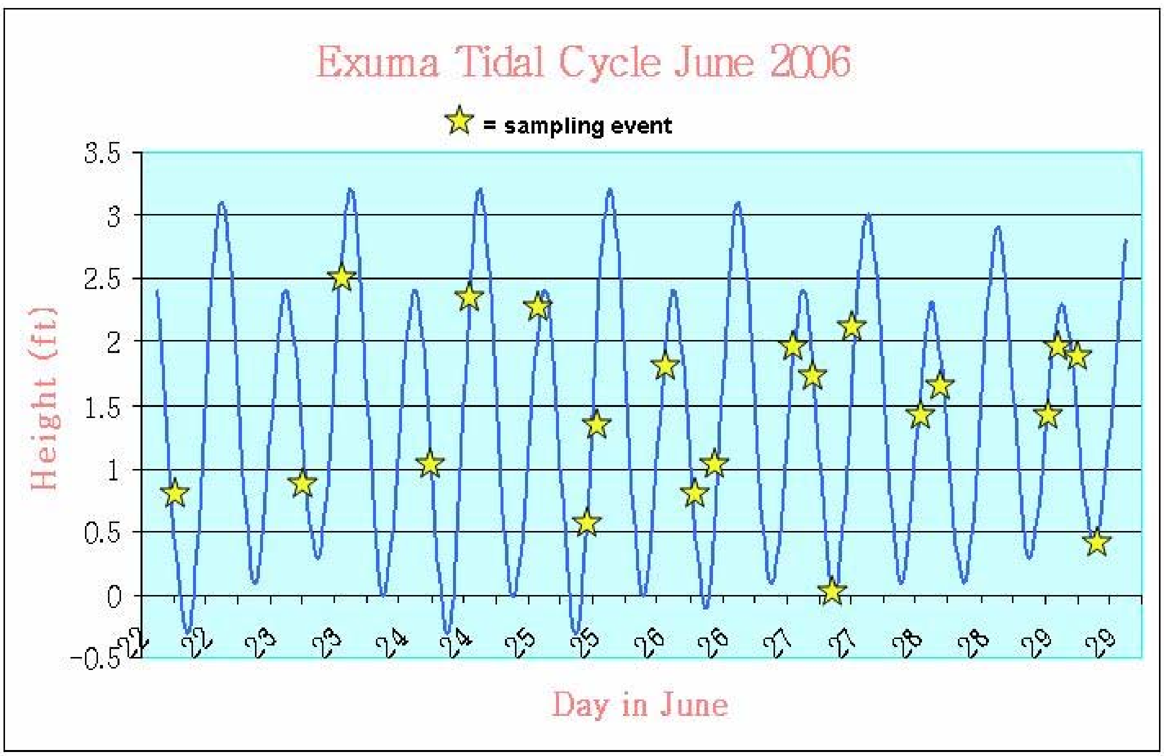
The primary water quality parameters measured are temperature, salinity, dissolved oxygen, and turbidity. Water temperature, salinity, and dissolved oxygen values were determined using a YSI probe. To confirm the data collected electronically, temperature, salinity, and turbidity measurements were taken manually using a pool thermometer, a hand-held refractometer, and a secchi disk, respectively. Water samples were collected in Nalgene bottles during every sampling event at each site, and turbidity was determined using a Nephlometer back at the Exuma Educational and Environmental Resource Centre (EERC).

The sampling design was established to capture the variability over tidal and diurnal timescales for the water quality parameters at different coastal and inland sites on Great Exuma. The sampling program was designed to capture:

- Water quality change between developed sites (many houses and people) and less developed sites (less people and more vegetation).

- Water quality changes over diurnal, tidal and season cycles.

Tidal Fluctuations and Summary of Sampling Events



Graph 1. Tidal fluctuations June 22-29, 2006, Great Exuma, Bahamas.

The previous graph shows the height in feet from sea level of the different tides from June 22-29, 2006. The stars denote sampling events. There were actually 61 water quality readings taken during the 7 days, but the stars show the general time of day and tidal state during the main times of sampling events. Sampling during many different tidal states allows us to monitor changes during the tidal cycle.

Salinity

Salinity is a measure of the inorganic salts dissolved in the water. It is generally measured in "parts per thousand" (ppt). This unit can also be written as ‰, so basically these numbers can be divided by 10 to get the percentage of dissolved salts in the water. For example, a water sample with a salinity of 35ppt contains 3.5% dissolved inorganic salts.

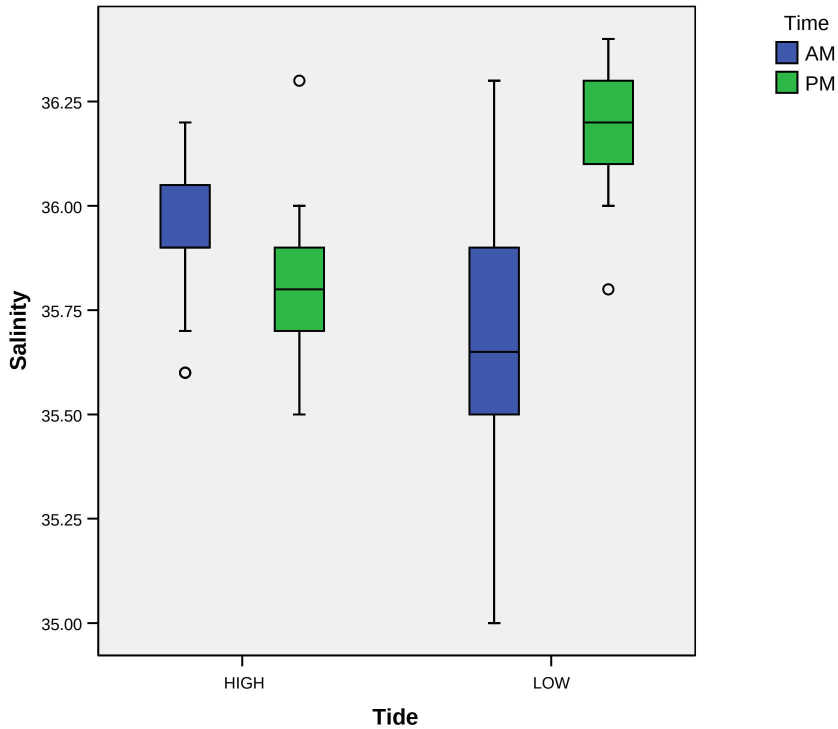
The salinity was taken using the YSI and also manually using a refractometer at each site. The table below (Table 1) shows a summary of the salinity measurements taken at all sites during the expedition for different tidal states and time of day. Standard deviation from the average, minimum and maximum salinities, and total number of readings taken (count) are also shown.

Salinity (ppt)

	HIGH	LOW	AM	PM
MEAN	35.9	35.9	35.9	35.9
S.D.	0.2	0.4	0.3	0.3
MAX	36.3	36.4	36.3	36.4
MIN	35.5	35.0	35.0	35.5
COUNT	42	19	34	27

Table 1. Salinity summary table from all water quality sites on expedition, June 22-29, 2006.

The graph below shows the variation of salinity between high and low tidal states, as well as time of day. The scale on this graph only covers a small range of salinities (only 1.5ppt), which means that the overall variation was extremely low. This is normal for the salinity to remain fairly constant over such a small period of time, unless there is extreme precipitation.



Graph 2. Salinity variance over tidal states and time of day.

Water Temperature

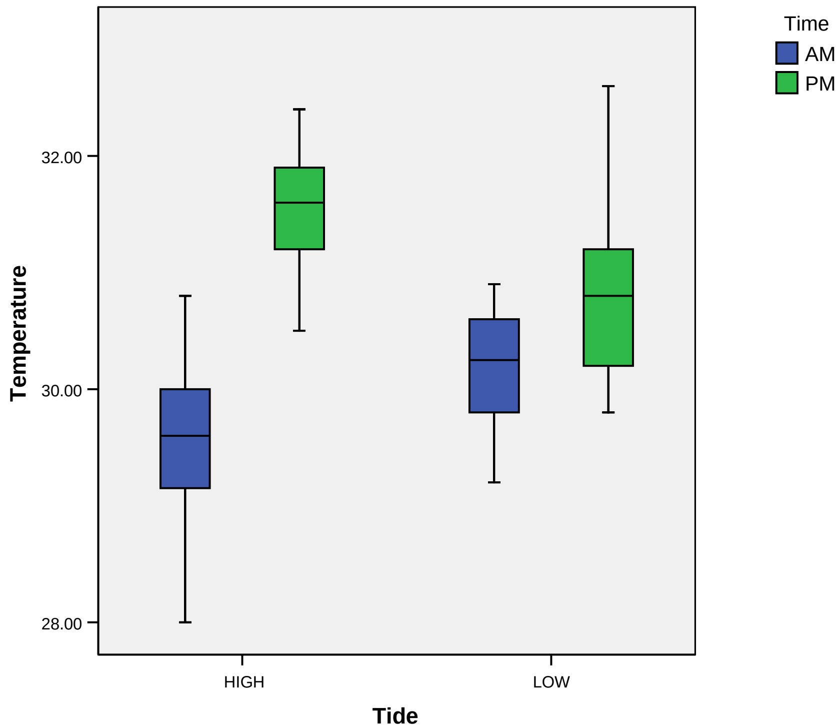
Temperature readings were taken at all sample sites using a YSI probe. The table below shows the average temperatures at high tide, low tide, AM and PM obtained from all sample sites during the entire expedition. Standard deviation from the average, minimum and maximum temperatures, and total number of readings taken (count) are also shown. Overall, temperatures varied little throughout the expedition. The largest difference was between morning and evening readings due to the water warming from UV radiation during the day.

Temperature (˚C)

	HIGH	LOW	AM	PM
MEAN	30.5	30.5	29.8	31.4
S.D.	1.2	0.8	0.7	0.7
MAX	32.4	32.6	30.9	32.6
MIN	28.0	29.2	28.0	29.8
COUNT	42	19	34	27

Table 2. Water temperature summary table from all water quality sites on expedition, June 22-29, 2006.

The graph below shows the variation of water temperature between high and low tidal states, as well as time of day. Again, this scale is fairly small, covering 5°C. Variation in temperature can be largely dependent on the volume of water present in the area of the reading due to the conducting properties of water. This causes the variations seen over the tidal states.



Graph 3. Water temperature variance over tidal states and time of day.

Dissolved Oxygen

Dissolved Oxygen readings were taken with a YSI probe. The importance of these readings is that the difference in DO at sunrise (AM) and at sunset (PM) can tell us something about the organisms living in the water. If the DO is significantly higher in the evening, this probably means that there is a good amount of photosynthesis occurring during the day and also lots of respiration occurring during the night hours, which causes DO to be fairly low in the morning.

