

## Introduction

The Sapodilla Cayes Marine Reserve (SCMR) was declared in 1996. That same year it was included when UNESCO named the Belize Barrier Reef a World Heritage Site. Despite the recognized importance of the reserve, onsite management did not begin until 2001. At this time the Fisheries Department began collection of some basic information about the status of the biological resources within the reserve. In 2006 the staff of the Toledo Association for Sustainable Tourism and Empowerment (TASTE) and the Belize Fisheries Department staff working at the SCMR, worked together to develop a monitoring plan for the SCMR. This plan was put into action in January of 2007. This monitoring plan covered the major areas for biological monitoring as well as some basic fisheries and visitation data. After one full year of data collection the staff of TASTE and the SCMR Fisheries staff are now evaluating the effectiveness of this monitoring plan. This report represents the synthesis of the data collected through the monitoring plan as well as other data that has been collected at the SCMR over the past three years. In order for effective management of the SCMR it will be important for managers to be able to understand and apply findings from biological monitoring. The goal of this report is to begin to analyze monitoring data as well as evaluate gaps and make adjustments to monitoring methods to better aid in management decision making.

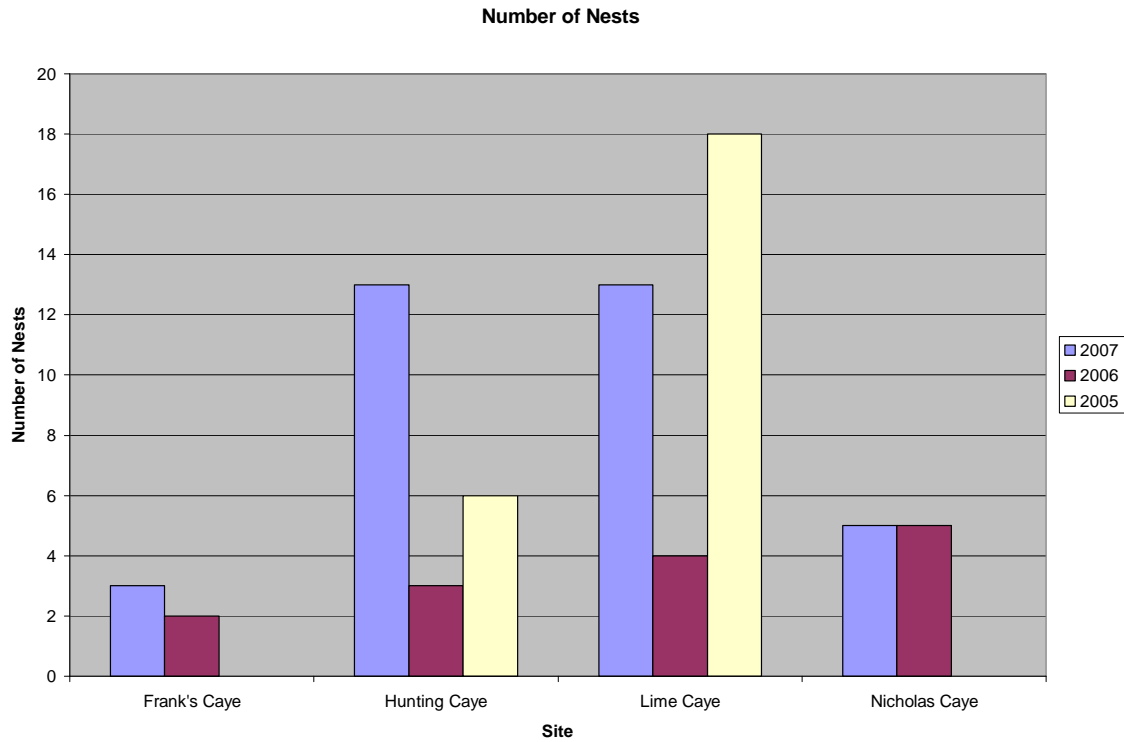
## Sea Turtles

The Sapodilla Cayes is a known nesting site for Hawksbill turtles (*Eretmochelys imbricate*), and likely Green Turtles (*Chelonia mydas*). The SCMR has been known to support relatively large nesting populations of Hawksbill. Hawksbill turtles are listed as an endangered species, and all marine turtles are protected under Belizean law. A good understanding of the numbers and health of the nesting turtle population is important for managers. Although the poaching of turtle eggs has been an issue in the past, improved enforcement of Fisheries Laws appears to have limited the effects in the SCMR. During the turtle nesting season an effort is made to monitor all nests. This includes the marking of turtle nests and if possible excavation of nests after hatching to determine nesting success.

### Results-

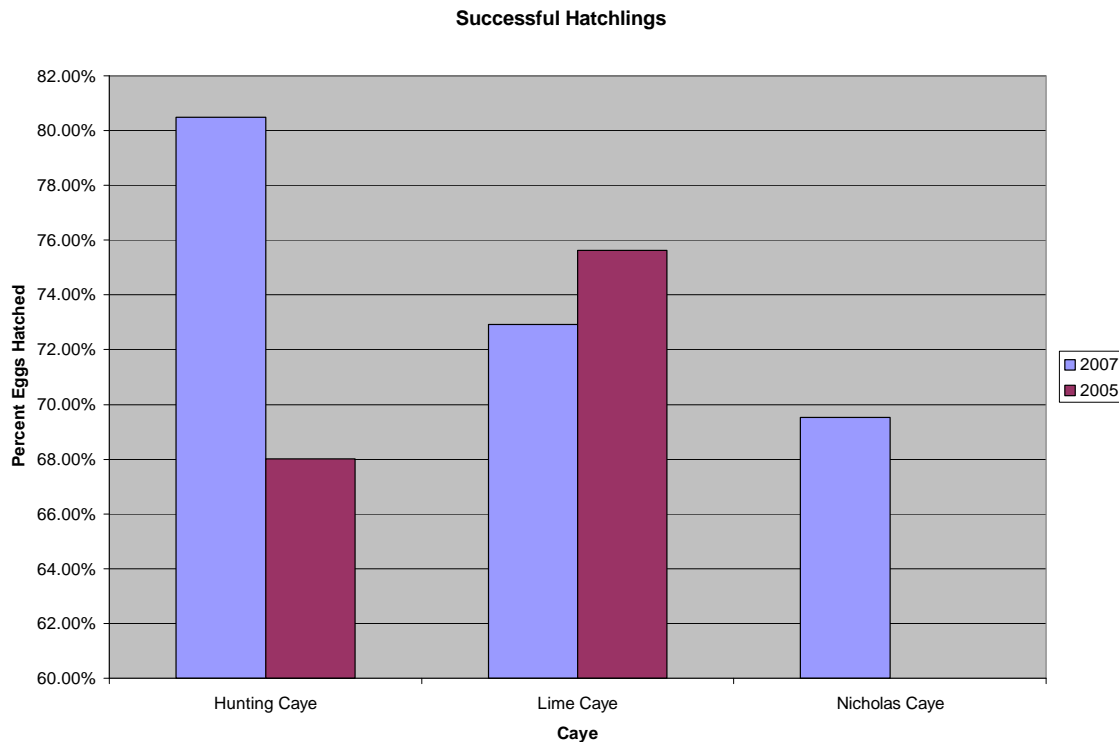
As noted above the vast majority of data sets collected on turtles within the SMCR are simple counts of turtle nests. Figure 1 shows the total number of nests observed at the different cayes from 2005-2007. Lime Caye and Hunting Caye traditionally have had the most consistent monitoring likely explaining the higher number of nests observed on those two islands. The most highest number of total nests were observed in 2007.

**Figure 1**



In addition to information on total nests, information was also collected on nesting success. Although it was only possible to calculate nesting success for about half of the observed nests in 2005 and 2007, Figure 2 shows percent of laid eggs that emerged as hatchlings. The graph illustrates an average success rate of between 68-81%. While the data seems to indicate fair success for most eggs laid, a more substantial data set is required to determine if there are changes in this rate over the monitoring period.

**Figure 2**



#### Evaluation and Recommendations-

Sea turtles are a charismatic and highly endangered group and careful management of the population is important to ensure their continued survival. The SCMR has historically supported large nesting populations. The data collected to date clearly illustrates the importance of the cayes in the SCMR for turtle nesting activities. This data has provided an important baseline for future turtle research within the SCMR, however there are a number of constraints to the data set. Currently most data is collected only after a turtle has nested and for most nests the date laid is unknown. This is due to a lack of consistent monitoring due to irregularities in the presence of monitoring personnel. Efforts should be made in 2008 to develop a more comprehensive monitoring plan that involves cayee residents to try to ensure more complete data collection. If it is possible efforts should be made to patrol beaches frequently during the night in order to begin to collect information about the size and number of nesting females. This will become even more important given current plans to begin tagging turtles at the SCMR in 2008. It is highly recommended that a complete plan for turtle tagging is developed to ensure that tagging is carried out in an organized manner as tagging will require much greater presence and observation during the nesting season. In addition, continued effort needs to be made to ensure that all data collected is properly recorded and stored. This might include the development of a basic database for turtle data.

