

## “State of the Park Report 2007” -Sapodilla Cayes Marine Reserve

### **Introduction**

In 2006 the staff of the Toledo Association for Sustainable Tourism and Empowerment (TASTE) and the Belize Fisheries Department staff working at the Sapodilla Cayes Marine Reserve (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 apply some monitoring data to management and to evaluate gaps and make adjustments to monitoring methods to better aid in management decision making.

### **Sea Turtles**

#### Overview of Monitoring Activities-

The Sapodilla Cayes is a known nesting site for Hawksbill turtles (and likely Green turtles). Hawksbill turtles are listed as an endangered species, and 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 effect of poaching 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.

Results-

NEED ADDITIONAL INFORMATION

### **Caye Bird Species**

#### Overview of Monitoring Activities-

Ragged Caye is a known nesting site for Laughing Gulls and Bridled Terns. (It is also thought that the Roseate Tern may nest or recently have nested in the SCMR.) During the breeding season efforts monitor nesting birds. This basically includes monitoring of bird behavior and the counting of nests and eggs during the season.

NEED ADDITIONAL INFORMATION

### **Commercial Fish 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 an alarming 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 four areas: conch, lobster, finfish and spawning aggregations. Monitoring for conch, lobster and finfish is focused at 13 strategically chosen sites. These sites are balanced between coral reef and sea grass habitat but are almost exclusively shallow sites, with only one being a dive site. Spawning aggregation monitoring at the SCMR focuses on the three known SPAG sites within the reserve, with most monitoring effort focused at the Nicholas Cut site which is a known aggregation for Nassau Grouper. It is hoped that the data collected through this monitoring will allow for greater comparison and management of key commercial species within the SCMR.

### *Conch*

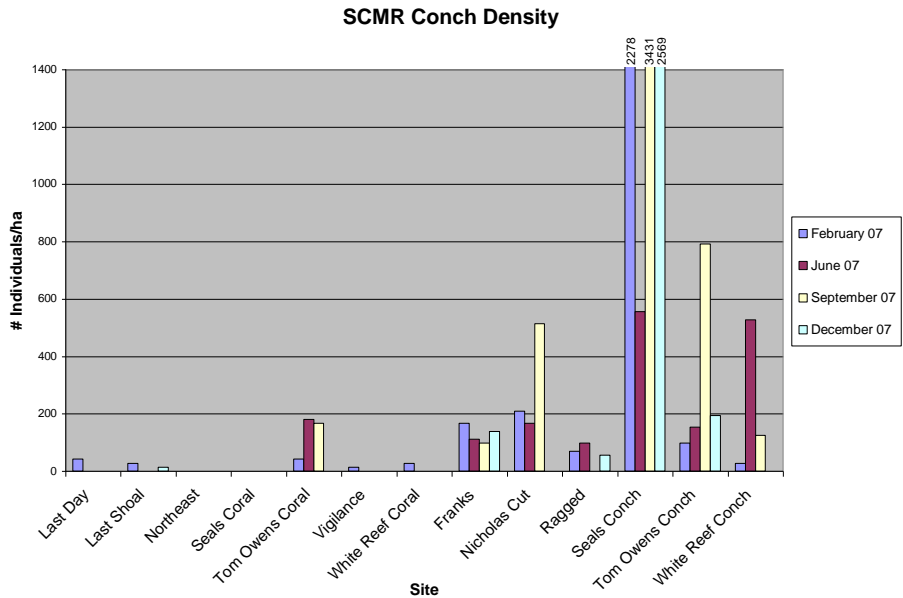
#### Overview of Monitoring Activities-

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. 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 us to make comparison across sites and time periods of conch density, size distribution and the current status of conch stocks.