The summary tables below confirm these expectations, as the average DO after 12pm is greater than the average DO prior to 12pm.

Dissolved Oxygen (mg/l)

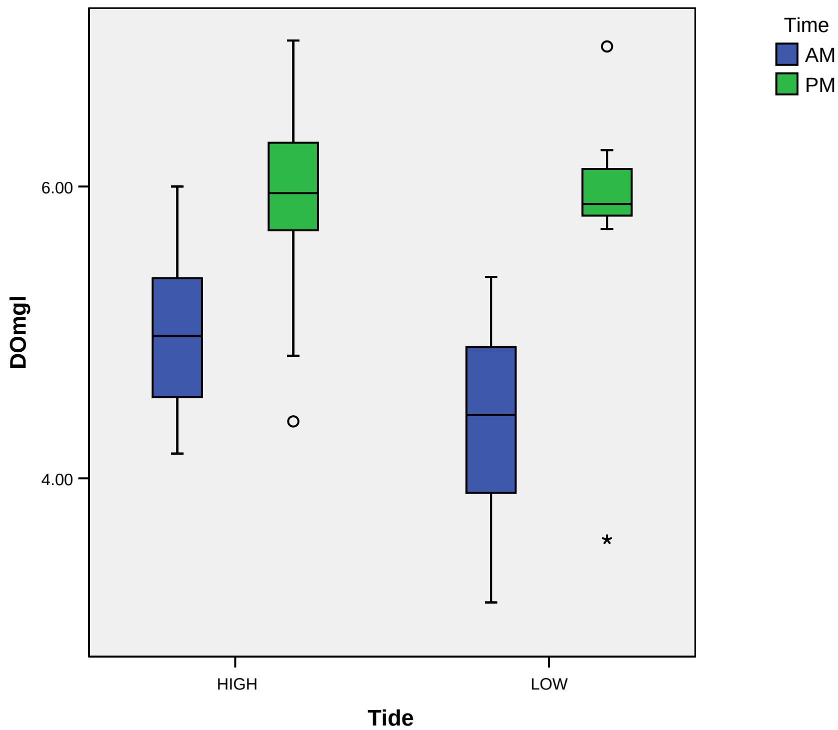
	HIGH	LOW	AM	PM
MEAN	5.4	5.0	4.8	5.9
S.D.	0.7	1.1	0.6	0.7
MAX	7.0	7.0	6.0	7.0
MIN	4.2	3.2	3.2	3.6
COUNT	42	19	34	27

Dissolved Oxygen (%)

	HIGH	LOW	AM	PM
MEAN	87.8	82.3	77.4	97.0
S.D.	13.1	17.0	9.7	11.9
MAX	114.7	117.0	95.6	117.0
MIN	66.8	52.0	52.0	67.5
COUNT	42	19	34	27

Table 3 and 4. Dissolved oxygen summary tables in mg/l and %, respectively from all water quality sites on expedition, June 22-29, 2006.

The following graph shows the variation of dissolved oxygen (mg/l) over high and low tidal states and also for different times of the day.



Graph 4. Dissolved oxygen variance over tidal states and time of day.

Turbidity

The seawater in the Bahamas is generally very nutrient poor, clear water, and the marine organisms there are suited to certain water temperatures and levels of UV radiation depending on the depth of their habitat. If the water becomes uncharacteristically cloudy, or turbid, in these habitats (turbidity levels of >1 NTU), these organisms have a difficult time surviving. This is particularly true for marine organisms that depend on ample sunlight for photosynthesis, like many species of corals and algae.

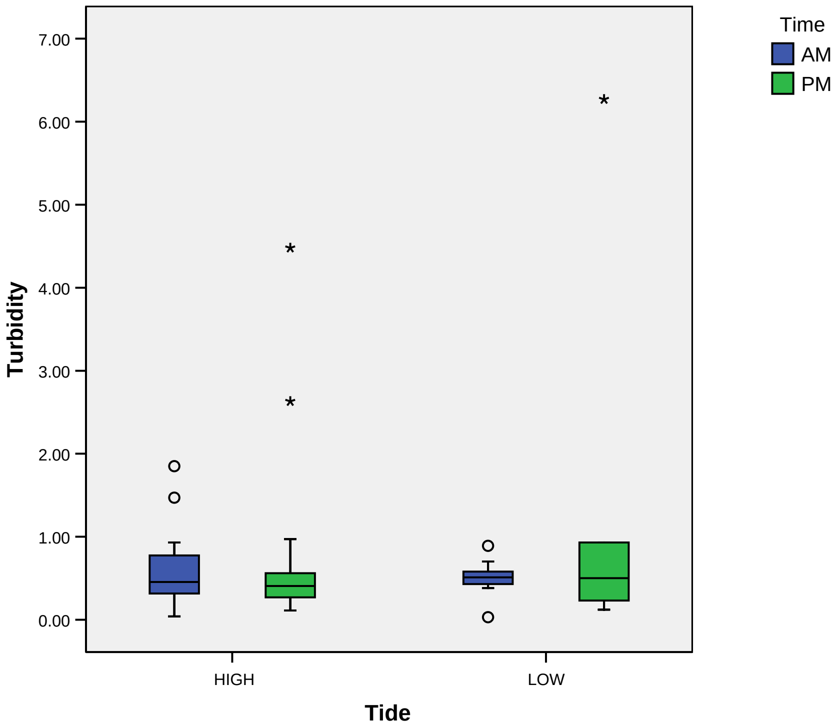
The turbidity readings taken with the nephlometer allow us to monitor the concentration of random particles suspended in the water column, which could range from chemicals to sediments. These readings are given in neplometer turbidity units (NTU). The table below shows the averaged data from all sample sites during the expedition.

Turbidity (NTU)

	HIGH	LOW	AM	PM
MEAN	0.7	0.9	0.6	0.9
S.D.	0.8	1.5	0.4	1.5
MAX	4.5	6.3	1.9	6.3
MIN	0.0	0.0	0.0	0.1
COUNT	38	15	29	24

Table 5. Turbidity summary table from all water quality sites on expedition, June 22-29, 2006.

The turbidity readings were generally very low, as expected. However, there were a few outliers in the turbidity data (readings >1NTU), which mainly occurred at one sample site in particular. The site is off the beach near the Fish Fry area, where many locals gather for a bite to eat. The turbidity readings were very high from all of the samples taken here because of dredging taking place directly off the shore very close to this site. These high numbers can be seen in the boxplot graph below as stars and circles and also in the summary table as the maximum values. These high readings from this area would cause us to expect fewer, if any, healthy organisms near the dredging activity.



Graph 5. Turbidity variance over tidal states and time of day.

<u>Great Guana Cay, Abaco 2006</u>

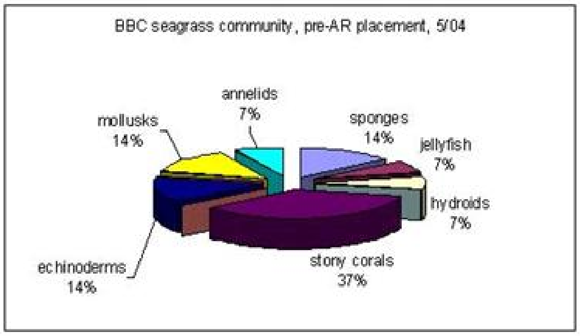
6-26 July 2007

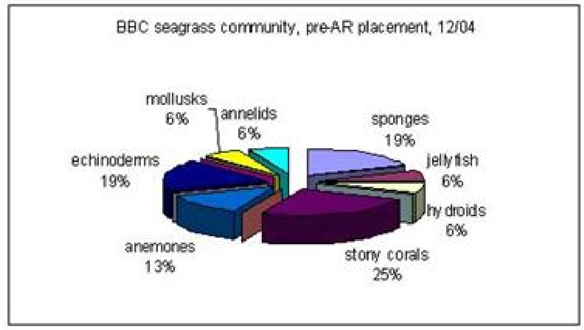
We hosted two Earthwatch teams on Great Guana Cay this year. In addition to our suite of fantastic volunteers and graduate and undergraduate students from the University of Miami, several students and associates from the College of The Bahamas and our project's alumnus, NOAA Fisheries Scientist Vanessa Nero, contributed to data collection and ongoing monitoring of sites around the island.

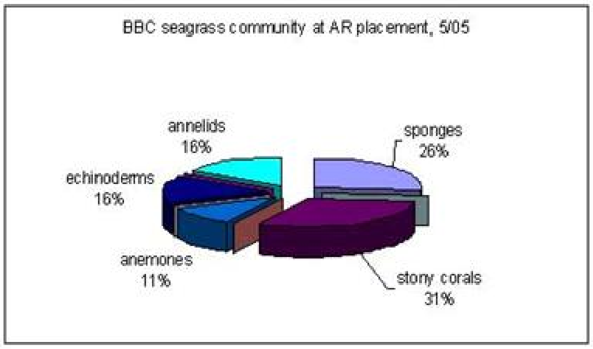
A. EPIFAUNA SURVEYS

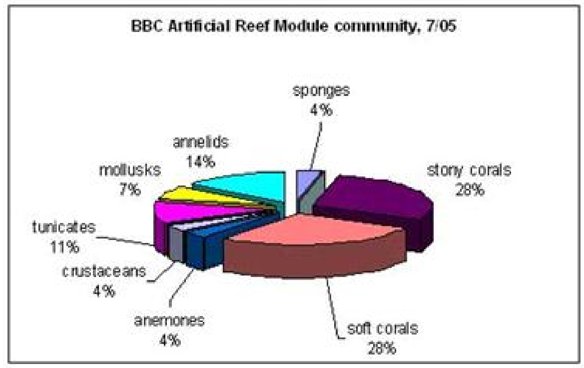
Summer 2006 marked our second year of marine macro-invertebrate community surveys around near shore areas of Great Guana Cay. We continued our roving diver surveys of 50 X 50 m areas, noting all benthic epifauna species present, as well as relative abundance (single, few (2-10), many (11-100), or abundant (>100)).