#### Cayee Bird Species

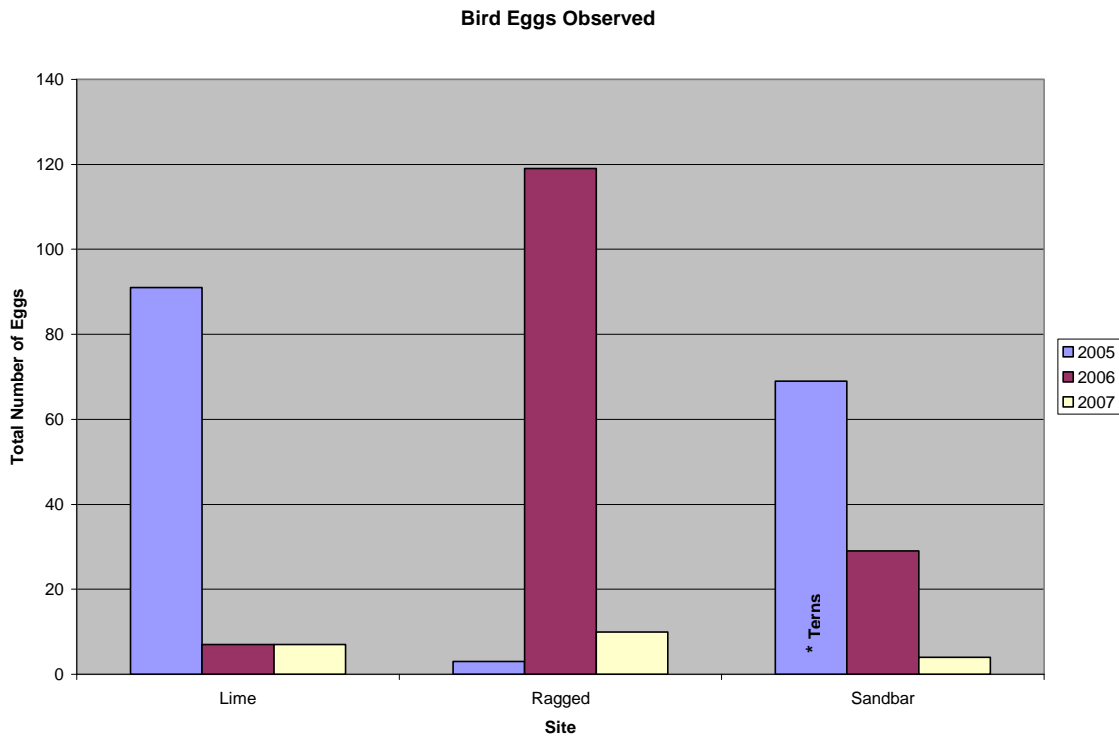
Ragged Cayee is a known nesting site for Laughing Gulls (*Larus atricilla*) and Bridled Terns (*Onychoprion anaethetus*). (It is also thought that the Roseate Tern (*Sterna*

*dougallii*) may nest or recently have nested in the SCMR.) During the breeding season efforts are made to monitor nesting birds. This basically includes monitoring of bird behavior and the counting of nests and eggs during the season. Osprey (*Pandion hiaetus*) are also known to nest in the SCMR which likely represents the southern most point in their range, however no data is currently being collected on their breeding habits.

**Results-**

From 2005 data has been collected about nesting birds within the SCMR. This survey has focused on the total number of eggs and nests observed on Lime Caye, Ragged Caye and the sandbar SW of Ragged Caye. Figure 3 shows the total number of eggs observed each year at each location. For all of the sites except the 2005 count at Sandbar the species observed nesting was the Laughing Gull. (Terns (spp?) were identified as the nesting species in 2005 at Sandbar.) The figure indicates a significant drop in observed eggs in 2007 although this may be due to sampling strategy.

**Figure 3**



**Evaluations and Recommendations-**

While the current system for the monitoring of bird nests seems to be yielding valuable information a few modifications could be implemented to better standardize data collection and improve links to management. It has been observed over the past few years that the birds may utilize different nesting locations in different years. That makes consistent monitoring and data collection important in order to track changes in bird populations. It has been noted that data collection can be hampered by the cryptic nature of the bird's nests making it difficult to accurately survey areas due to concerns about disturbing or destroying nests and eggs. While it is important to exercise extreme caution when monitoring nesting birds so as not to negatively effect the hatchlings, it is also important to be thorough with the data collection. This may include more frequent monitoring of nesting populations during the nesting season. It is recommended that in

addition to recording the total number of eggs, the number of observed nests also be recorded. It has already been noted that bird identification books are needed at the SCMR and it is recommended that efforts be made to train biologists, rangers and other data collectors in basic identification and monitoring techniques. Consistent monitoring is necessary and this will also include improved methods for data collection and data management.

In addition to monitoring nesting birds it is recommended that a yearly bird census be carried out at the SCMR. It is recommended that this census be conducted in a similar manner to the "Christmas Bird Count" currently conducted throughout Belize. However, as opposed to having the count around Christmas time it is recommended that the count be conducted during the migratory season either in October or March. This type of census will require greater training in bird identification, but would provide valuable information about both resident and migratory birds that use the SCMR.

### **Commercial Species**

At the SCMR a number of surveys have been conducted to specifically monitor the status of commercially important species. Anecdotal evidence and historical interviews indicate that the SCMR was once an important commercial fishing grounds. Although the SCMR is still fished today, most fishermen have indicated that stocks of lobster, conch and finfish have declined at a noticeable rate. Since one of the major management goals for marine reserves throughout the country of Belize is the maintenance of commercial fish stocks, it is important to have some scientific data to be able to determine the impacts of both extraction and management on these commercial stocks. At the SCMR this monitoring has focused on three areas: conch, lobster, and finfish. Monitoring for conch, lobster and finfish is focused at 13 strategically chosen sites. (See map in Appendix 1.) These sites are balanced between coral reef and sea grass habitat but are almost exclusively shallow sites, with only one being a dive site. The methodology follows the Long Term Atoll Monitoring Protocol (LAMP) developed by Dr. Charles Acosta (Acosta).

#### *Conch*

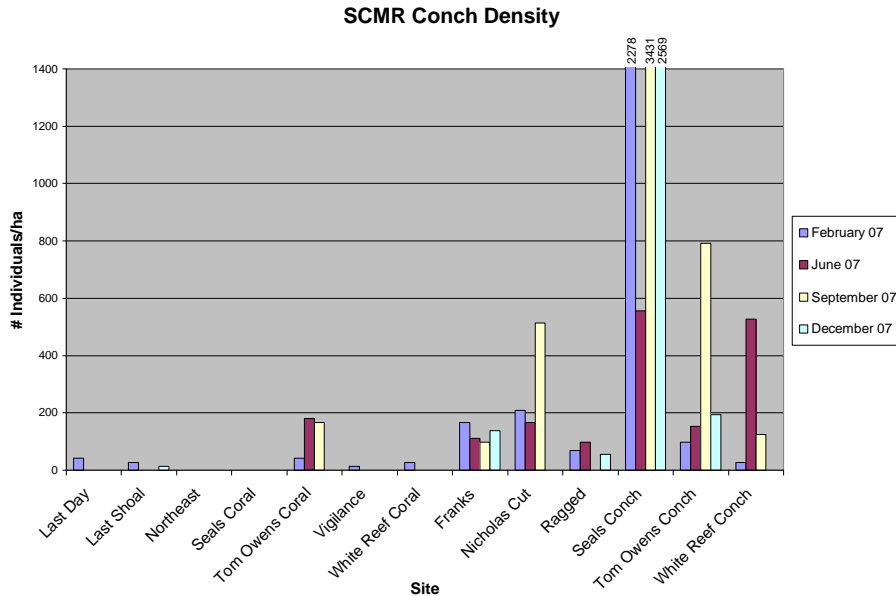
Queen conch (*Strombus gigas*) is a major fisheries export for Belize. Traditionally the SCMR has been a major conch fishery, with a number of known conch "crèche" and nurseries. In addition to Queen conch, the SCMR is home to a variety of other non-commercially exploited mollusks such as milk conch (*Strombus costatus*). Given the importance of the conch fishery, monitoring of conch populations has been conducted for the past 6 years by the Belize Fisheries Department. This monitoring has focused on ensuring that conch populations are stable enough to continue export. In 2007 a more comprehensive monitoring program for conch populations was established. Based on Charles Acosta's Long-term Atoll Monitoring Program (LAMP), this monitoring strategy focuses on 13 sites chosen strategically throughout the reserve. At each of these sites six 30m by 4m belt transects are run to evaluate conch density. In addition to counting conch, basic measurements are taken including shell length and lip thickness. These measurements allow for comparison across sites and time periods of conch density, size distribution and the current status of conch stocks.

#### Results-

Figure 5 shows the average density of conchs found at each of the sites. Although the number of conchs at some sites was extremely high, especially at the well known

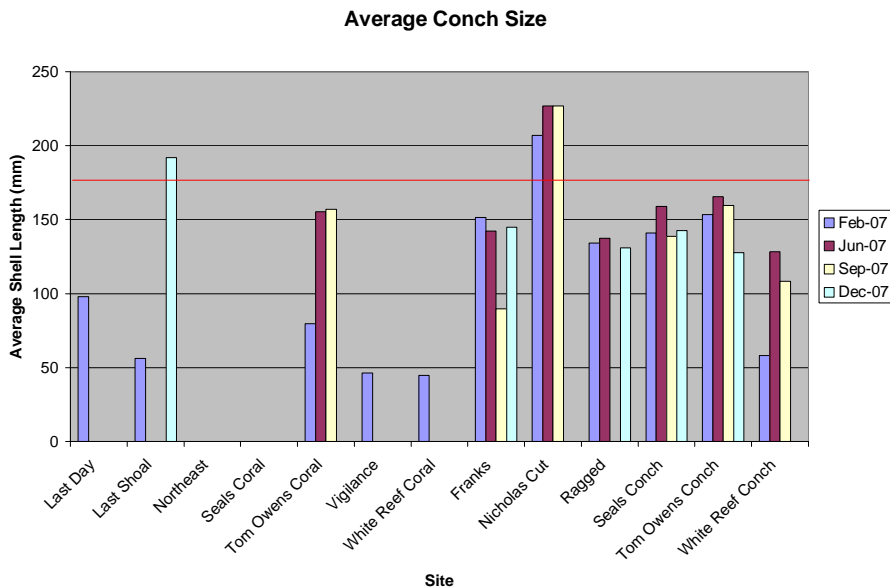
nursery near Seals Caye, at most sites there were relatively few individuals encountered. The overall average for conch density was around 252 individuals/ha with the Seal's site included and 98 individuals/ha excluding the Seal's site. Density is an important indicator for conch population viability as it is thought that at densities of less than 50 individuals/ha, successful reproduction is not likely (Stoner & Ray-Culp, 2000).