#### Results-

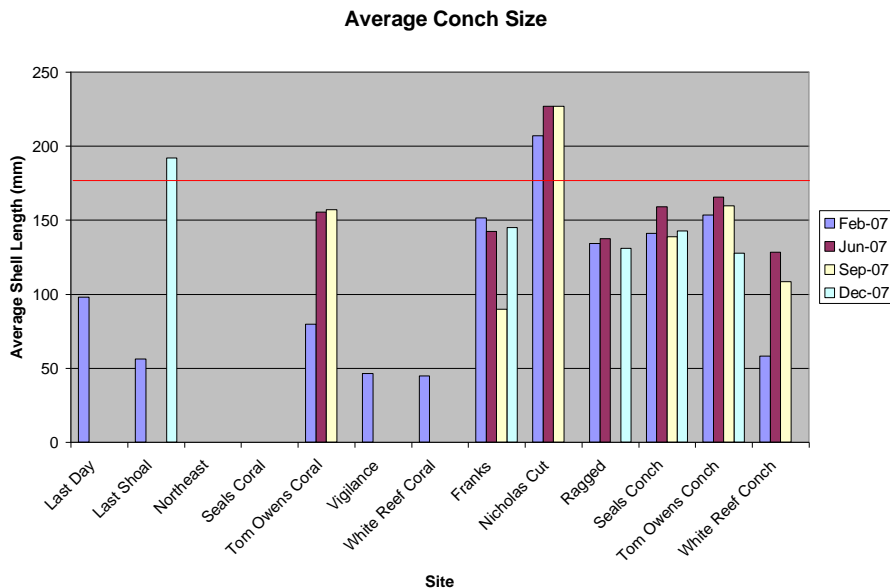
Figure 1 shows the average density of conchs found at each of the sites. Although the number of conchs at some sites was extremely high, especially at the well known nursery near Seals Caye, at most sites there were relatively few individuals encountered. The overall average for conch density was around 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 1**



Despite significant densities at a number of sites Figure 2 illustrates that only one site had significant numbers of sexually mature individuals. The red line on Figure 2 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 and a mature conch is usually identified by a shell flare with a lip thickness of 5mm (CITATION). Recent research has suggested however that even individuals with a lip thickness of 5mm may not actually be sexually mature (CITATION). 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 2**



#### 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 thorough 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 would be taken only at these six sites (i.e. running of transects), 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*

### Overview of Monitoring Activities-

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 3 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 3