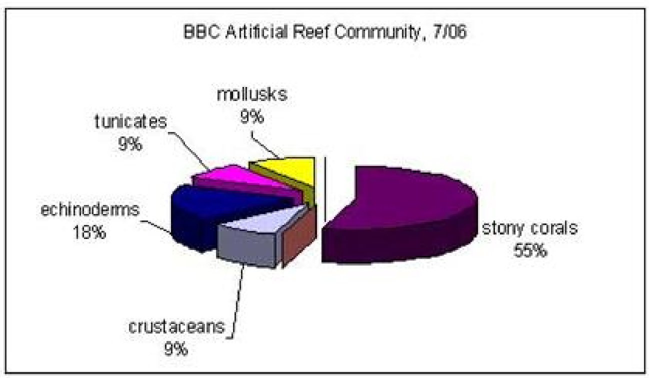
One of our favorite survey sites is the Artificial Reef Module location in Baker's Bay. Established in May 2005, the eight DERM artificial reef modules were a joint project between the University of Miami Bahamas Coastal Ecology lab and Baker's Bay Club. In order mitigate a deteriorated near shore habitat, lab members transplanted coral colonies from a boat wreck to the artificial reef modules. Since that time, we're monitored changes in the local macro-invertebrate community. These changes are as follows:





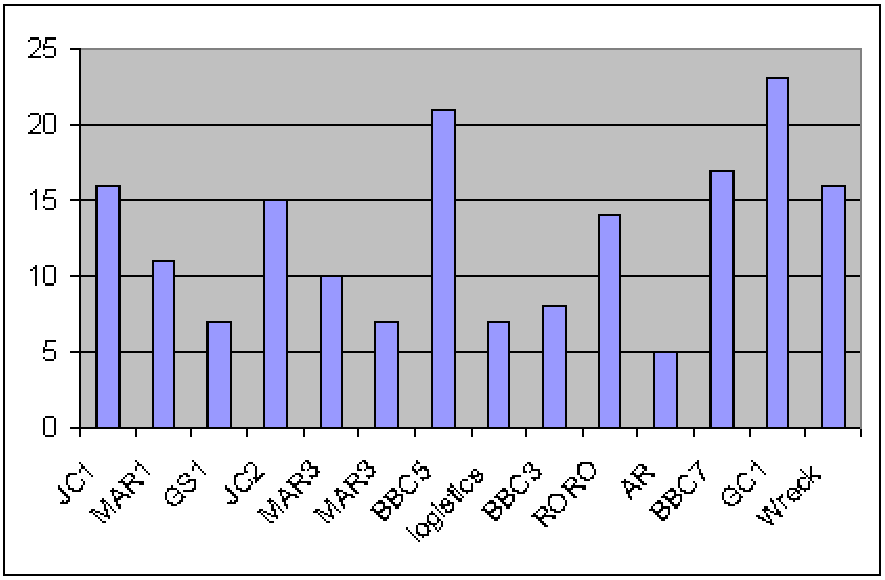






A cyanobacteria bloom of *Lyngbya sp.* began to cover the artificial reefs in August 2005. Cyanobacteria are well-known indicators of elevated nutrient levels in seawater as they respond to the limiting nutrients phosphorous and iron, and are also unpalatable to herbivorous fishes. As is visible at left, the invertebrate community changed remarkably within a year - taxa noticeably absent or reduced in richness include soft corals, anemones, and annelid worms.

Overall species richness observed during Summer 2006:



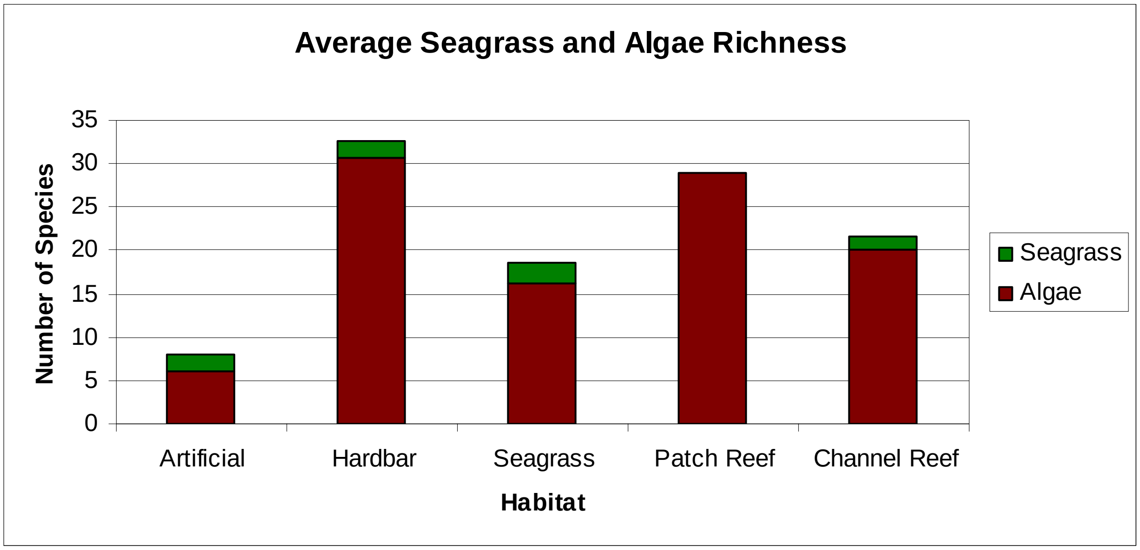
Algae are one of the four main groups of organisms the Earthwatch teams collect data on. They are an integral part of the Bahamian ocean environment as a food source for fish and epifauna and as resource and space competitors with corals. By studying the types and abundance of algae, along with the other four groups of organisms, we can start to see how one affects the other and what the trends mean for the future of the undersea environment.

Methods:

Our method of data collection for the algae and seagrass surveys was the roving diver technique. This involves one or two staff members, along with several volunteers, swimming around the area of interest and identifying all the species of algae present. They carry plastic baggies so that the unidentifiable species can be collected and sorted out later with a reference book. The data can then be analyzed for species richness at each site.

Results:

After collecting the species richness we looked at how the data differed between different habitat types. We found that the hardbar habitat had the most different species of algae as shown in the graph below:



The reason for the hardbar habitat having the greatest species richness might be attributed to the

B. FISH POPULATION SURVEYS

"1 Fish, 2 Fish :An Insiders Guide to Fish Research at Great Guana Cay"

Introduction:

What are fish? Well to many of us they are either a delicious feast best served with a lemon wedge and tartar sauce or the scaly, slimy inhabitants of the oceans deep. In the scientific community, fish can be biological indicators of the overall health and wellbeing of an island's marine, and to some extent, terrestrial ecosystems. Both quantitative data (i.e. fish population sizes, diversity, biomass, distribution, etc.) and qualitative data about fish give scientists some clue as to how fish and affected by their environments. Ideally, fish would be as abundant as they were when the settlement of the Bahamas and adjacent Caribbean archipelagoes occurred in the 7th century CE. But, that is not the case because as the population and tourism increased in the Bahamas, so did the need and dependence on fish. What many people don't realize is how closely fish are tied into many aspects of Bahamian culture, and even more recently in with the economy. Fish aren't just important locally as they provide millions of dollars in exports, thousands of jobs in the harvesting, and fishing is a major tourism industry that supports much of the islands populations.

Seeking to evaluate nationally the coastal fish communities of the Bahamas, this research expedition focused on fish in the northern part of the county, on Great Guana Cay (GGC), a small island in the Abacos. The main focus of this study was to gather data about fish species richness in differing habitats, fish abundance and production in the near shore marine ecosystems surrounding Great Guana Cay. The research focused on characterizing fish communities in seven monitoring locations around the northern end of GGC where a large-scale development and golf community is slated to be built. With regards to the Coastal Ecology of the Bahamas project, the goals of this project were: 1) to characterize and compare the fish populations of the northern Bahamas to other populations in the Bahamas (e.g. Eleuthera, New Providence, Andros), and, 2) to interpret our data so that scientists and the Government of the Bahamas will have information to compare after the development is constructed. By looking at factors such as fish diversity and the number of top predators over a long timeframe, changes can be detected to see if the precautions are effective and/or if fish populations are being altered by local (development, fishing) and regional (water quality, warmer temperatures) impacts. These data provide a starting point to look at sustainable develop in the area and to attempt to keep the ecosystem thriving even after human intrusion.

Methodology:

In order to estimate population sizes and species diversity at surveys sites surrounding Great Guana Cay *roving diver surveys* and *fish tagging* methods were used.

Roving Diver Surveys:

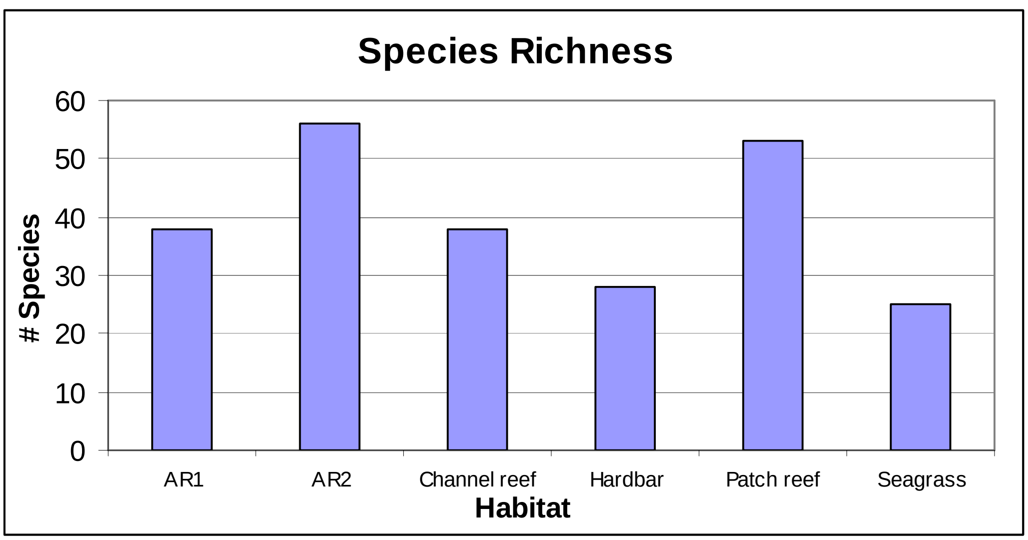
R.E.E.F. (Reef Environmental Education Foundation), roving diver surveys, were conducted on this expedition and surveys were performed at different sites and habitats. More details about the R.E.E.F. project can be obtained at www.reef.org. Teams consisted of a group of staff members and Earthwatch volunteers. The purpose of these surveys is to determine the species abundance and rough population sizes at each of the seven monitoring sites around Great Guana Cay. While snorkeling (less than three meters) for a specified time frame, staff members would survey and record the data on underwater papers or slates while the volunteers aided in fish identification and population estimates. Data consisted of identifying fish species and a population estimate for each species indicated by the following categories: single (1), few (2-10), many (11-99), and abundant (100+). Once the survey was complete, the staff would lead a debriefing and help clear up any problems or questions in identification techniques for individual fish species. Finally, at the end of each day, the data were entered onto a REEF® Fish Survey Forms along with other data (i.e. survey time, habitat, temperature, visibility determined by secci disk, and current) and into a computer spreadsheet. We analyzed the data to see which sites were the most diverse.