**Figure 4**



Despite significant densities at a number of sites Figure 6 illustrates that only one site had significant numbers of sexually mature individuals. The red line on Figure 6 illustrates an average shell length of 178 mm, the legal size for harvest according to Belize Fisheries Regulations. It takes approximately 3-4 years for conch to reach maturity, a mature conch is usually identified by a shell flare with a lip thickness of 5mm (Gascoigne & Lipcius, 2004). Recent research has suggested however that even individuals with a lip thickness of 5mm may not actually be sexually mature (Gascoigne & Lipcius, 2004). At the SCMR the extremely low occurrence of individuals possessing a lip thickness of over 5mm, the only site surveyed which yielded significant numbers of adult individuals was the Nicholas Cut site, which is a known spawning area for Queen Conch. Out of the almost 842 conch surveyed in 2007 less than 10% of had a lip thickness of 5mm or more, and only 18% were of legal size. These two numbers may indicate that although the SCMR seems to have considerable numbers of juvenile conch, fishing pressure on mature individuals is extremely high at many shallow sites.

**Figure 5**



**Evaluation and Recommendations-**

Although monitoring for 2007 can be deemed highly successful a number of changes in the monitoring protocol and further analysis are planned for 2008. Successful management of the conch fishery will depend on accurate data about the status of the population within the SCMR. This data seems to indicate that the SCMR is an important nursery site for conch; however it also indicates a very low number of large mature individuals. This may be due to the sampling strategy which includes a number of known nursery sites but only one deeper spawning site. The vast majority of sites are shallow snorkel sites and the addition of one to two deeper commercial species sites might reveal more significant numbers of mature individuals. In addition, due to the current lack of enforced zoning regulations at the SCMR and the lack of control sites outside the reserve it was not possible to link any of the results to management actions. Again sites were chosen based on the proposed zoning scheme for the SCMR. A through reevaluation of the sites based on the new zoning plan and the inclusion of control sites should be considered in 2008.

Of the thirteen commercial sites, six were chosen specifically for their known conch abundance. These six sites have shown densities of conch at or greater than 50 individuals/ha. Starting in December of 2007 it was decided that density specific measurements (i.e. running of transects) would be taken only at these six sites, while the remaining six sites would be monitored using a timed swim CPUE methodology. It is hoped that this change in methodology will continue to allow for comparisons of key density measures but will be better suited to comparison with data collected at other parks. It will also expand the potential sample area for sites with typically low densities.

With only one year of data with which to make comparisons there did not seem to be significant temporal variation within the data. Continued collection of data and statistical analysis will be necessary to determine if there is any seasonality to conch density and size distribution. TASTE is currently working to improve its capacity for statistical analysis and hopes to work with partners such as TNC, WCS, FoN and the Fisheries

Department to develop more rigorous statistical analysis of the data collected so far. In the coming year, TASTE hopes to be able to work with these partners to develop a more user friendly database for all commercial species data collected. Finally, access and incorporation of previously collected survey data now housed with the Department of Fisheries would help to improve knowledge about the status of conch populations within the SCMR.

### *Lobster*

Spiny Lobster (*Panulirus argus*) and to a much lesser extent Spotted Lobster (*Panulirus guttatus*), are the major lobster species facing commercial exploitation within the SCMR. Like Queen Conch, lobster is an important part of the commercial fisheries of Belize. Because of its importance to the local economy it has been monitored on a somewhat regular basis by the Fisheries Department. Most lobster fishermen in Belize use hook sticks to remove lobster however there has been a growing use of lobster shades. Over the past ten years fishermen have noticed a decline in lobster populations within the reserve. In 2007 a standardized monitoring method was established for lobster within the SCMR. Again this method was based on Charles Acosta's Long-term Atoll Monitoring Program (LAMP) and focused on 13 sites strategically located within the reserve. At each site timed swims were conducted and each lobster encountered was evaluated for sex, egg presence and carapace length.

#### Results-

Figure 7 shows the abundance of lobster found in the SCMR at each of the sites. As you can see from this graph although certain sites do seem to have more lobster, on average lobster distribution seems to be patchy. The one exception is at Tom Owens Coral where there are always a high number of individuals. It is important to note that both Spiny Lobster (*Panulirus argus*) and Spotted Lobster (*Panulirus guttatus*) were recorded. Spotted lobster tends to be smaller and is often more difficult to locate, for this reason only relatively large and old spotted lobster are harvested for commercial sale. Approximately 80% of the lobsters surveyed were Spiny Lobster, with spotted lobster observed at a number of different sites.

Figure 6

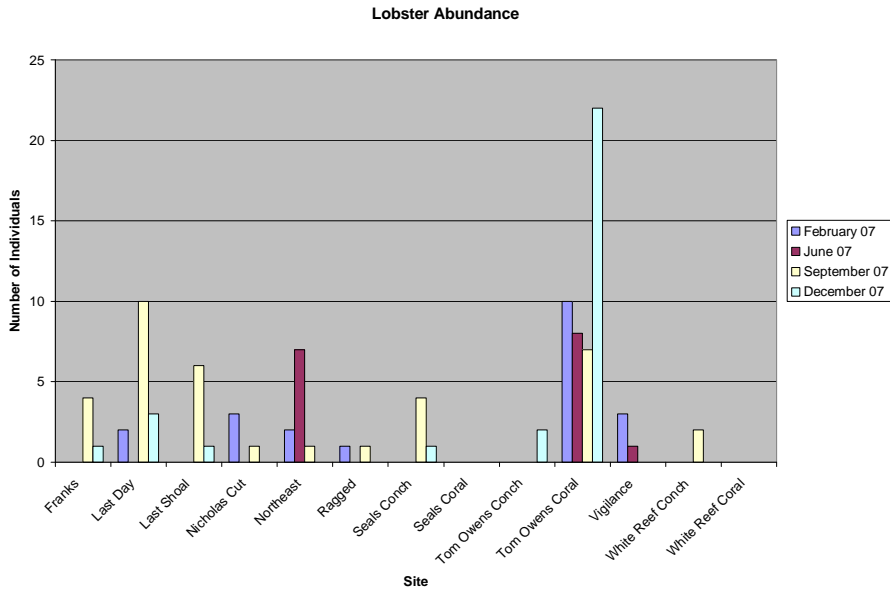
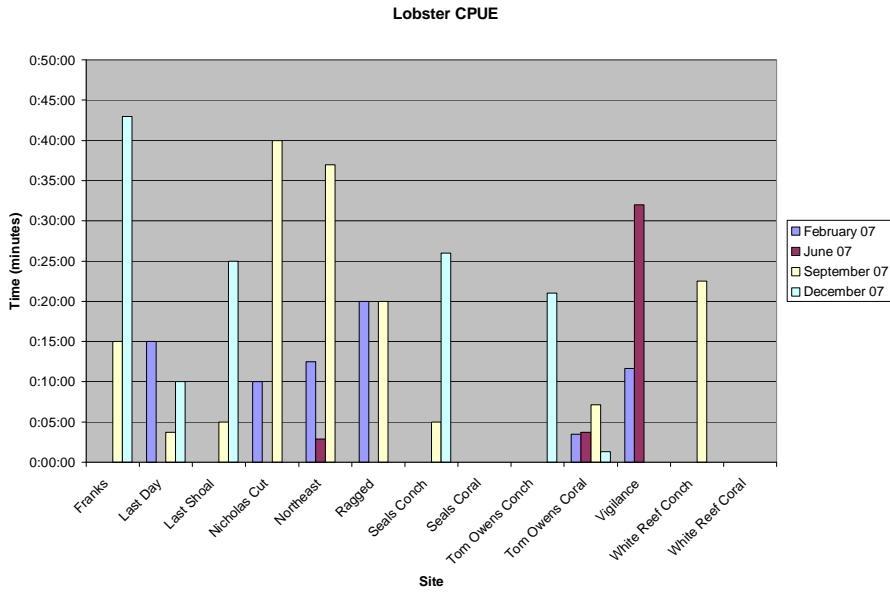


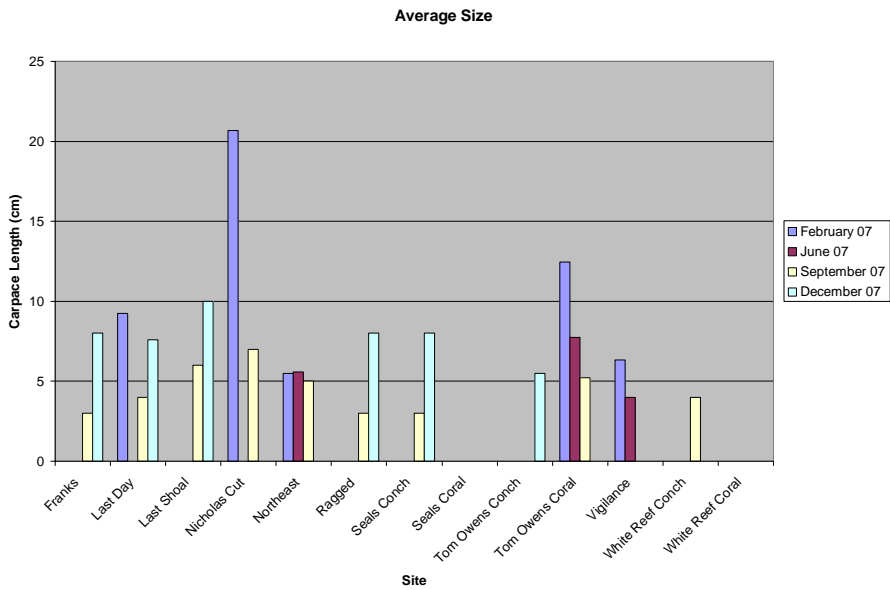
Figure 8 uses catch per unit effort (CPUE) as a way to help evaluate lobster abundance within the park. This methodology mimics the way that most commercial fishermen would fish for lobster with a hook stick and can be expressed as the number of minutes (or effort) necessary for the capture of one individual. Again at most sites the CPUE is fairly high as only one or two individuals were encountered during the search period. This is not true at Tom Owens Coral where the CPUE is around five minutes. Because the SCMR is not currently zoned we would not expect to see non-random differences between CPUEs at the different sites and the overall average for lobster CPUE within the SCMR varies from a high of 20 minutes in February to a low of 10 minutes in December. Further data will be necessary to determine if these seasonal averages are significant, as one might expect CPUE to be lowest during the closed season sampling of June.

**Figure 7**



Additional data was collected about the size and sex of lobsters encountered. Due to inconsistencies in data collection the sex distribution data did not seem to be of value. Lobster size was estimated by measuring the carapace length, measured from the back of the carapace to between the eyes for each individual. Figure 9 shows the size distribution for lobsters encountered. Since there did not appear to be a significant difference in carapace length between spiny and spotted lobsters the table below represents the average for both species combined. (Further analysis on this data is necessary.)