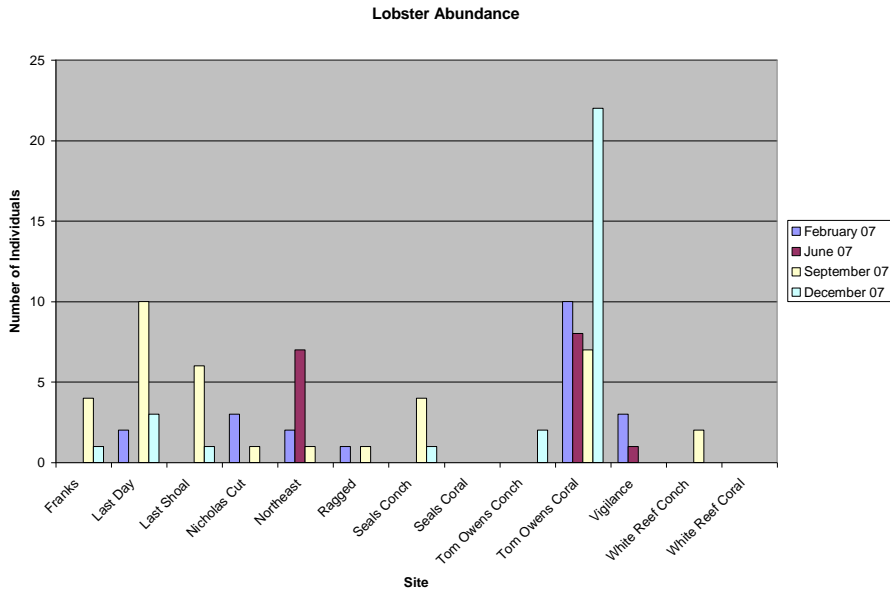
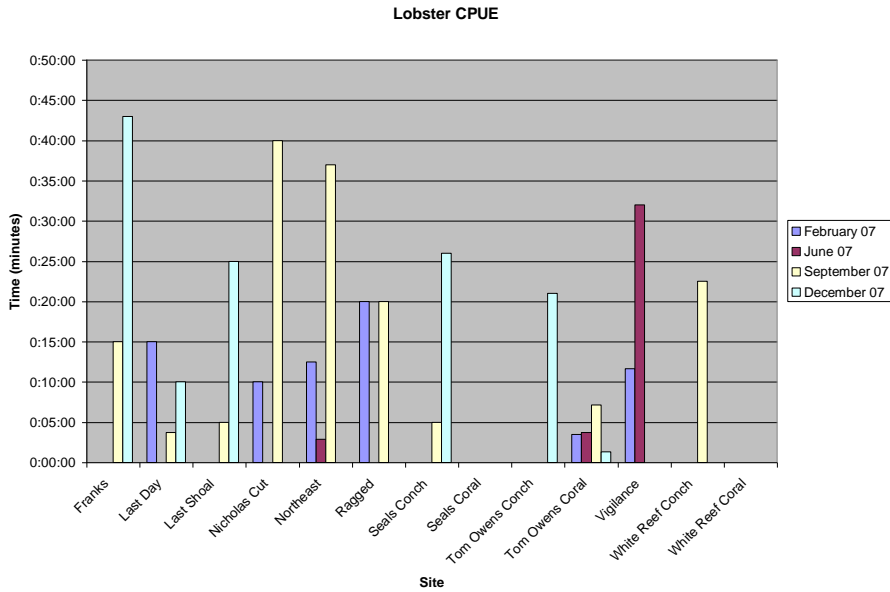


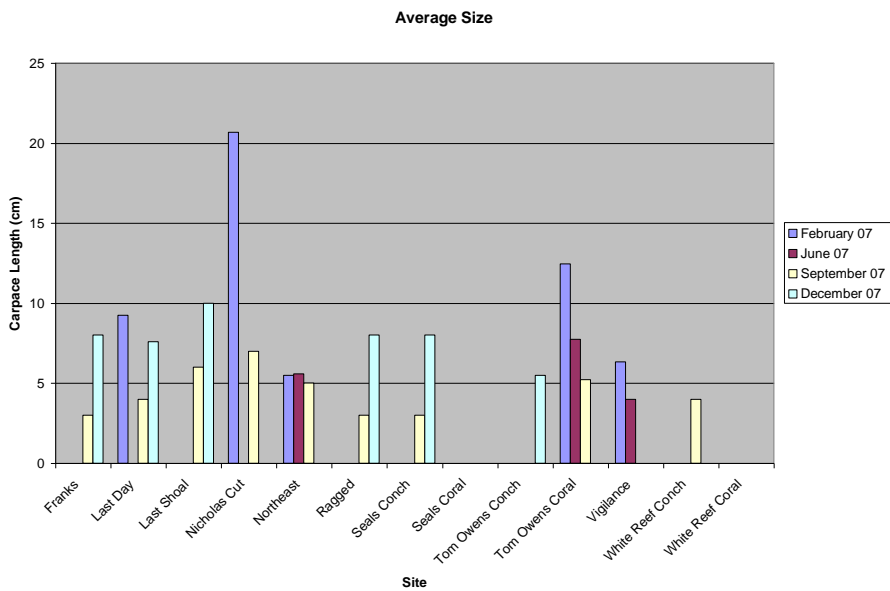
Figure 4 uses catch per unit effort (CPUE) as a way to help evaluate lobster abundance within the park. This methodology mimics the way that most commercial fishermen would fish for lobster with a hook stick and can be expressed as the number of minutes (or effort) necessary for the capture of one individual. 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 4**



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 5 shows the size distribution for lobsters encountered. There did not appear to be a significant difference in carapace length between spiny and spotted lobsters so the table below represents the average for both species combined.