Data summary:

- 68 surveys completed
- 76hr 45 min of surveys
- 66 min per survey average

On average 20 species were seen per survey and the **Most Abundant Fish were:**

1. Slippery Dick
2. Sergeant Major
3. Bluestripe Grunt
4. Bluehead Wrasse
5. White Grunt
6. Yellowfin Mojarra
7. French Grunt



Species richness (the greatest # of species) counted in different habitats next to Great Guana Cay. (AR1 is a near shore artificial reef and AR2 is an offshore wreck in deeper water.)

Fish Tagging:

Focusing on commercially valuable fish, tagging was done as part of a long-term study to get information on the abundance and growth of fish in the northern Bahamas. Fish were caught and tagged at three different locations (BBC Wreck, Guana Seaside, and Artificial Reef) over five days using hand lines. Upon capture the fish were put on a fish board and measured for standard length, or the length from the snout to the base of the tail, and total length, which included the length to the tip of the tail. Then one of the staff members would use a tagging gun and insert a colored, numbered tag into below the dorsal fin of the fish and the data was recorded quickly so that the fish could be released back into its habitat. Almost 200 were tagged in total and although only in the starting phase, this fish tagging/capture-mark-recapture project will provide valuable information as to the numbers of fish residing around Guana. During post-tagging visual surveys few tagged fish were seen, and three were recaptured while attempting to tag new fish. This is a very good sign that the fish may be plentiful and as the fish are recaptured, the data will be tracked by staff members.

Data summary:

Total # of Tagged Fish: 194

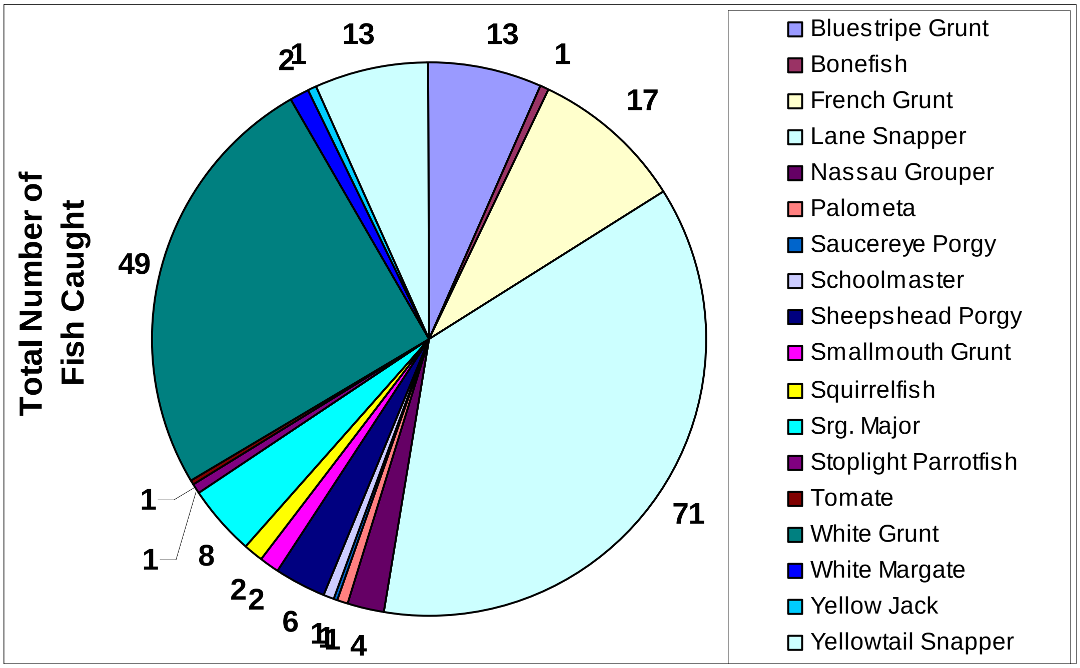
Coincidental Recaptures: 3

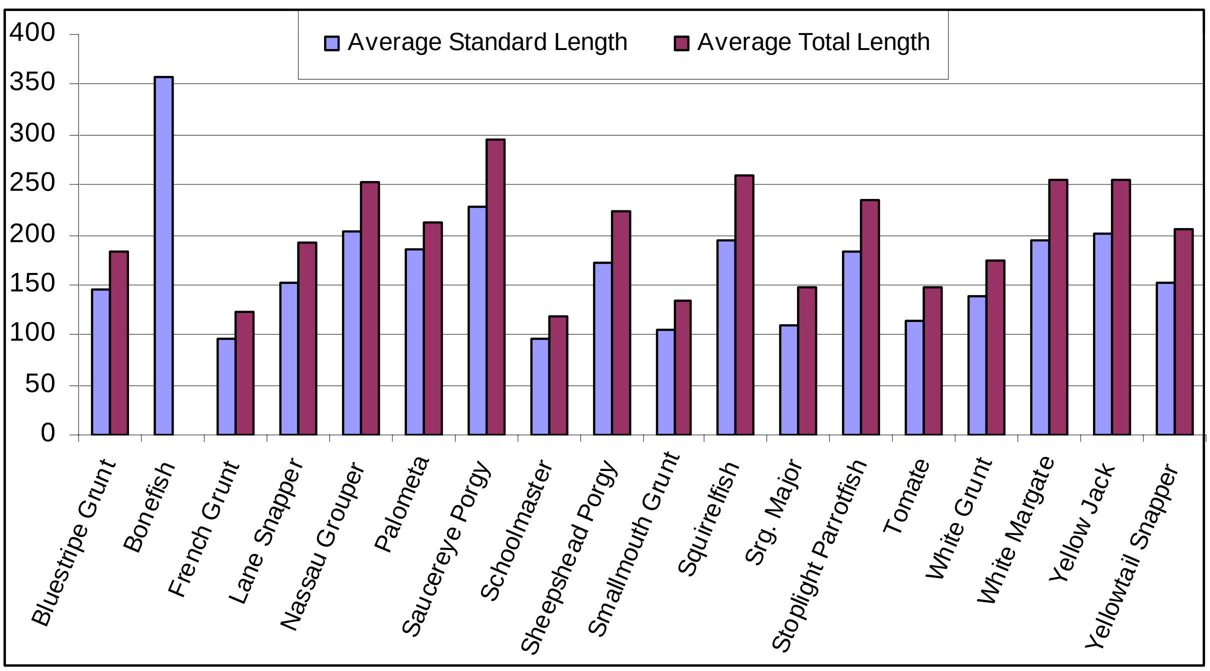
Average Standard Length (mm): 144.10

Average Total Length (mm): 182.90

Species	Average Standard Length	Average Total Length	Number Caught
Bluestripe Grunt	144.6	182.3	13
Bonefish	357	None	1
French Grunt	96	122.3	17
Lane Snapper	150.9	192.4	71
Nassau Grouper	202.5	252	4
Palometa	186	212	1
Saucereye Porgy	229	295	1
Schoolmaster	96	119	1
Sheepshead Porgy	173.1	224.3	6
Smallmouth Grunt	105.5	133	2
Squirrelfish	195.5	259	2
Srg. Major	109.2	148.1	8
Stoplight Parrotfish	183	234	1
Tomate	115	148	1
White Grunt	138.8	175.1	49
White Margate	194	255	2
Yellow Jack	201	254	1
Yellowtail Snapper	152	205.4	13

Site	**Days**	**Total # of Fish**	**# of Species**
BBC Wreck	3	92	7
Artificial Reef	4	40	6
Guana Seaside	3	62	9





Conclusions:

This information represents 21 days of intensive field work. The data collected through roving diver surveys and fish tagging will prove to be very useful not only for our analysis of fish production in the near shore ecosystems of Guana Cay, but also for other scientists battling similar issues around the world. In addition, we hope that it will to help scientists and the general public better understand the processes that shape the marine ecosystems so that these fragile fish habitats can be protected adequately. Looking collectively at the fish data gathered from the Coastal Ecology of the Bahamas we will be able to determine what biotic and abiotic factors cause fish production to be higher at certain sites and whether preventative measure incorporated into developments will help sustain fish biodiversity and abundance.

Highlights of this summer's finding are:

- Species richness differs between habitats in coastal waters, with artificial reefs having the most species.

- Coastal systems are very dynamic and long timeframe of preliminary data from different seasons and years is needed to adequately characterize fish communities. Only then can impacts from local (development, fishing) and regional (water quality, warmer temperatures) occurrences be measured.

- There is a diversity of commercial fish in the northern Bahamas. White grunts and lane snappers were the most abundant caught during the tagging studies. However, a minimal number of large top-level predators were caught.

- An invasive Pacific lion fish was seen during the R.E.E.F. surveys. Future studies should watch for this species and report sighting to R.E.E.F.

C ALGAE SURVEYS

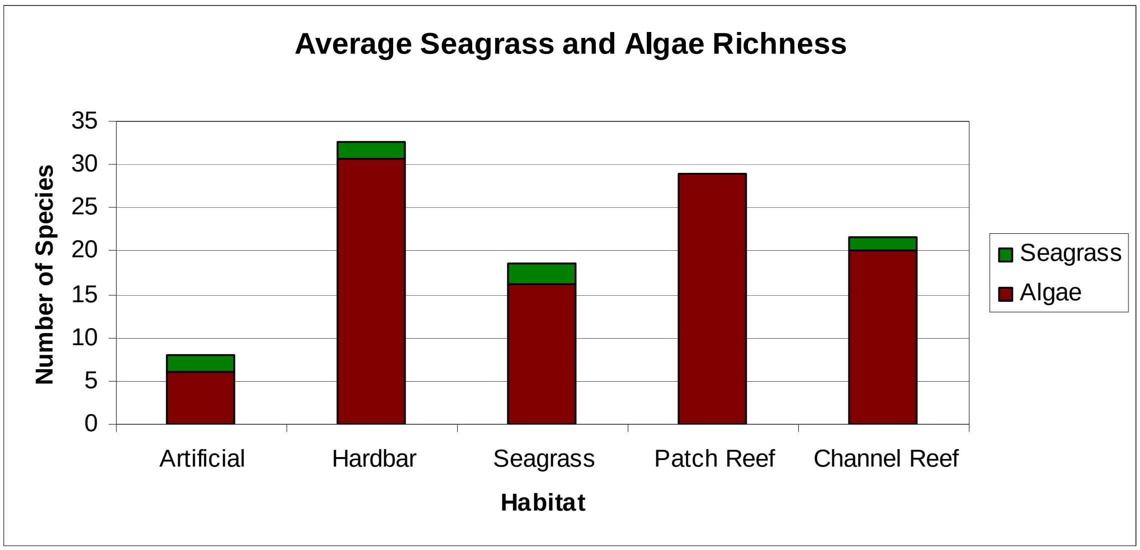
Algae are one of the four main groups of organisms the Earthwatch teams collect data on. They are an integral part of the Bahamian ocean environment as a food source for fish and epifauna and as resource and space competitors with corals. By studying the types and abundance of algae, along with the other four groups of organisms, we can start to see how one affects the other and what the trends mean for the future of the undersea environment.