**Figure 8**



Evaluation and Recommendations-

This initial year of monitoring has provided critical data for improved management of lobster populations within the SCMR. However, there are a number of improvements that could be made to the monitoring protocol and data analysis to provide more accurate and useful information about the lobster populations. With only one year of data it is difficult to really evaluate the current status of the lobster populations at the SCMR. Further data is necessary to be able to answer some of the key questions. Similarly to the conch the data is not sufficient to detect seasonal variations in population dynamics. In fact the overall data appears patchy. This is likely due in part to the behavior of lobster themselves. However, there are some concerns about survey technique and accuracy. Lobster can be cryptic and require a trained eye and careful searching to locate. There are discrepancies within the data set with key measurements such as sex and size being excluded for a significant number of recorded sightings, efforts should be made to ensure that both sex and carapace length are recorded for each individual. The failure to include this data makes true analysis difficult. Additionally efforts should be made to record all measurements in centimeters for consistency. At least one more year of complete data collection will improve the understanding of lobster populations within the reserve.

As mentioned above, the zoning plan for the SCMR has not been finalized and is currently not being enforced. During the site selection process sites were strategically chosen to be located within the proposed preservation, conservation and general use zones. It is recommended that a number of control sites outside the reserve boundaries be added to allow for comparison. With the exception of the deep Nicholas Cut site, all of the survey sites are shallow snorkel sites. The addition of one to three additional deeper fore reef sites would improve our picture of lobster populations at the SCMR. Finally further statistical analysis should be conducted with the existing data in order to determine validity of the data collected thus far. This data should also be combined with any existing lobster data for the SCMR currently housed at the Fisheries Department to provide a better picture of the status of the lobster populations.

### *Finfish*

Like conch and lobster, finfish make up an important commercial export from the SCMR. A wide variety of fish including snapper, grouper, barracuda, hogfish and some other species are fished within the reserve. The SCMR is also home to at least three important spawning aggregations sites. Finfish is one area where fishermen note a noticeable decline in product. In fact, the vast majority of fish taken from the reserve are not fished by Belizean fishermen. The one exception is mutton snapper which is often fished during the months of April, May and June. In order to get a better picture of the actual status of the commercial fish populations within the SMCR monitoring has again followed Charles Acosta's LAMP protocol. This focuses on conducting timed swims for a specified species list. These swims allow researchers to calculate catch per unit effort (CPUE) similarly to how a fishermen might look for fish to spear. The specified species list includes Nassau grouper (*Epinephelus striatus*), Hogfish (*Lachnolaimus maximus*), Queen Trigger (*Balistes vetula*), Black Grouper (*Mycteroperca bonaci*), Mutton Snapper (*Lutjanus analis*) and all species of Parrotfish. For each fish of from the specified list an estimate of size is made to allow comparisons of CPUE and size between sites. As with all of the commercial species monitoring this monitoring protocol is carried out at 13 strategically selected sites within the reserve

Results-

Analysis on finfish data is pending. Due to the nature of the finfish data no analysis has been conducted to date. This will be further discussed below.

#### Evaluations and Recommendations-

As mentioned above the analysis has yet to be completed for the data collected to date on commercial fish species. After a number of discussions with a number of local organizations who use this monitoring methodology it was unclear exactly how to use the data collected to date. The key characteristics that are of importance to managers such as fish density were difficult to calculate due to the monitoring protocol. In general at the SCMR parrotfish make up the vast majority of fish from the specified list. It was common that only one or two other fish might be encountered at each site. This made it difficult for researchers to conduct any rigorous comparisons between sites. The reason for these low numbers is likely due to the methodology, lack of fish in the reserve and the location of the survey sites. Again 12 of the 13 survey sites are in shallow back reefs which are often heavily fished by local fishermen. Additionally due to the lack of zoning and sites outside the reserve it is not possible at this time to compare the effectiveness of the reserve. It is recommended that these sites be reevaluated and a number of deeper sites as well as control sites be added for more complete coverage.

TASTE is currently working with partners Friends of Nature, TNC, WCS and others to look more closely at how commercial species data for finfish is collected. Managers need to carefully evaluate the information necessary for management is being sufficiently collected. It is suggested that at least two fish species, Barracuda (*Spyraena barracuda*) and Dog snapper (*Lutjanus jocu*), be added to the species list, as these are common commercially fished species which are also frequently found within the reserve. The species list between GSSCMR, LBCNP and SCMR should be the same. In addition to reevaluating the species list it is necessary to develop improved methods for data analysis including statistical analysis. TASTE is hoping that this will be completed early in 2008 with the development of an improved commercial species database and systems for basic statistical analysis.

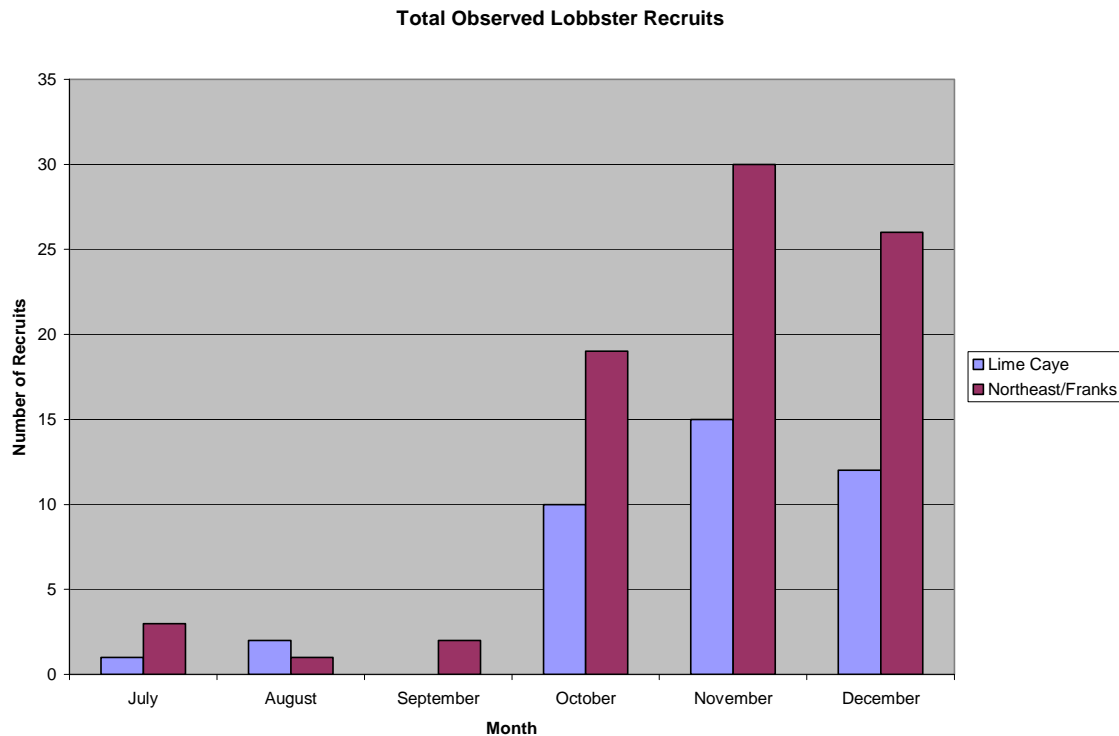
#### **Lobster Recruitment**

In cooperation with the "Connectivity-Targeted Research Project" and Dr. Mark Butler recruitment data for Spiny lobster (*Panulirus argus*) has been collected at the SCMR. The goal of this project is to collect consistent data on lobster recruitment for the validation of a lobster recruitment model of the Caribbean region. Data on lobster recruitment is collected using "Withman" post-larval lobster collectors. Eight of these collectors were placed at the SCMR in appropriate channel habitat, four between Northeast Caye and Franks Caye, and four around Lime Caye. These collectors are checked monthly seven days after the full moon. This data is then forwarded to researchers with the "Connectivity-Targeted Research Project".

#### Results-

Figure 9 shows the total number of recruits observed at each site over the survey period. The graph indicates a much higher level of recruitment during October-December. The larval period for spiny lobster is thought to be between 5-7 months. If spawning does indeed occur during the closed season months from February to June then one would expect the highest number of recruits to be found from October to January. Further monitoring will be necessary to track trends in lobster recruitment.

**Figure 9**



#### Evaluation and Recommendations-

All lobster recruitment data is currently being collected for use in the “Connectivity-Targeted Research Project”. The current plan is to continue to collect lobster recruitment data into 2008. It is hoped that in the future it will be possible to use this data to develop a more in-depth analysis of recruitment within the SCMR.

### Spawning Aggregation

There are three recognized spawning aggregation sites within the SCMR. These include: Nicholas, Rise and Fall Bank, and Seals. Monitoring of these sites has been on-going from 2002. Although there have been a number of restraints to truly consistent data collection for Spawning Aggregations within the SCMR. The Fisheries Department and TASTE in collaboration with the Nature Conservancy have been able to monitor SPAG sites, specifically Nicholas, during the spawning season for Nassau grouper. This monitoring follows the “Reef Fish Spawning Aggregation Protocol” developed by MBRS and the Nature Conservancy (Heyman et al., 2004). It consists of conducting a series of dives during peak spawning activity in order to estimate the number, size and activity of fish at known spawning sites.

#### Results-

Analysis of spawning aggregation data is pending. See below.

#### Evaluations and Recommendations-

In 2005 TNC began the development of a Spawning Aggregations database. As a part of the development of the database all partners were asked to enter all existing data into a database. These databases were then collected for entry into the newly completed web-based database. During this period the computer that housed the data crashed

leaving TASTE without copies of the data set. Efforts have been made to contact both the Fisheries Department and the Nature Conservancy to regain access to this data but to date the data is not available for analysis within this report.