**Figure 5**



**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*

#### Overview of Monitoring Activities-

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, Hogfish, Queen Trigger, Black Grouper, Mutton Snapper 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 and dog snapper, be added to the species list, as these are common commercially fished species which are also frequently found within the reserve. 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.

#### **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 management priority for the SCMR and the maintenance and improvement of the reef ecosystems is of key 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. 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. Data collected during all of these monitoring events is compared and discussed below.

#### *Benthic Cover*

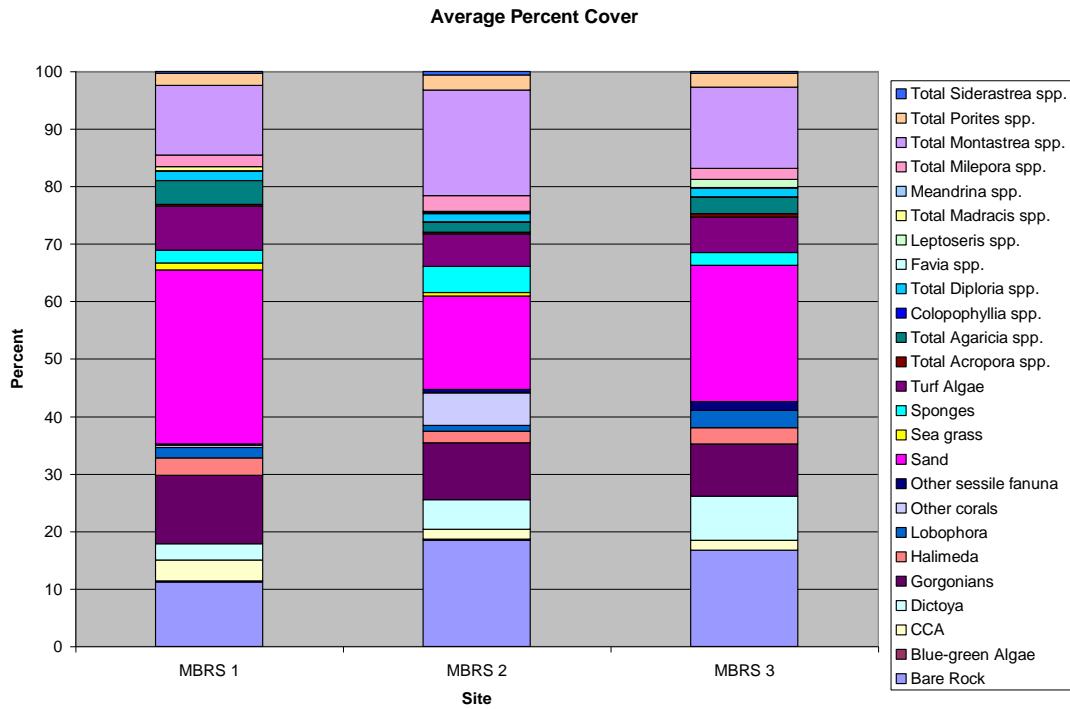
##### Overview of Monitoring Activities-

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. The MBRS SMP uses a point intercept method to estimate coral cover at different sites. This focuses on laying 30 m transects and then recording benthic components at 25 cm intervals along the length of the line. At the SCMR six 30 m 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 10 m 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 macroalgae, fleshy macroalgae, 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-