Methods:

Our method of data collection for the algae and seagrass surveys was the roving diver technique. This involves one or two staff members, along with several volunteers, swimming around the area of interest and identifying all the species of algae present. They carry plastic baggies so that the unidentifiable species can be collected and sorted out later with a reference book. The data can then be analyzed for species richness at each site.

Results:

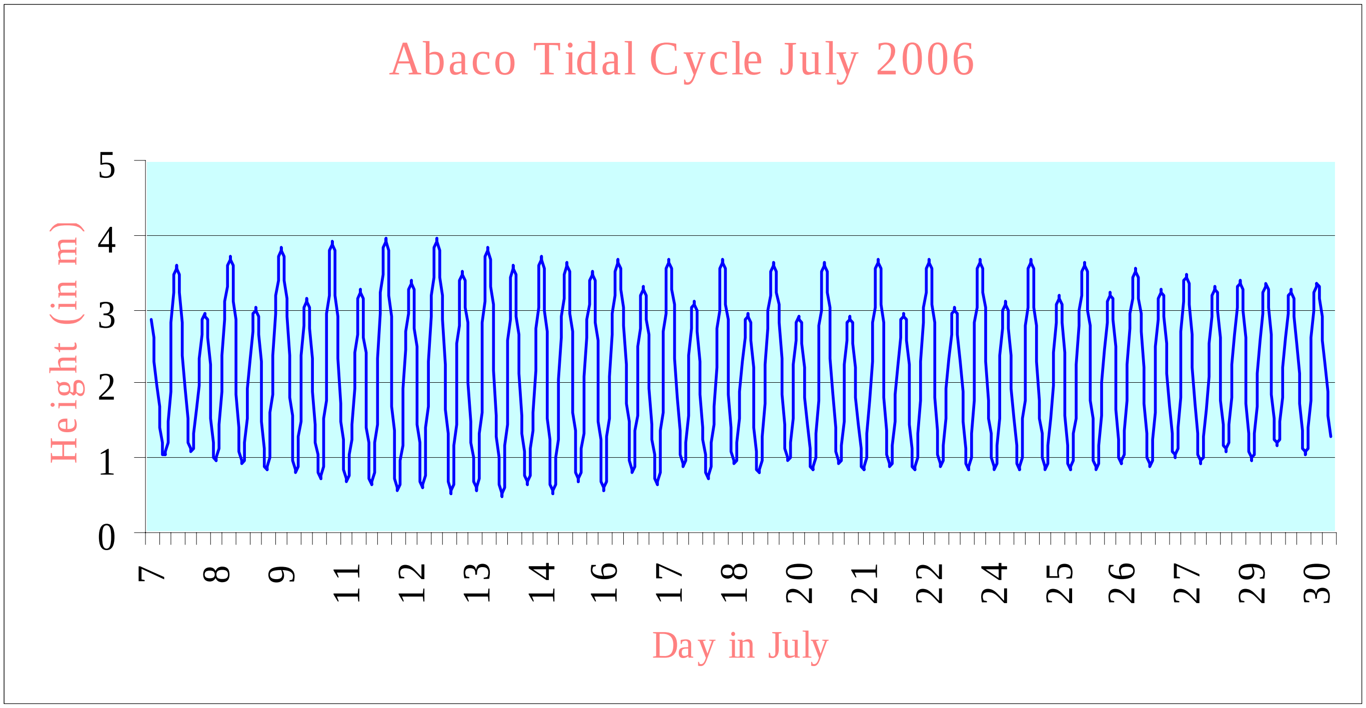
After collecting the species richness we looked at how the data differed between different habitat types. We found that the hardbar habitat had the most different species of algae as shown in the graph below:



D. WATER QUALITY AND WEATHER SUMMARY

Water quality was monitored by volunteers and staff at several sites around Great Guana Cay and along off-shore and long-shore transects off the coast of the island. Water quality monitoring sites were pre-determined based on past sampling sites, in order to re-survey for seasonal data and to provide water quality data at the sites used to coral, epifauna and fish surveys. Water temperature, salinity, dissolved oxygen, and conductivity were determined using a YSI probe. To confirm the data collected electronically, temperature, salinity, and turbidity measurements were taken manually using a pool thermometer, a hand-held refractometer, and a secchi disk, respectively. Water samples were collected at each site in Nalgene bottles and turbidity was determined later that day using a Nephlometer.

Tidal Fluctuations and Summary of Sampling Events



The graph above shows the height in feet from sea level of the different tides throughout the month of July when water sampling was completed. The tidal cycle in Abaco is semi-diurnal, with two high and two low tides per day. There were 322 water quality readings taken over 23 days at all different points in the tidal cycle. Sampling during many different tidal states allows us to monitor changes during the tidal cycle.

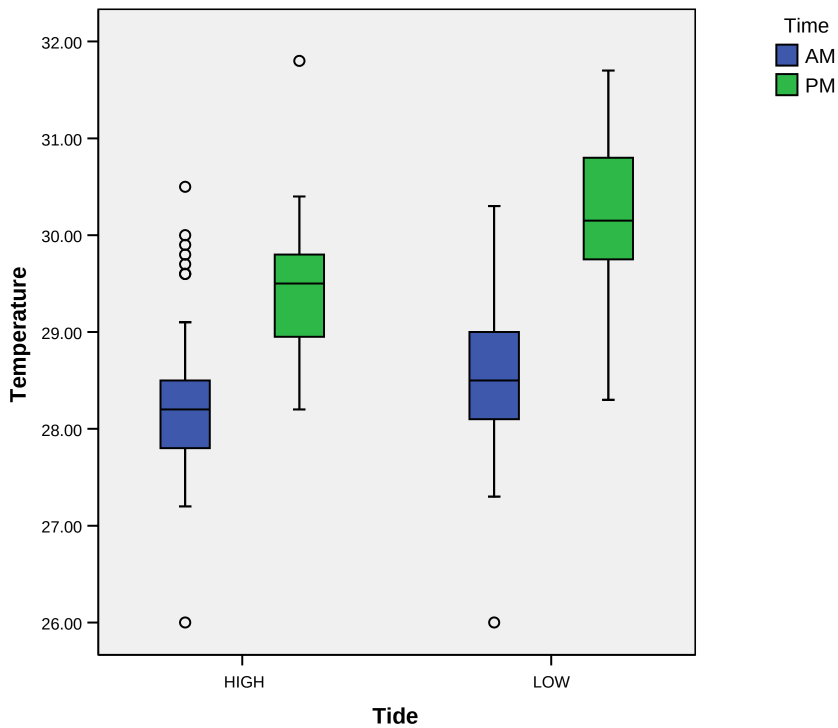
Water Temperature

Temperature (°C)

	HIGH	LOW	AM	PM
MEAN	28.4	28.8	28.3	29.8
S.D.	1.0	0.8	0.8	1.2
MAX	31.8	30.8	31.8	31.7
MIN	26.0	27.3	26.0	27.5
COUNT	87	74	131	30

Temperature readings were taken at all sample sites using a YSI probe. The table above shows the average temperatures (in degrees Celsius) at high tide and low tide, and also for AM and PM obtained from all sample sites during all expeditions in July. Standard deviation from the average temperature, minimum and maximum temperatures, and total number of readings taken (count) are also shown. Overall, temperatures varied little throughout the expedition. The main difference was between morning and evening readings, probably due to the water warming from UV radiation during the day.

The graph below shows the variation of water temperature between high and low tidal states, as well as time of day. Variation in temperature can be largely dependent on the volume of water present in the area of the reading due to the conducting properties of water. This causes the variations seen over the tidal states.



Dissolved Oxygen

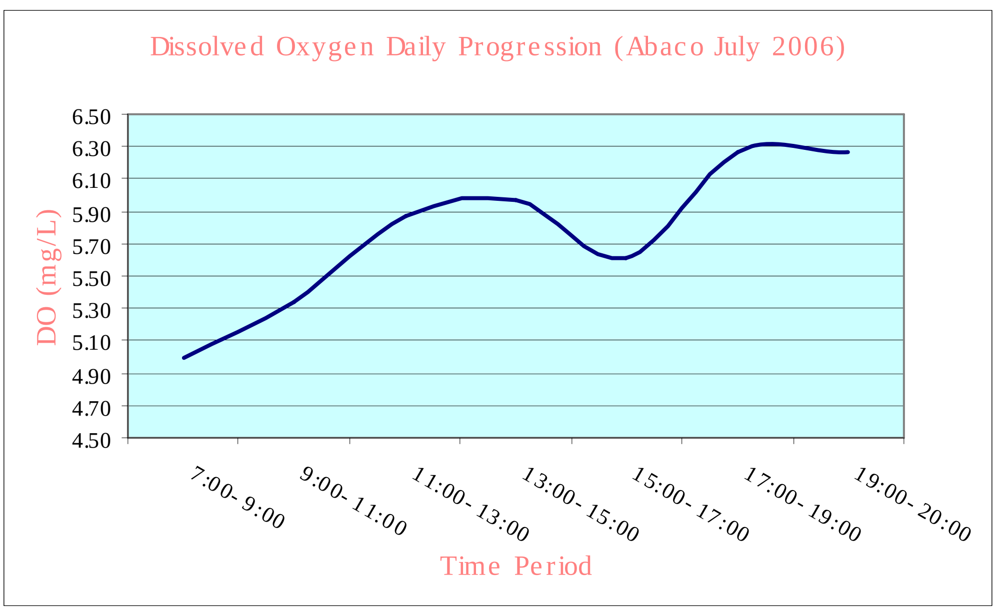
Dissolved Oxygen readings were taken with the YSI probe. The importance of these readings is that the difference in DO at sunrise (AM) and at sunset (PM) can tell us about something the organisms living in the water. If the DO is significantly higher in the evening, this probably means that there is a good amount of photosynthesis occurring during the day and also lots of respiration occurring during the night hours, which causes DO to be fairly low in the morning.