## **Coral Reef**

The SCMR protects important coral reef ecosystems at the southern terminus of the Belize Barrier Reef system. The Sapodilla Cayes were included in the Belize Barrier Reef World Site because they contain reefs representative of the Southern province of the barrier reef. The health and status of these coral reef ecosystems is an important aspect of effective management of the reserve. Tourism is another key management priority at the SCMR. The maintenance and improvement of the reef ecosystems is of importance for the SCMR. A variety of monitoring methods have been employed at the SCMR to assess the status of the reef ecosystem. This has included evaluation of benthic cover; coral diversity, health and size; and reef fish populations. Monitoring using the Mesoamerican Barrier Reef System Coral Reef Synoptic Monitoring Protocol (MBRS SMP) has been conducted since 2004. MBRS data is collected at three shallow reef sites at the SCMR. (See map in Appendix 2). In addition to data collected using the MBRS protocol, TASTE has collected additional data on coral health during 2007 as part of an Earthwatch sponsored coral bleaching research project. TASTE has used seven shallow back reef sites as indicators for Earth Watch's coral bleaching project. (See map in Appendix 3.) Data collected during all of these monitoring events is compared and discussed below.

### *Benthic Cover*

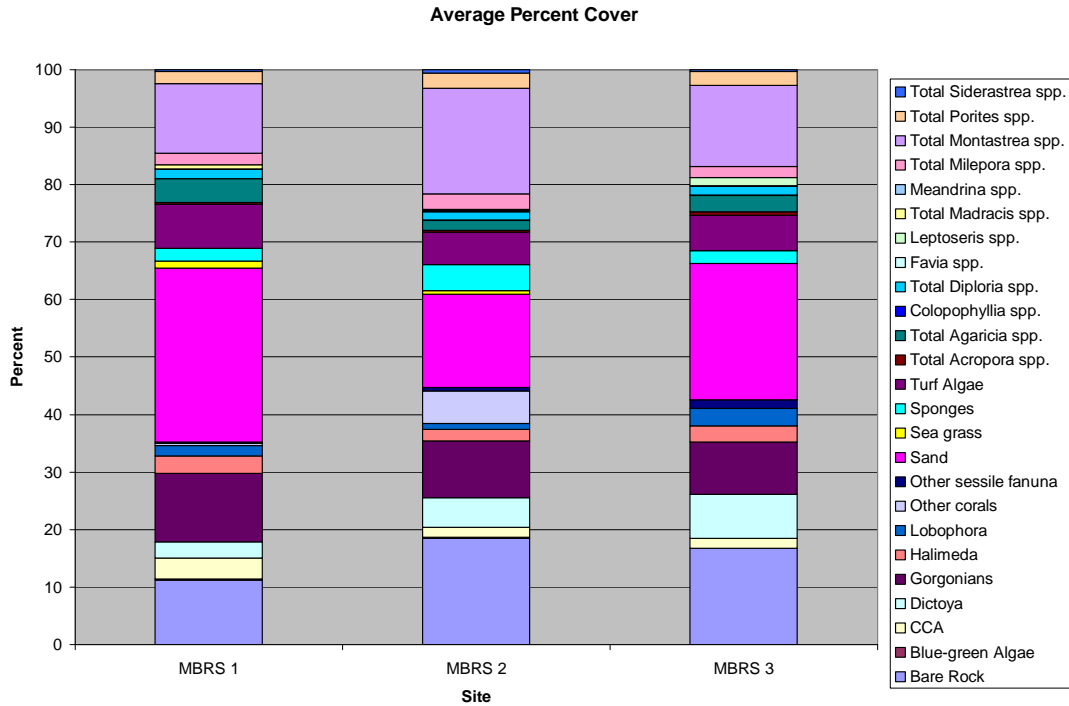
Benthic cover is basically a description of what different components make up the reef. By understanding changes to the percentage of live coral cover, algal cover, gorgonians, sand and other benthic indicators managers are able to track changes in reef health. Shifts in dominant cover type from live coral to algae may indicate changes in coral health, predation or nutrient availability. At the SCMR benthic cover has been estimated in two ways. MBRS SMP uses a point intercept method to estimate coral cover at three different sites within the SCMR. This focuses on laying 30m transects and then recording benthic components at 25cm intervals along the length of the line. At the SCMR six 30m transects are run at each of the three monitoring sites. In addition to the MBRS SMP protocol, TASTE has adopted a modified AGRRA method to estimate benthic cover at seven additional back reef sites. This method uses 10m transects and estimates the coverage for six key factors along the length of the line. The six components measured using this method include: live coral, calcareous macro algae, fleshy macro algae, crustose coralline algae, sand and other sessile invertebrates (such as gorgonians, palythoa, sponge, etc.). The collection of this data should provide valuable information about the current status of the reefs within the SCMR.

### Results-

Data has been collected at the three MBRS sites at least once yearly from 2004. This should give managers a good idea about the reef conditions at each of the sites monitored. The three MBRS sites are all shallow sites and are most often surveyed snorkeling. Although data exists from six different surveys, at this time statistical comparisons of this data is not possible. (For further discussion see the evaluation and recommendations section.) However, this survey info does provide a good idea about the average status of the reefs over the sample period. Figure 10 shows the average percent cover for each of the sites over the four year sample period. As you can see from the graph each of the sites had fairly high coral cover, ranging from 23 to 33%. As

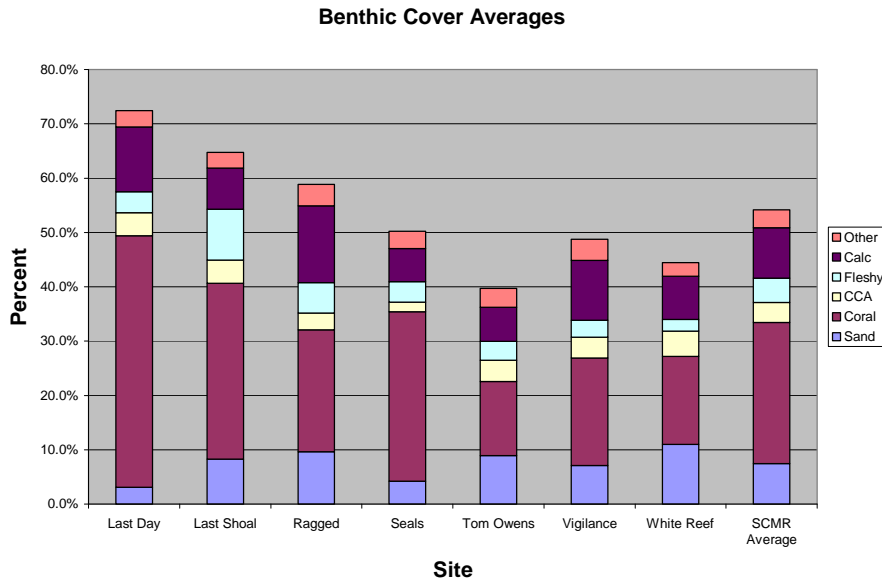
expected the massive reef building corals *Montastrea spp.* made up the majority of corals encountered at each site. Another key indicator of reef health is algal cover. Percent algal cover (including turf algae) at each of the three sites was between 14 to 19%. These levels of live coral and algal cover seem to indicate that the reefs in the SCMR are in good to optimal condition (Salgado et al., 2006).

**Figure 10**



In addition to data from the MBRS survey TASTE, in cooperation with Earthwatch conducted surveys in the SCMR during 2007 to get a better idea of coral health, benthic cover and disease. The results shown in Figure 11 show the percentage cover for the six categories recorded during this project. The seven sites selected for this project were all shallow back reef sites and were surveyed snorkeling. This data shows high coral cover for all sites with an average live coral cover of 26%. Last Day had the highest average coral cover at 46% and Tom Owens the lowest at 13%. Also of note is the algal composition which averages about 14% at the sites sampled. At all sites the ratio of live coral to macro algae cover was greater than 2:1. This indicates substantial live coral at the SCMR, which is was slightly surprising given the common perception about the lack of fish and relatively stressed reef environment. Further analysis of this data is necessary to determine significance.

**Figure 11**



In addition to collecting data on the percentage cover, some data is also available on the species composition for each of the sites monitored during the coral bleaching project. (This data is also available from the MBRS monitoring, however the data from the bleaching project was easier to sort to individual species level and so is discussed here.)

**Figure 12**

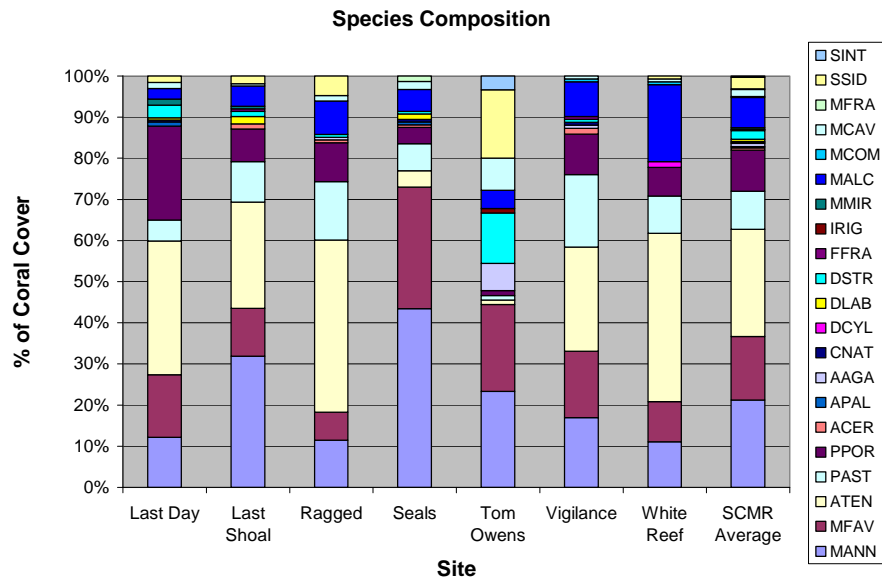


Figure 12 illustrates the observed species types at each of the different sites monitored as well as the overall SCMR average. The averages were derived based on the number of individual corals for each type monitored. There were a total of 21 coral species observed along transects in the SCMR with an individual site average of 12 different species per site. This number is consistent with other surveys done across the MBRS

region (Salgado et al., 2006). As indicated in this graph a small number of species make up the majority of individual corals observed along transects. It would appear that most of the back reef sites at the SCMR are dominated by the massive *Montastrea annularis* and *Montastrea faveolata* along with *Agarica tenuifolia*, *Porites asterodites* and *Porites porites*. Combined these five species made up over 50% of the corals encountered at almost all of the sites, and on average over 80% of the corals encountered were one of these five species. On average fire coral *Millepora spp.* made up about 5% of the remaining corals at most sites. Dominance by a limited number of species is not surprising given the survey method.