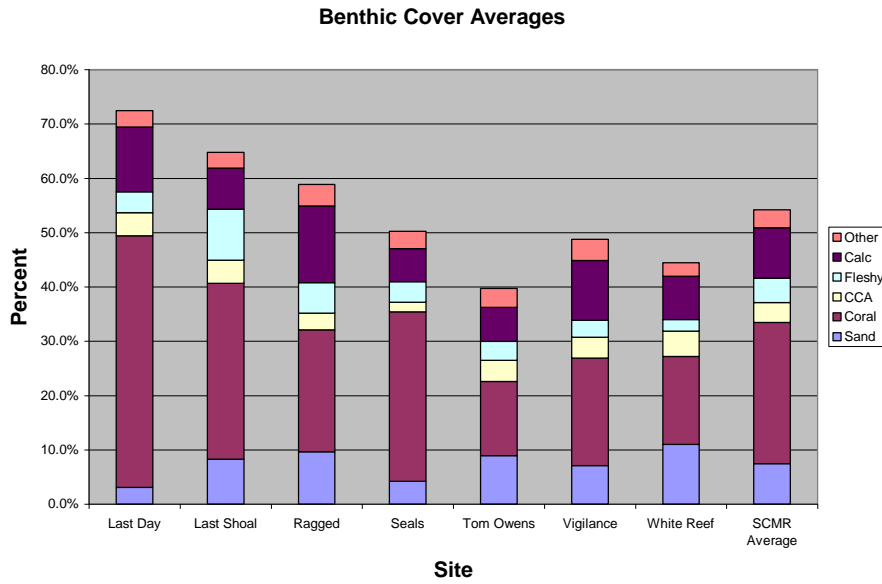
Data has been collected at the three MBRS sites at least once yearly from 2004. This should give us a good idea about the reef conditions at each of the sites monitored. The three MBRS sites are all shallow sites and are most often surveyed snorkeling. Although we have data from six different surveys at this time it is not possible for us to do a statistical analysis to determine if there have been significant changes in benthic cover. (For further discussion on this please see the evaluation and recommendations section.) However we can use this survey info to develop a good idea about the average status of the reefs over the sample period. Figure 6 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 (CITATION).

**Figure 6**



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 7 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. The like the MBRS results 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.

**Figure 7**



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 8**

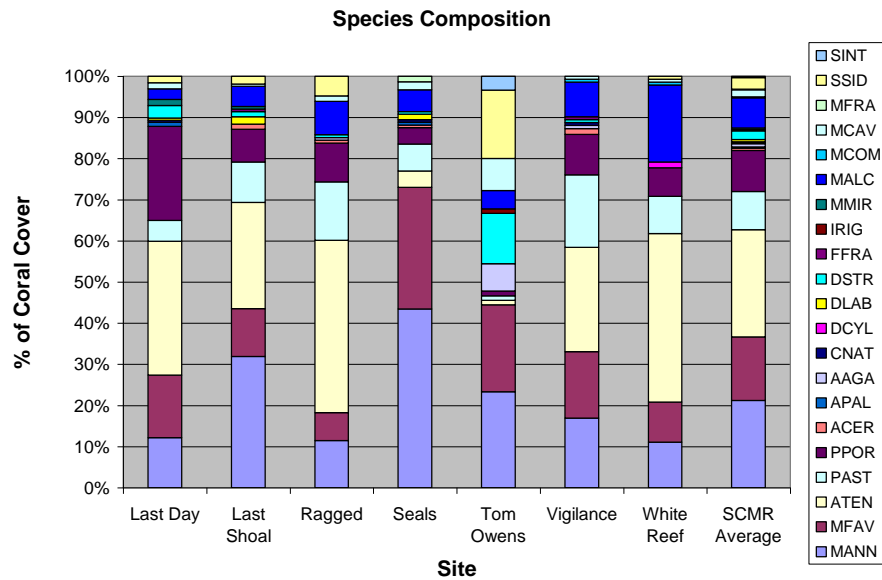


Figure 8 illustrates the observed species types at each of the different sites monitored as well as the overall SCMR average. The averages were derived based on the number of individual corals for each type monitored. There were a total of 21 coral species observed along transects in the SCMR with an 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-