DO(mg/l)

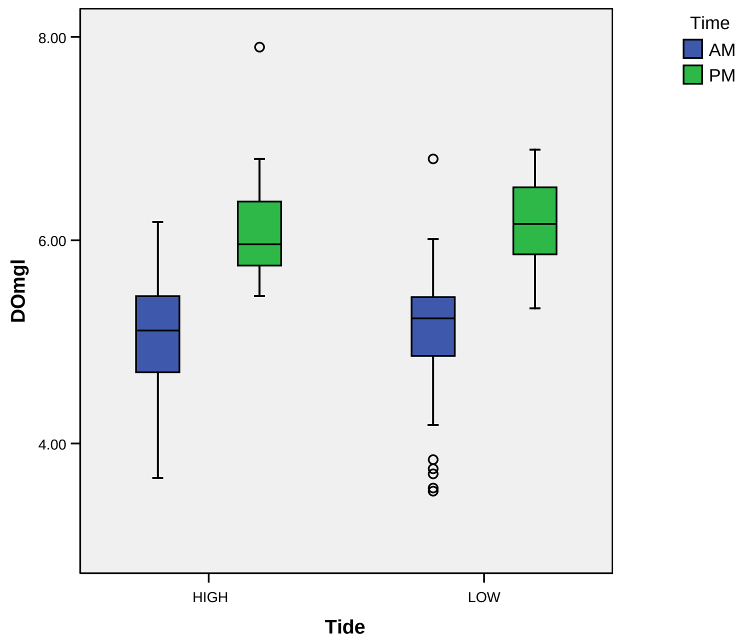
	HIGH	**LOW**	**AM**	**PM**
MEAN	5.2	5.3	5.1	6.1
S.D.	0.6	0.8	0.7	1.0
MAX	7.9	6.8	7.9	6.5
MIN	3.8	3.5	3.5	4.2
COUNT	78	66	121	23

The table above shows the summary of the dissolved oxygen data (in mg/l) from all sample sites around Great Guana. The important numbers to notice here are the average DO readings for AM and PM. The average for all readings after 12pm is higher than that for readings before 12pm, however the difference is not as great as what we have seen in previous studies around the Bahamas.

The graph below shows the progression of dissolved oxygen concentrations (mg/l) for all sample sites throughout the day. The drop occurring around 16:00 is unusual but is probably due to the low number of samples taken during that time period (n=1).



The following graph shows the variation of dissolved oxygen (mg/l) over high and low tidal states and also for different times of the day.



Salinity

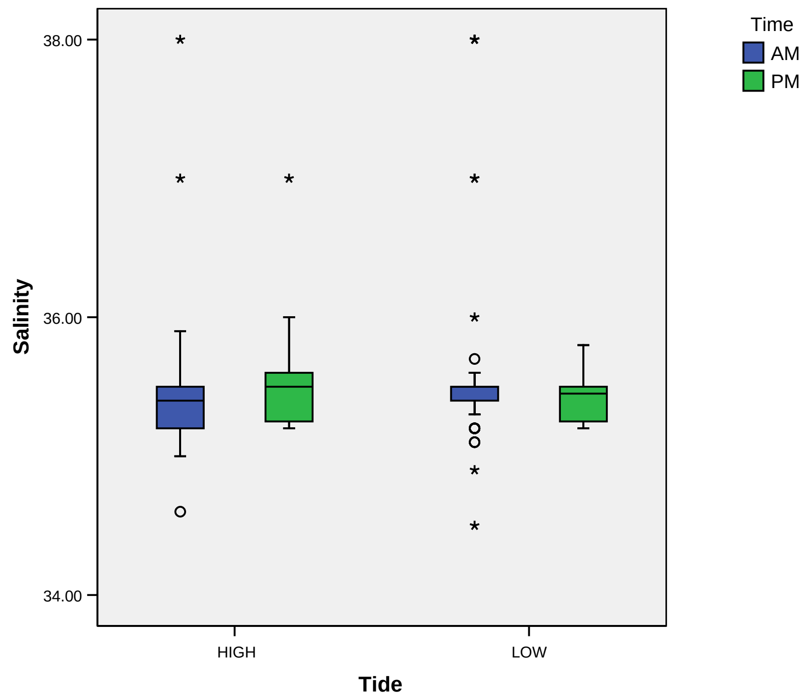
Salinity is a measure of the inorganic salts dissolved in the water. It is generally measured in “parts per thousand” (ppt). This unit can also be written as ‰, so these numbers can be divided by 10 to calculate the percentage of dissolved salts in the water. For example, a water sample with a salinity of 35ppt contains 3.5% dissolved inorganic salts.

Salinity (ppt)

	HIGH	LOW	AM	PM
MEAN	35.4	35.6	35.6	35.5
S.D.	0.4	0.7	0.6	0.4
MAX	38.0	39.0	39.0	35.7
MIN	34.9	34.5	34.6	34.5
COUNT	87	74	131	30

The salinity was taken using the YSI and also manually using a refractometer at each site. The table above shows a summary of the salinity measurements taken at all sites during the expedition for different tidal states and time of day.

The graph below shows the variation of salinity between high and low tidal states, as well as time of day. Generally, the variation in salinity was very low, with the exception of a few outliers, denoted as stars and circles on the graph. It is normal for the salinity to remain fairly constant over such a small period of time, unless there is extreme precipitation. The outliers could be due calibration problems with the YSI meter.



Turbidity

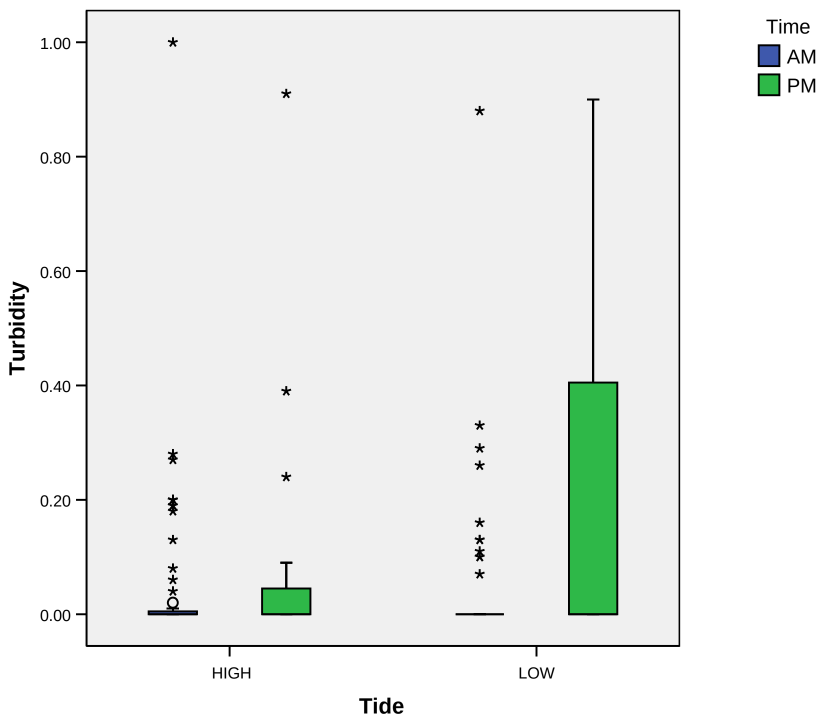
The seawater in the Bahamas is generally very nutrient poor, clear water, and the marine organisms there are suited to certain water temperatures and levels of UV radiation depending on the depth of their habitat. If the water becomes uncharacteristically cloudy, or turbid, in these habitats (turbidity levels of >1 NTU), these organisms have a difficult time surviving. This is particularly true for marine organisms that depend on ample sunlight for photosynthesis, like many species of corals and algae. Dredging, on-shore development, and other anthropogenic activities can often cause uncharacteristically turbid waters, so turbidity levels are of key interest around Guana Cay, where development is currently taking place.

The turbidity readings taken with the nephlometer allow us to monitor the concentration of random particles suspended in the water column, which could range from chemicals to sediments. These readings are given in neplometer turbidity units (NTU). The table below shows the averaged data from all sample sites during the expedition.

Turbidity (NTU)

	HIGH	LOW	AM	PM
MEAN	0.1	0.1	0.0	0.2
S.D.	0.2	0.2	0.2	0.2
MAX	0.9	1.0	1.0	0.7
MIN	0.0	0.0	0.0	0.0
COUNT	86	73	129	30

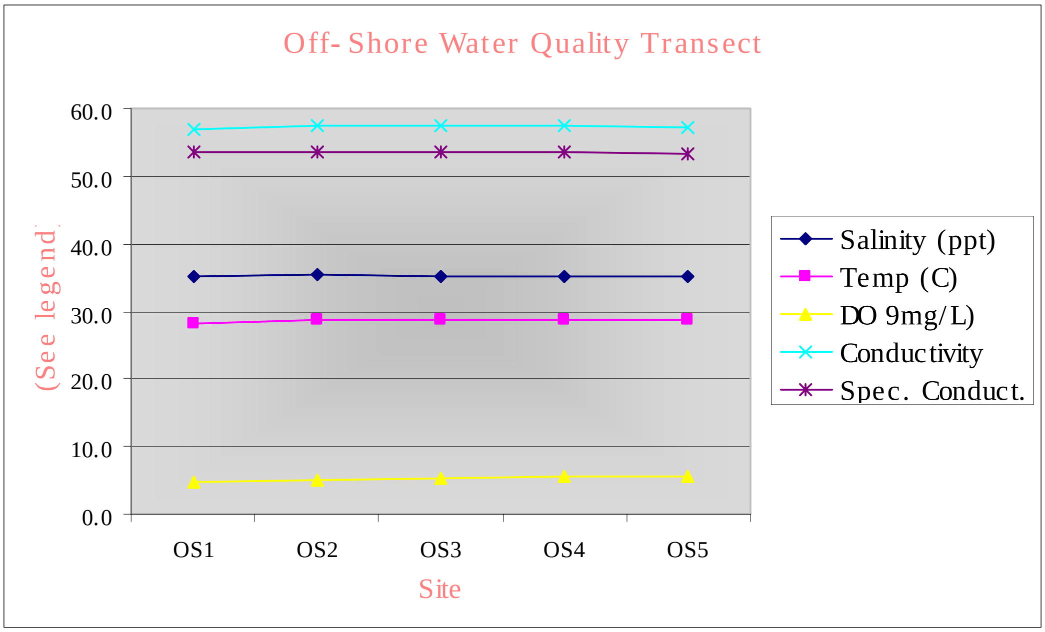
The graph below shows the variation in turbidity levels between high and low tidal states, as well as time of day.



Overall, the turbidity around Great Guana Cay was very low at all sites in July. There were a few outliers, but this was most likely due to human flipper action or the boat motor mixing up sediments in the water where the water sample was collected. All turbidity readings taken were ≤1 NTU, which is very low. These numbers are significantly lower than the levels of turbidity that cause to damage corals or block sunlight for other organisms.