#### Evaluation and Recommendations-

Taken together the results from both the MBRS data and the TASTE/EW coral bleaching project seem to indicate relatively healthy ratios of algae and live coral cover. This tends to back up casual observation in the SCMR where most tour guides, fishermen and other users speak to the relatively healthy reefs but noticeable lack of fish.

One of the major constraints at the SCMR is the focus of most monitoring on shallow snorkel sites. This is due in part to the lack of sufficient and suitable equipment to conduct survey at deeper sites. It is recommended that at least three additional deeper MBRS sites be added in 2008. Statistical analysis is another area of weakness for data collected in the SCMR. Up until this report there had been little or no effort to interpret the data that has been collected using the MBRS SMP protocol. The data from the SCMR was included in the MBRS report on the synoptic monitoring efforts but upon close inspection these results raised a number of questions about the veracity of the data that has been collected to date. There appear to be significant variations in data based on the person collecting as well as some ambiguities in the collection methodology. In 2008 efforts should be made to ensure that all persons involved in data collection agree on labeling protocols. This specifically relates to the degree of specificity in coral species identification and the grouping of algae. It is recommended that the monitoring team establish clear protocols and stick to them. Additionally, site locations with accurate GPS points should be agreed upon and finalized by team members. MBRS monitoring depends on predictable measurements at the same sites over a period of years. It is recommended that all sites remain at the 2007 locations and that the GPS points and site descriptions be updated in the MBRS database to match the 2007 locations. Given the discrepancies in data collection and site location statistical analysis of the existing data may not be entirely accurate, however it is recommended that the co-managers work with other agencies and partners to develop a more substantial capacity to apply statistical analysis to the data collected. This would include comparisons of changes in percentage cover over the survey period. It is expected that the implementation of these changes in monitoring methods and analysis will improve knowledge about changes in percent cover and reef status over the coming years.

#### *Coral Health*

##### Overview of Monitoring Activities-

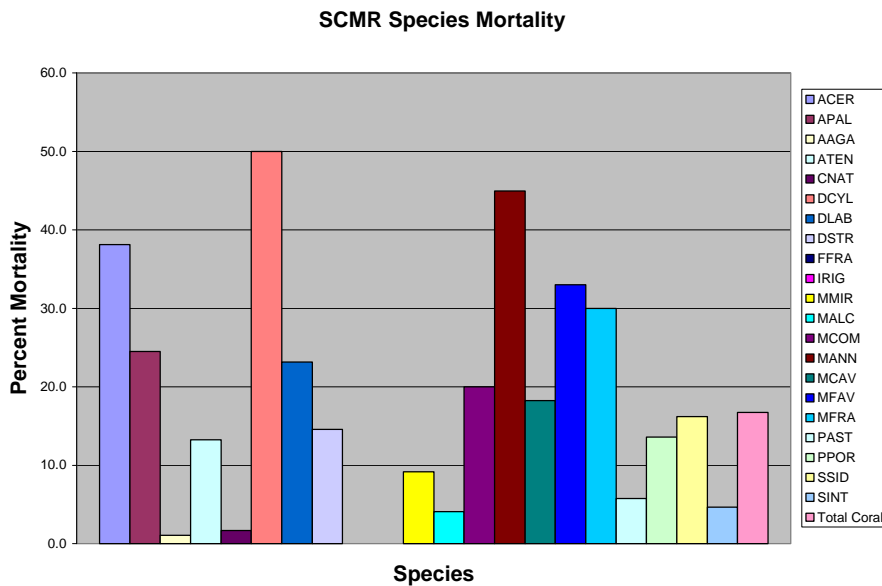
In addition to understanding the benthic cover it is important for managers to have a good understanding of coral health. Over the past three decades there has been a significant drop in the health of corals throughout the Caribbean this is likely due to an increase in coral bleaching events, decrease in water quality, changes in fish density and other factors. At the SCMR the major methods used to evaluate coral health have been the MBRS SMP methodology as well as the coral bleaching project undertaken by TASTE and EW. When following the MBRS SMP protocols at each coral site at least 50

individual corals are measured and assessed for bleaching, disease and percent mortality. The data collected from these 50 corals is then used to assess the overall coral health at that site. As indicated before the TASTE/EW bleaching project has followed a modified AGRRA protocol which involved measuring and assessing the health of each coral under the 10 m transect line. The data from these two monitoring techniques can provide information about the health of a representative sample of the coral colonies at each site.

Results-

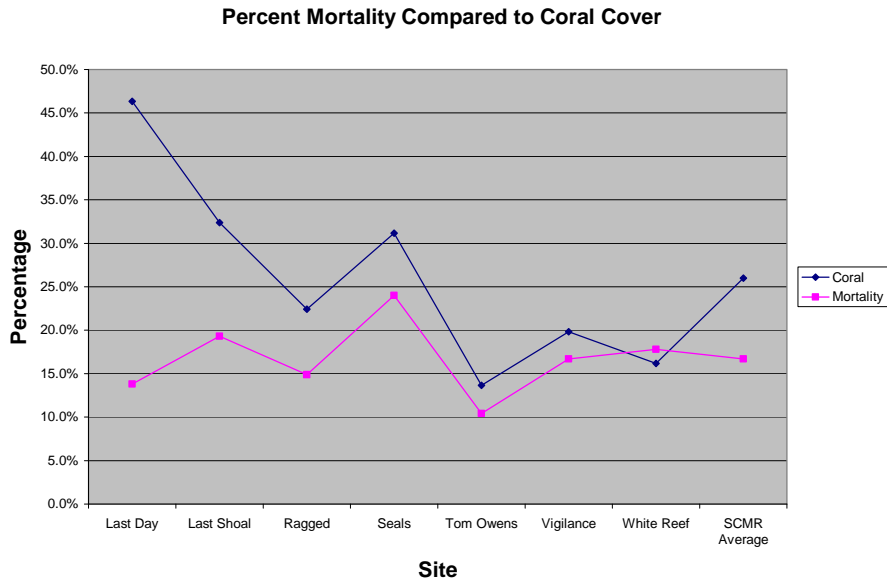
Like the benthic cover data further statistical analysis is necessary to make comparisons in coral mortality over the period from 2004-2007. The data shown below is from the coral bleaching project. Figure 13 shows the average mortality for each coral species observed in the SCMR.

Figure 13



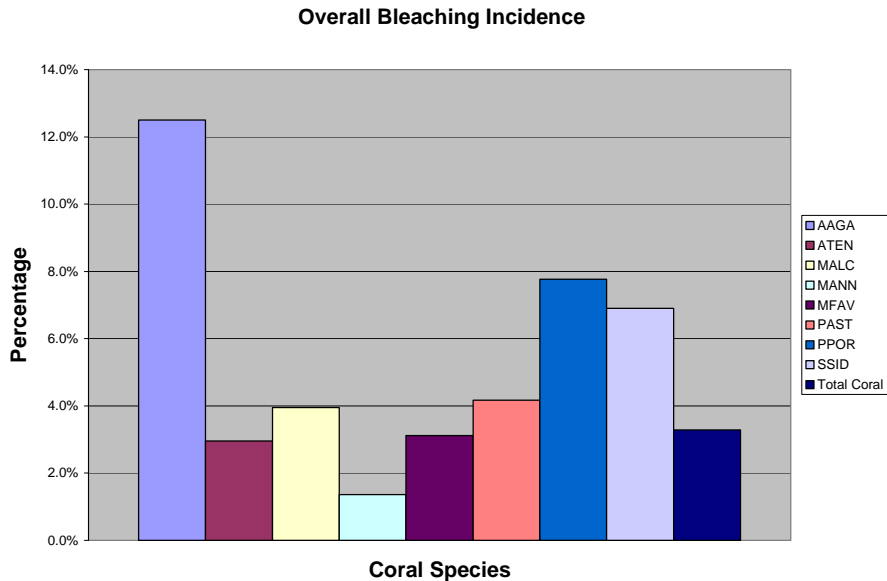
Overall coral mortality at the SCMR was around 17%. The vast majority of this mortality was old mortality attributed to algal overgrowth. As expected the large major reef builders *Montastrea spp.* exhibited high amounts of mortality, as shown in Table 2. As would be expected with the focus of sampling in shallow back reef areas, there were corals of the *Montastrea spp.* who exhibited 70-80% mortality. The high mortality for *Acropora cervicornis* and *Dendogyra cylindricus* is likely due to their relatively low abundance within the sample group. The graph of average mortality done for the MBRS data did not appear to show significant differences from the graph shown above, however statistical analysis is necessary to determine trends and actual significance of the data set.

**Figure 14**



From the data taken during the coral bleaching project it was hypothesized that the percentage mortality might be directly linked to the percentage cover at each of the sites. It seems logical that at places where there are greater numbers of corals there would be higher rates of mortality. This proved to be true at five of the seven sites monitored and as Figure 14 shows mortality at these five sites appears to be directly related to the percent coverage in a fairly predictable way.

**Figure 15**



One of the issues relating to coral health that has gotten a lot of attention in recent years is coral bleaching. The project designed by TASTE and implemented with support from EW was designed to evaluate the effects of coral bleaching in the shallow back reefs.

Over the five months of monitoring only 34 of the 1036 individual coral colonies monitored (3.3%) showed any signs of bleaching. Of these colonies seven coral species were observed with some form of bleaching. Figure 15 shows the percentage of colonies for each species that were observed with some form of bleaching. The majority of bleaching observed was partial bleaching where only a portion of the colony was bleached. Most of the corals observed with some form of bleaching were observed in the months of August and September as would be expected. Further monitoring over an extended time period will be necessary to track trends in bleaching incidence.