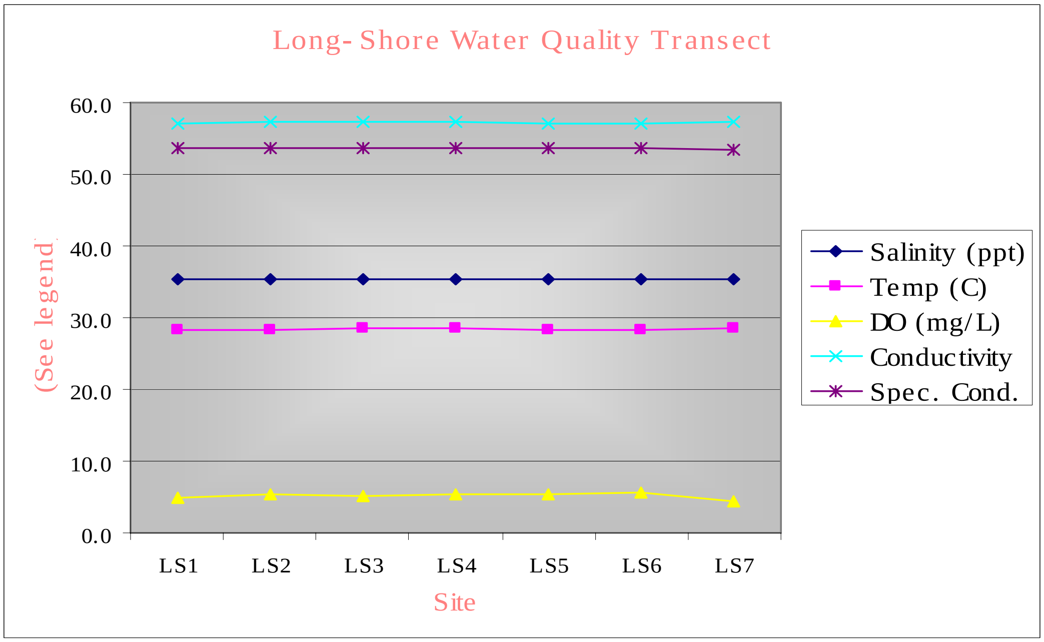
Water Quality Transects

The off-shore transect consisted of 5 sites from the bay-side coast of Great Guana starting from the Guana Seaside Resort dock and heading off-shore, perpendicular to the island (OS1—>OS5). The transect sites were sampled 4 times over 9 days in July.



The graph above shows the parameters measured at each site along the off-shore transect. Measures of conductivity and specific conductivity were taken with the YSI and are used to aid in salinity measurements. Although the scale is very large on this graph to account for the range of values of the different parameters, it is easy to see that there were only negligible changes in all of the parameters along the transect.

The long-shore transect consisted of 7 sample sites along the bay-side coast of Great Guana starting from the Guana Seaside Resort dock and heading toward the northwest, along the island toward the new development area (LS1—>LS5). The transect sites were sampled 3 times over 4 days in July.



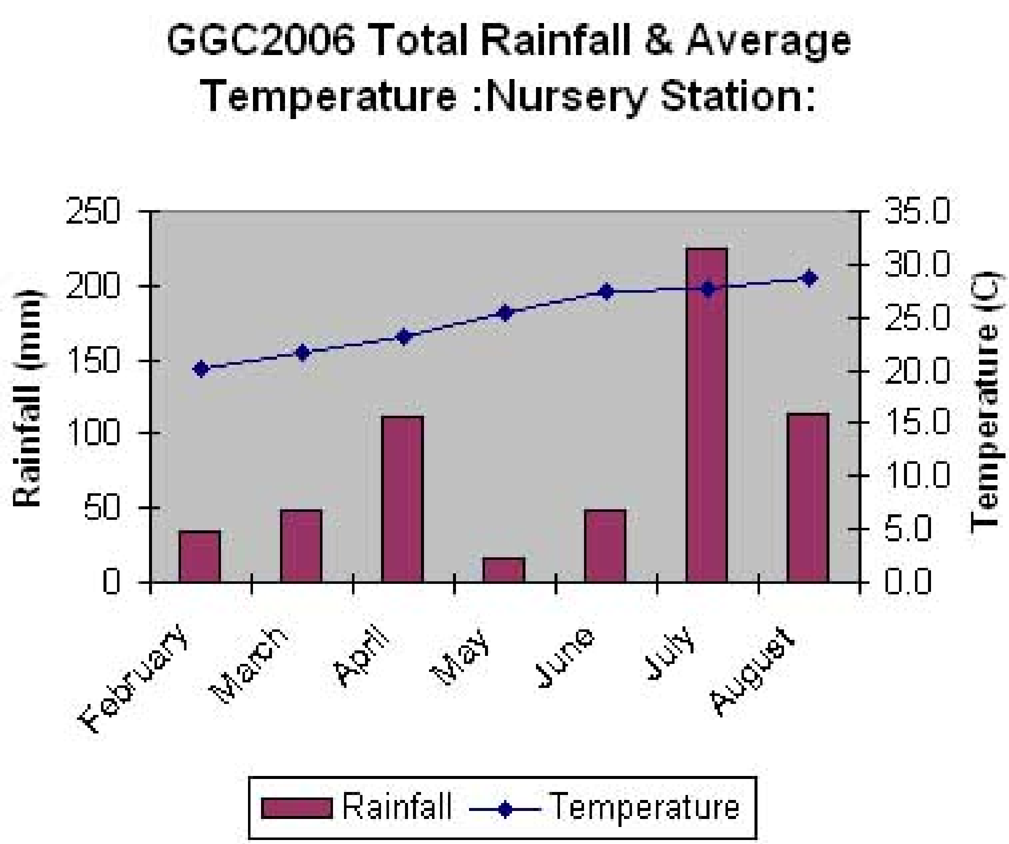
The graph above shows the parameters measured at each site along the LS long-shore transect. This graph also shows very negligible changes in all measured parameters over the length of the transect.

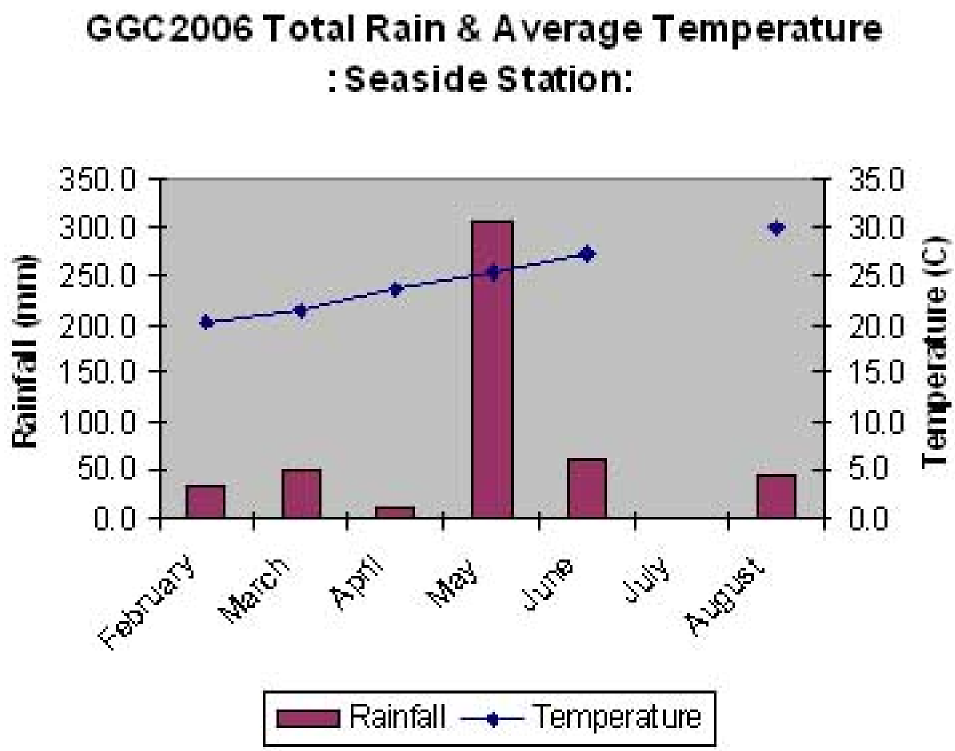
These transect results suggest that the measured parameters vary little along and around the bay-side of Great Guana Cay, and do not seem to be affected by different levels of development taking place onshore relative to the different transect sample sites. In comparing the data from the long-shore and off-shore transects, we can see that the water quality parameters measured are very similar and consistent both close to shore and relatively further off-shore.

Guana Weather

In ecological science it is important to understand the relations between the physical factors, such as, climate and the distribution of the living species. As part of the research in the Coastal Ecology of the Bahamas project, weather information is gathered to help better understand the local distribution and abundance of the coastal and marine plants and animals investigated. Regionally, monitoring weather conditions (e.g. temperature and rainfall) over time will be used to understand patterns of nutrient cycling which is important for pollution and coastal dynamics studies. Also, coastal management can be improved by looking at data historically, for proper hurricane and large-storm preparedness.

This report highlights eight months of weather data collected from Great Guana Cay, The Abacos, The Bahamas. Two weather stations were installed at the end of January, 2006, with the aid of The Bahamas Department of Meteorology. They were installed as an aid for coastal management, in consideration of a large-scale development slated to be built on the northern end of the island. The data shows large differences in annual rainfall and temperatures and highlights the random, often extreme short-term rainfall events that affect the island. The graphs also show large differences between the two weather stations, and thus, the sporadic nature of the local climate. This means that long-term monitoring is needed to best understand the influence of climate on the local ecology of the area. Currently this information is used to correlate sedimentation rates to rainfall and these initial findings will be used to understand the basic climate over a one year cycle in the northern Abacos.





E. Land Crab Population Study

Surveys were conducted primarily at dawn and at night from July 7 to July 25, 2006. The number of land crabs sighted, tagged, and re-sighted were documented. Data collected also included sex, mating status, and carapace length (mm).

Results:

Species	Carapace length (mm)		Sex Ratio[1]	Females with eggs (%)	Population Size[2]	Population Density (Individuals/m²)	Tagged[3] (%)	Re-Sighted[4] (%)
	Male	Female						
Gecarcinus lateralis	32.2 (14.5)	32.2 (10.9)	1	2.8	187474	10.89	9	5.5
Cardisoma guanhanii	89.2 (15.7)	84.0 (14.8)	1	16.1	930.3	0.23	12.2	19.1
Ucides cordatus	77.5 (17.5)	61.3 (8.1)	3	76.9	140.5	0.04	30	22.2
Pachygrapsus crassipes	45.2 (8.2)	52.0 (20.8)	1	100	N/A	N/A	N/A	N/A

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[1]Number of males per female

[2]Calculated using the following equation:

Population = tagged individuals (un-captured + tagged + (re-sighted +1) / re-sighted +1))

[3]Total individuals tagged / (total individuals tagged + total un-captured)

[4]Re-sighted individuals / total tagged

DISCUSSION

1. Males and females are not distinguished by size; *Ucides* may be an exception to this caveat.

2. Populations were comprised of equal numbers of males and females, except for *Ucides*, where males were three times more abundant than females.

3. Abundance: *Gecarcinus* greatly outnumbered the other species; *Cardisoma* (0.23 individuals/m^2) and *Ucides* was the least abundant (0.04 individuals/m^2)..

4. Mating status: All *Pachygrapsus* females and the majority of *Ucides* females (77%) were observed with eggs at capture.