#### Evaluation and Recommendations-

Overall a large quantity of data has been collected on coral health in the SCMR. This data has provided managers with a good picture of the current status of reef health. Although there are some questions as to the veracity of the data collected early in the MBRS monitoring, more recent data seems to indicate that the corals in the SCMR are in reasonably good health. It is however important to note that all of the data collected thus far in the SCMR is on shallow back reef sites and at sites that were specifically selected for their cover. It is crucial that more data is collected at deeper sites. Data collected by Mr. Burton Shank in the SCMR as well as anecdotal reports from tour operators and other researcher seems to indicate that disease and bleaching are much more prevalent in the deeper fore reef sites. The addition of at least 3 deep sites for MBRS monitoring is a necessity for managers to be able to track these observations. It is also very important that some statistical analysis be made on existing MBRS data to determine if there have been any changes in reef health over the four years of survey.

### *Reef Fish*

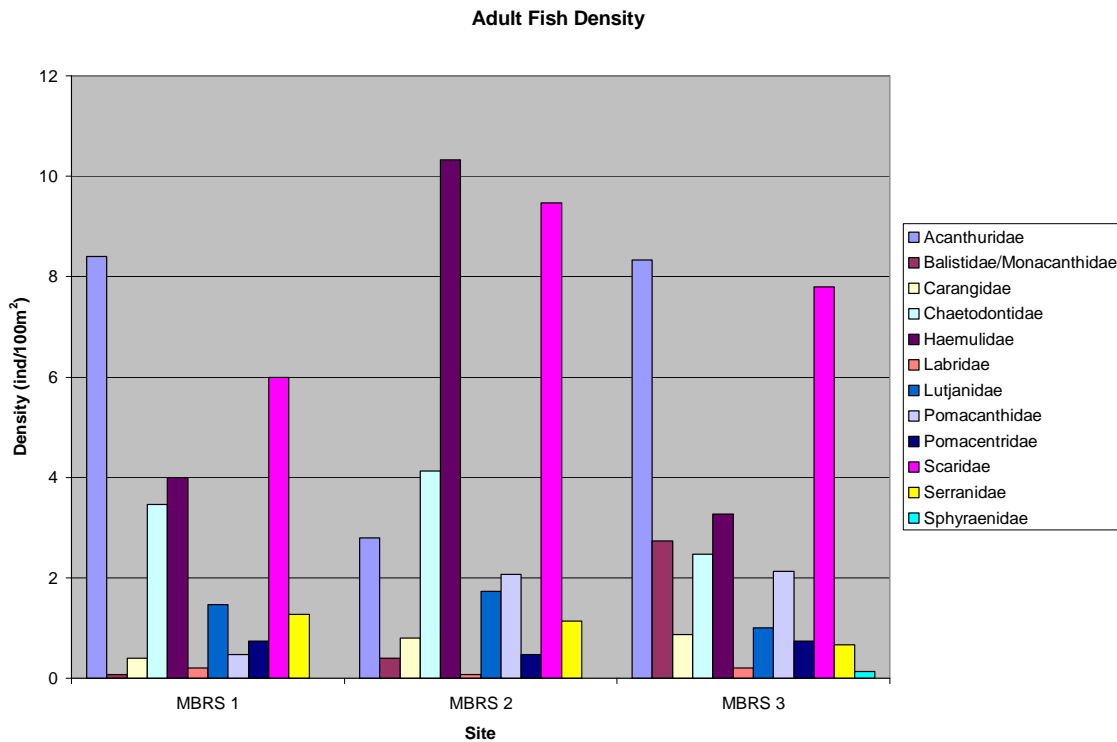
#### Overview of Monitoring Activities-

The MBRS SMP method also includes a methodology for monitoring reef fish. This methodology consists of running 6-8 30 m x 2 m belt transects at each of the MBRS sites. The researcher then records the number and size of fish from a specified species list. This methodology allows managers to calculate density and biomass for a specified list of species.

#### Results-

Only a very preliminary analysis of the reef fish data has been done to date. Due to a lack of statistical capacity, this analysis has focused on densities for the families monitored using the MBRS SMP method. Figure 16 shows the average density (the number of individuals for each family that would be encountered in a 100 m<sup>2</sup> area) for each family monitored at each MBRS site from 2005-2007. As would be expected given anecdotal accounts the adult fish density is extremely low, especially for commercially valuable species such as barracuda, grouper and snapper. Parrotfish (*Scaridae*), surgeonfish (*Acanthuridae*) and grunts (*Haemulidae*) were the most common fish families encountered at the SCMR. These results seem to back up observations that there are very low fish densities within the SCMR.

**Figure 16**



Some preliminary analysis has been conducted on fish biomass, which seems to indicate extremely high levels of herbivores, however further analysis is necessary before those results are presented.

#### Evaluation and Recommendations-

The lack of fish within the SCMR is a casual observation by most divers and snorkelers in the area. The data collected and analyzed thus far from the MBRS SMP monitoring seems to back up these claims, showing very low fish density. Again given the concentration of monitoring efforts on shallow sites it is unclear if these results are indicative of deeper areas as well. Expanding the surveys to include deeper sites will improve knowledge about the fish populations within the SCMR. In addition further analysis of the existing data should provide greater insight into the status of the reef fish populations. There is some management concern that the apparent lack of high level predators could have a negative effect on reef health, however the current data on reef health seems to indicate otherwise. Healthy fish populations are vital for a healthy reef ecosystem and the scarcity of fish at the SCMR raises an alarm and should continue to be monitored. It would be hoped that the finalization and enforcement of the no-take zones at the SCMR will have a positive effect on reef fish populations. In addition, it is recommended that the managers engage in discussions with other research partners in order to develop further information about the status of reef fish within the reserve. Although the MBRS SMP methodology can give some valuable information, the small number of sites sampled and the relatively small species list may not be the best way to monitor fish populations. It is important for the co-managers to evaluate the ratios of herbivores to carnivores in order to ensure a balanced reef system.

#### Sea Grass

Currently there is no active monitoring occurring on sea grass in the SCMR. There are large pastures of sea grass within the reserve. Given the importance of this habitat for juvenile conch, lobster and fish it is strongly recommended that sea grass monitoring is begun at the reserve. Either MBRS or Sea Grass Net methodologies would be appropriate for this monitoring. Discussions have been held with MBRS to set up a sea grass monitoring program at the implemented, however due to the current status of the MBRS project that monitoring was never begun. The main factors of interest in regard to sea grass habitats at the SCMR are: biomass, density, species composition and associated species. It is recommended here that at least two sites for sea grass monitoring be established within the SCMR in order to provide managers with greater information about the status of these important habitats.

### **Diseases and Other Natural Phenomenon**

Currently there are no established monitoring programs which target diseases or other natural phenomenon. Coral health and disease are specifically targeted under the MBRS project and the TASTE/EW coral bleaching project, and those results have been presented here. There have been reports of high levels of yellow-blotch disease in *Montastrea spp.* at a number of deeper fore-reef sites. It is hoped that the establishment of new deeper monitoring sites for both the MBRS SMP and coral bleaching project will allow managers to better track these incidents. In this area it is highly recommended that managers work together to develop an emergency response plan for disease, bleaching and hurricanes. In order for managers to react appropriately do these threats it is vital that a mapping project be undertaken within the SCMR. This program should seek to ground truth the existing habitat maps for the SCMR generated by the Coastal Zone Management Authority and Institute. A good understanding of the locations and current status of the reef will allow managers to properly address outbreaks of disease and other threats to the reef.

### **Water Quality**

#### Overview of Monitoring Activities-

In 2005-2006 under a grant from PACT, TASTE and the SCMR instituted a very basic water quality monitoring program. This program consisted of taking samples at five strategically chosen locations throughout the reserve. These surface and 3m samples were then analyzed for pH, salinity, total dissolved solids (TDS), and dissolved oxygen. The monitoring under the PACT project took place from October 2005 to July 2006 and but was stopped due to financial and equipment problems. Additional data on water quality was planned to be collected during the TASTE/EW coral bleaching project. However due to malfunctioning equipment no significant data was collected. The bleaching project did provide for six temperature and light meters to be placed within the SCMR, however data from these underwater sensors has not yet been analyzed.

#### Results-

The results from this project were presented in a newsletter that was distributed to partners. Although the project did yield some data, there were large discrepancies in the data collection protocol and the sites were changed halfway through the project. Due to these constraints and the already published data it does not seem necessary to go through the results in detail here. The trends from the data seemed to indicate that there were expected seasonal variations in temperature and salinity. Temperatures seemed to be higher during the dry season and salinities lower during the wet season.

#### Evaluation and Recommendations-

Water quality is a crucial parameter, especially at the SCMR which due to current patterns and its location in the center of the Gulf of Honduras is heavily influenced by

river outflow and pollutants from Belize, Guatemala and Honduras. Efforts are currently underway for collaboration between the co-management partners and other researchers working in the area to develop a more substantial water quality program, which would include monitoring of the physical parameters measured under the PACT project along with key chemical parameters such as nitrates, phosphates and chlorophyll. Efforts are currently being undertaken to locate funding for the necessary equipment to carry out this monitoring. The PACT project has taught the co-managers some valuable lessons about the importance of predictable sampling and the need for easy and reliable systems for sample collection and analysis. It is hoped that a new water quality program can be developed by mid-2008

### **Meteorological Data**

To date the only meteorological data being collected at the reserve is rainfall information which is collected by the rangers in a fairly predictable manner. Although rainfall data is of use it would be useful to get more consistent meteorological data including: rainfall, air temperature, surface temperature, and wind speed. There was at one time a meteorological station at Hunting Caye, however this station was destroyed in Hurricane Mitch. TASTE had undergone initial consultation with the Meteorological Department about the replacement of this weather station; however this does not appear to be coming in the near future. It is recommended that in addition to more regular rainfall data a small outside thermometer be used for collection of air temperature information.

### **Recreational Activities**

#### Overview of Monitoring Activities-

The rangers at Hunting Caye are responsible for the sale of tickets to all SCMR visitors. A system for ticket sale has been established by the Fisheries Department and all revenue from ticket sales is deposited into an account with the Department. This data is also reported by the reserve manager to the Fisheries Department.

#### Results-

Due to the logging system for tourist visitation it was not possible for visitation data to be thoroughly included in this report. Only basic data about visitors is currently being recorded. This includes information about country of origin, time spent in reserve and number of visitors.