5. Mating status was inversely related to population size.

F. FERAL CAT POPULATION SURVEY AND TRAPPING

The Problem: Feral or stray cats have had significant impacts on biodiversity in island systems, and are listed as one of the 100 worst invasive species (Lowe et al. 2002). Feral cats are particularly problematic in decimating small mammal, bird, and reptile populations in islands; in The Bahamas, feral cats are attributed to reduced populations of Sandy Cay Rock Iguanas (Fry 2001), Grand Bahama Brown-headed Nuthatch (Hayes et al. 2004), the Bahama Parrot (Gnam and Burchsted 1991), and several Long Island bird species (Buden 1992). Although the literature contains no record of feral cat impact on land crab populations, such interactions have been recorded from other island systems (Alexander 1979, Algar et al., Merton et al. 2002) and therefore feral cats are most likely impacting Land Crab populations in The Bahamas. Additionally, cats are known hosts for a number of diseases and parasites, including *toxoplasmosis*, hookworm, and "ground itch." Conservation techniques employed to control cat populations on islands have been successful in preventing extinctions and restoring ecosystems in the past decade (and is reviewed by Nogales et al. 2004). In order to prevent further negative impacts on bird, reptile, and land crab populations on Great Guana Cay, control and eventual eradication of feral or stray cats is suggested.

Methods of dealing with feral cats: Methods employed in cat population control include trapping (gin traps or cage traps), hunting (with dogs, rifles, or guns), poisoning, and viral disease introduction. Trapping has been cited as the most effective method employed due to its success on 44 islands (Nogales et al. 2004). Toxins and biological controls are reported to be most successful at the beginning of an eradication operation, while hunting and trapping proved to be most effective at eliminating all cats.

Traps employing bait as well as olfactory and auditory stimuli have been effective in controlling cat population on New Zealand; luring cats with Felid Attracting Phonic (FAP) producing cat call sounds, as well as blended mixtures of urine and feces allowed for the removal of 230 cats from Cocos Islands (Algar et al. 2003). Some cats were also hand-caught. Common cat baits used in traps include food items such as sausage and fish, and suspending bait serves to prevent non-target species from entrapment. Catnip and matatabi powder have also proved to be promising cat lures, and may be more effective than social odors, including urine (Clapperton et al. 1994).

Estimation of population size: Methods for feral cat population estimation have been described by Van Rensburg et al. (1987). The island study area is stratified into coastal and interior zones, and further divided into equal sized grid blocks.

Population size ($\hat{Y}$) is estimated as

$$\hat{Y} = \Sigma N_i y_i$$

where N_i is the total number of grid blocks in the *i*th zone and y_i is the average number of cats observed or caught in each of the sampled grid blocks.

Fate of trapped cats: Feral cat health is generally low to moderate due to ease of parasite contraction and viral disease spread within family units. Reported gastrointestinal parasite rates have been reported as high as 45%, roundworms at 25 to 75%, hookworms at 10-60%, and *Giardia* at 5% (Urban Integrated Pest

Management, University of Arizona). Feral cats are generally not recognized as natural rabies vectors, but can be exposed to the virus through wildlife attacks by other carnivores (rabies is absent on Great Guana Cay due to lack of suitable vector species, and is not present on any Bahamian Island as of July 2006). FIV and FeLV affects less than 2-4% of feral cat populations (lower than in domestic cats), and distemper is relatively rate in feral cats (SPCA).

Plan for Controlling Cat Populations on Great Guana Cay: Our goal is to eradicate feral cats on the island, and continue trapping to monitor the introduction of new cats. The use of 15 cage traps has been approved by Mr. Pinder, Director of The Bahamas Ministry of Agriculture. These traps will be loaned by Mr. David Knowles, and will be placed at various locations around the Baker's Bay Club property. The traps will be baited with fish and catnip, and checked daily. Hand-capturing will also be attempted. Dr. Derek Bailey, a veterinarian based in Marsh Harbour, will be assisting with cat disease testing, sterilization, and euthanasia.

Captured cats are sent to Dr. Bailey on the 8 a.m. ferry from Guana Cay on the day they are caught. Tests for Feline Leukemia Virus (FeLV) and Feline Immunodeficiency Virus (FIV) will be administered, and any cats testing positive for either of these diseases or who show signs of intense parasite infections will be euthanized. Data collected on disease incidence will be employed in Dr. Bailey's ongoing study of disease spread on offshore cays. Healthy cats will be spayed or neutered (at $70 per cat for both disease testing and sterilization), and home placement attempts will be made in Marsh Harbour. Cats that are not adopted out will be released back into the field.

Results of Feral Cat Trapping at Bakers Bay Golf and Ocean Club

The BBC Environmental Management Team and Earthwatch volunteers initiated the feral cat trapping project, as part of the Integrated Pest Management Plan, at the southern end of the Bakers Bay Property and Guana Seaside beginning 8 July 2006. Shenique Albury picked up 15 traps from Mr. David Knowles in Abaco prior to the arrival of the UM Environmental Monitoring Team and Earthwatch volunteers, who set and monitored nine traps to establish a protocol and synopsis of trapping methods. The traps received were large "Humane Box Traps" (Safeguard Brand 52842) measuring 42"x15"x18"H. The manufacturer suggests a smaller trap for cats; the traps employed in this initial project were designed for large raccoons.

Over the past two years, the UM EMT has recorded first the presence of feral cats around the Guana Seaside resort, and since January of 2006, a noticeable increase in cats not only around the resort but on the BBC property proposed preserve. The opening of roads and increased human activity on the BBC property may have facilitated feral cats to move north. The cats were seen as a significant threat to wildlife on the BBC property, particularly birds and small herpifauna. The EMT was particularly concerned with the threat of cats in the coastal buffer zone to emerging turtle hatchlings and nesting shore birds. The Integrated Pest Management Plan (IPM) calls for the removal and control of both feral cats and rats on the BBC property. Although cats may not be an immediate threat to Bahamas parrots on Guana Cay, the experiences gained on this eradication project could help other groups starting to trap cats on Abaco.

Summary of Methodology and Results:

Nine trap locations were selected where cats had been sighted near Guana Seaside and on to the southern edge of the BBC property. Traps were placed on the ground with vegetation cover. The traps were baited with leftover chicken, tinned corned beef, or tinned tuna fish and set in the evenings at approximately 6 pm.

Traps were checked in the mornings at 7 am and closed during the day to prevent trapping. During the summer, the potential for dehydration and heat stress in trapped cats was considered, and thus trapping was only done at night. Trapped cats were secured in the traps and accompanied into Marsh Harbour to Dr. Bailey's office. Cats were tested for Feline Immunodeficiency Virus (FIV) and Feline Leukemia (FeLV), and euthanized if positive results were obtained. Healthy cats were either sterilized and returned to Guana Cay, or adopted out in Marsh Harbour. Pregnant cats were generally found to be in poor health and euthanized upon Dr. Bailey's recommendation.

Dr. Bailey and his veterinary staff were very concerned that the humane traps were too large to ensure the safety of cats and raccoons. Trapped cats were visibly stressed in the trap, and had sufficient room to injury themselves. Several cats were observed ramming themselves against the cage doors and inflicting cuts on the head and face. The veterinary staff often had difficulty injecting sedatives into the caged cats as they could easily move about the cages. Dr. Bailey recommended the acquisition of smaller cages with barriers capable of pushing trapped animals to one corner of the trap to enable easy injections of sedative through the cage. The Safeguard Company sells a smaller size trap specifically for cats (Humane Box Traps 53200 35″x11″x12″ or 52830 30″x11′x12″ (Safeguandm P.O. Box 8, New Holland, PA 17557 USA). Smaller cages would be easier to handle and reduce injury to the cats.

Feral Cat Trapping Initial Results:

Feral cats were caught both in the immediate vicinity of Guana Seaside as well as in the bush on the BBC property. Cats caught and fate:

- 9 July 2006: Pregnant female approximately two years old caught behind Guana Seaside Rental house; negative for FIV and FeLV; euthanized.

- 10 July 2006: Male approximately two years old caught in front of Guana Seaside former cook's house; positive for FIV; euthanized.

- 11 July 2006: Male kitten approximately two months old caught in bushes immediately behind Guana Seaside hotel building; negative for FIV and FeLV; adopted out in Marsh Harbour.

- 11 July 2006: Pregnant female approximately two years old caught behind Baker's Bay guard house; negative for FIV and FeLV; euthanized.

- 22 July 2006: Female approximately two years old caught next to Guana Seaside trash cans; negative for FIV and FeLV; spayed and released back into Guana Cay.

- 25 July 2006: Pregnant female approximately two years old caught at Lay-Down area; negative for FIV and FeLV; unborn kitten removed and kept by vet to be weaned and eventually adopted out, mother cat spayed and released back into Guana Cay.

Spayed cats to be released back onto Guana Cay have notched ears for identification purposes.

INITIAL OBSERVATIONS AND RECOMMENDATIONS FOR THE ABACO CAT ERADICATION PROJECT:

1. It is imperative that male cats be caught and either neutered or euthanized to control further feral cat population growth. The capture of male cats is likely to be more difficult due to their wilder nature and possible avoidance of traps. We recommend that the Baker's Bay Environmental Staff continue trapping efforts at

key locations around the Baker's Bay property. Female cats that are pregnant or lactating will have high energetic demands, and thus will be more likely to be trapped.

2. Trapping around garbage dumps and feeding areas (e.g. of human occupation) is likely the easy part of addressing the growing feral cat population problem. Truly feral cats will avoid people and be much more difficult to catch. These wild cats are likely having the biggest impact on wildlife. A consistent and relentless trapping program will eventually prevent more cats from becoming feral and thus reduce threats to wildlife.

For Bakers Bay, suggested additional trapping sites include the Baker's Landing kitchen area and solid waste staging areas, as well as coastal zone sites where cat sightings have been reported. Trapping needs to be continuous.

3. We propose a community workshop in Guana Cay settlement to talk about the impacts of feral cats on both wildlife and the threat to domestic cats. We would wish to solicit dedicated volunteers to trap and neuter wild cats. Additionally, community workshops would be aimed at current Great Guana Cay resident education on the importance and justification of feral cat population control programs as a component of island stewardship. Cooperation of Baker's Bay staff, Ministry of Agriculture, as well as Guana community members, will further contribute to successful population control initiatives if residents are advised against feeding feral cats, and urged to sterilize and collar any pets.

There is a great need for public education on the impact of feral animals on wildlife as well as the threat of disease transmission to domestic cats. The trapping and transporting of the cats to the vet is labour intensive. The success of the programme will depend on community support and dedicated volunteers.

We found that MOST people supported the trapping initiative, knowing that the cats were to be treated humanely at the veterinarian's office, and supported neutering and release of healthy animals that are likely fed by humans.