#### Evaluation and Recommendations-

Although basic information about the origins and number of visitors is useful, more detailed visitation data would provide managers with improved knowledge about the uses and impacts of tourist visitation within the reserve. It is recommended that the rangers collect basic information about the visitor activities as well as areas used within the park. The development of a simple data sheet would greatly accommodate the collection of this data. In addition the development of a simple computer based format for visitor information would allow for greater incorporation of this data into management activities. The completion of the SCMR visitors center will likely assist in the collection of this data as it will offer a centralized location for all SCMR visitors to utilize.

### **Conclusion**

Overall there has been a concerted effort to collect valuable data about the status of the resources at SCMR. The Fisheries Department staff along with the staff and volunteers at TASTE should be commended on their efforts to contribute to the existing information about the marine reserve. 2007 represented a pivotal year in the collection of data about the status of the resources within the SCMR. The data collected to date has provided a clearer picture as to the status of the resources within the marine reserve.

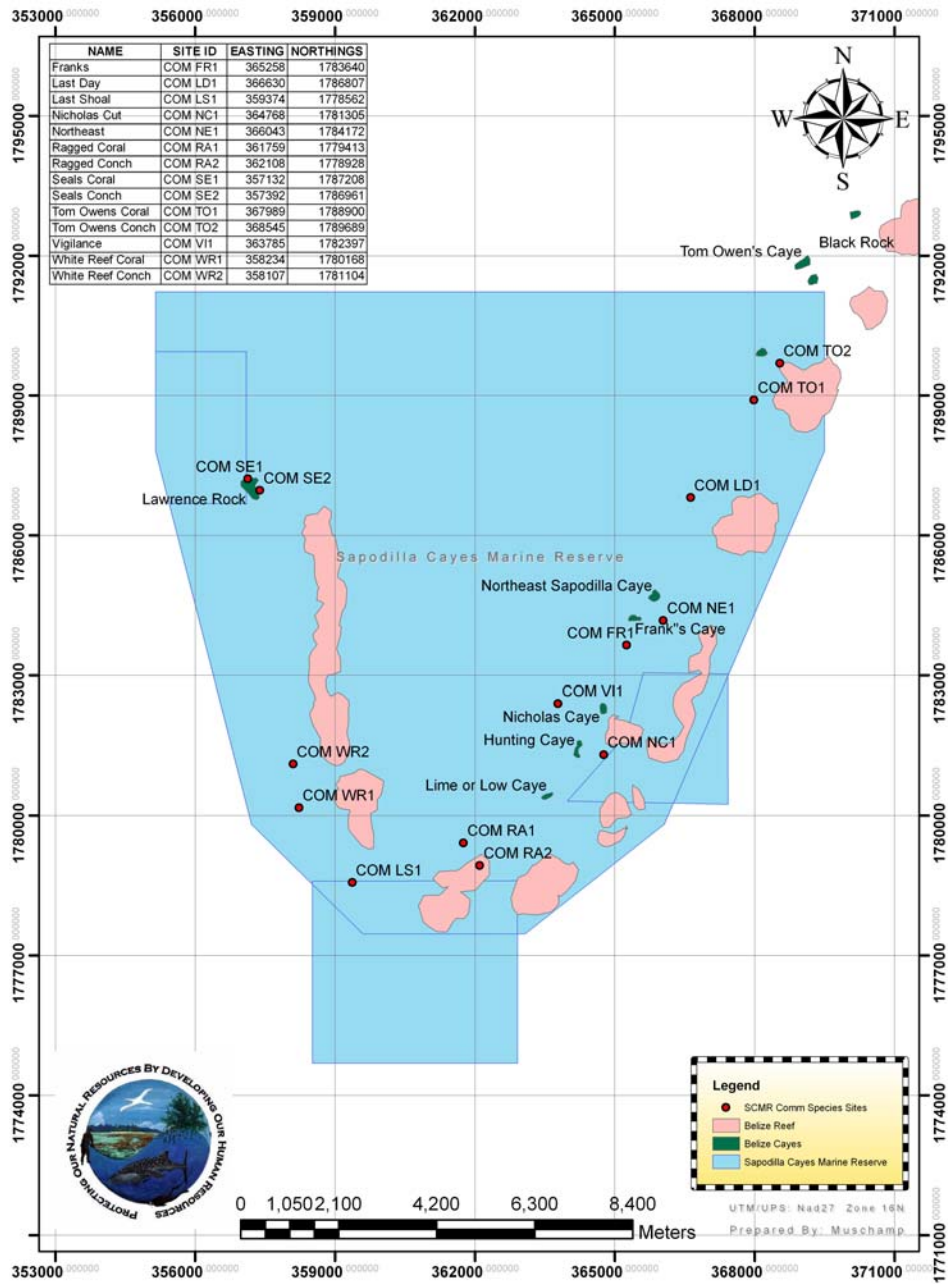
Along with improvements recommended here, additional statistical analysis of the data presented is essential to determining the significance of these findings. Biologists and technical staff should be trained in basic statistics so as to ensure better integration of monitoring activities and management actions. This report highlights a number of actions that should be taken in the future so as to improve current information about the marine reserve. It is hoped that this report will represent the continuation of efforts to improve links between science and management at the SCMR.

## References

- Acosta, C. A. Field Protocol for monitoring coral reef fisheries resources in Belize. WCS, 1-8.
- Gascoigne, J., & Lipcius, R. N. (2004). Conserving populations at low abundance: delayed functional maturity and Allee effects in reproductive behaviour of the queen conch *Strombus gigas*. *Marine Ecology Progress Series*, 284(284), 185-194.
- Heyman, W. D., Azueta, J., Lara, O., Neal, D., Luckhurst, B., Paz, M., et al. (2004). *Reef Fish Spawning Aggregation Monitoring Protocol for the Meso-American Reef and Wider Caribbean*: Meso-American Barrier Reef Systems Project.
- Salgado, G. M. A., Camarena, T. L., Vasquez, M., Gold, G. B., Galland, G., Nava, G. M., et al. (2006). *Baseline of the Status of the Mesoamerican Barrier Reef Systems Results of Synoptic Monitoring from 2004 and 2005*: MBRS.
- Stoner, A. W., & Ray-Culp, M. (2000). Evidence for Allee effects in an over-harvested marine gastropod: density-dependent matine and egg production. *Marine Ecology Progress Series*, 292, 297-302.

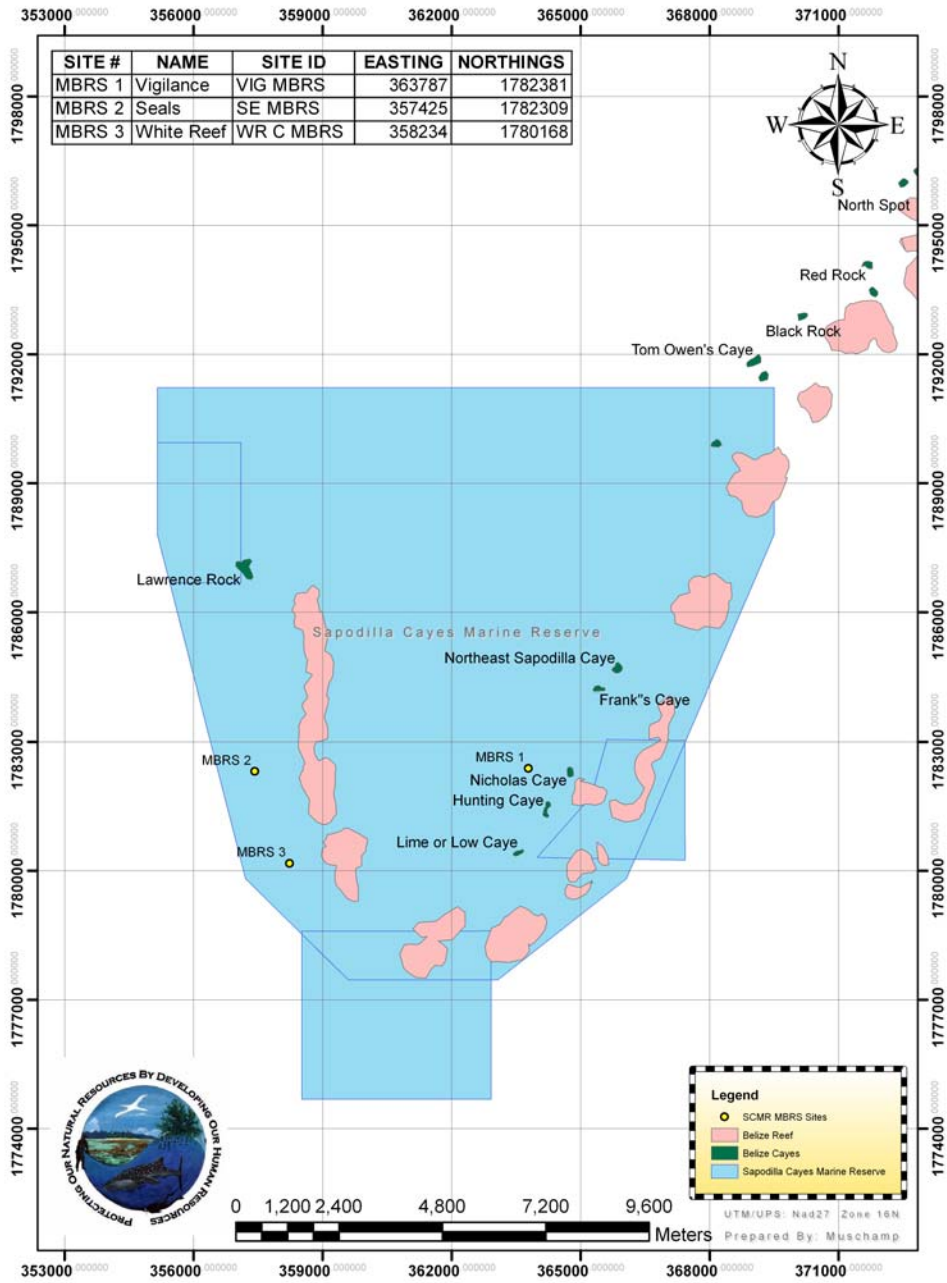
Appendix 1

Sapodilla Cayes Marine Reserve Commercial Species Map



Appendix 2

Sapodilla Cayes Marine Reserve MBRS Map



# Appendix 3