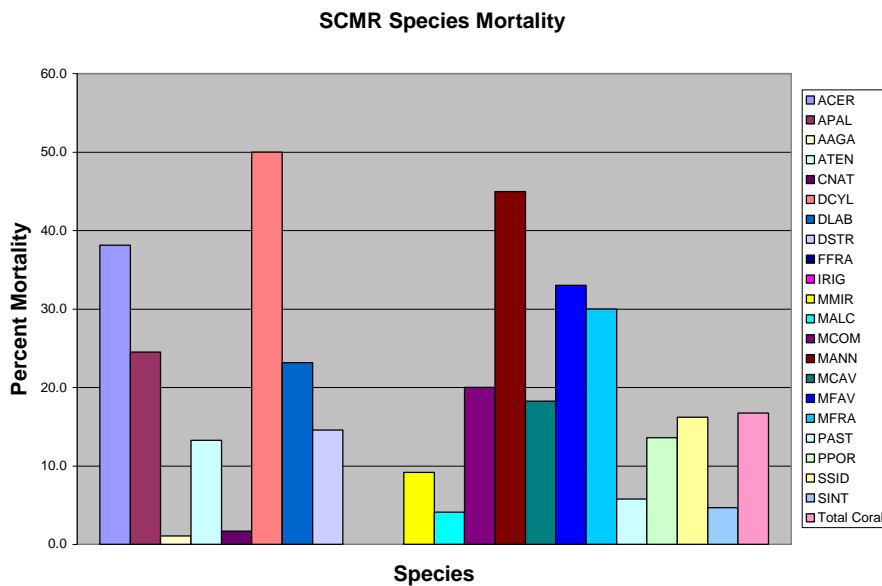
In addition to understanding the benthic cover it is important for managers to have a good understanding of coral health. Over the past three decades there has been a significant drop in the health of corals throughout the Caribbean this is likely due to an increase in coral bleaching events, decrease 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-**

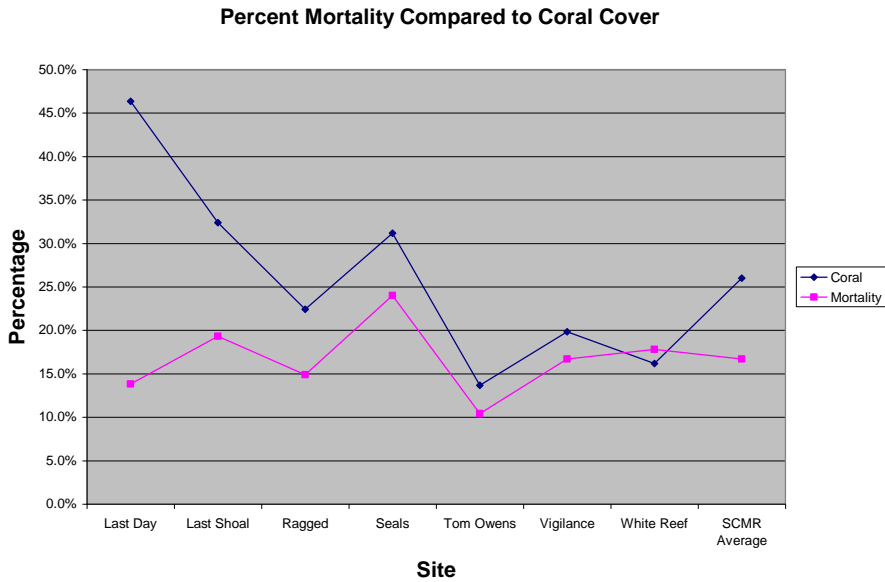
Like the benthic cover data further statistical analysis is necessary to make comparisons in coral mortality over the period from 2004-2007. The data shown below is from the coral bleaching project. Figure 9 shows the average mortality for each coral species observed in the SCMR.

**Figure 9**



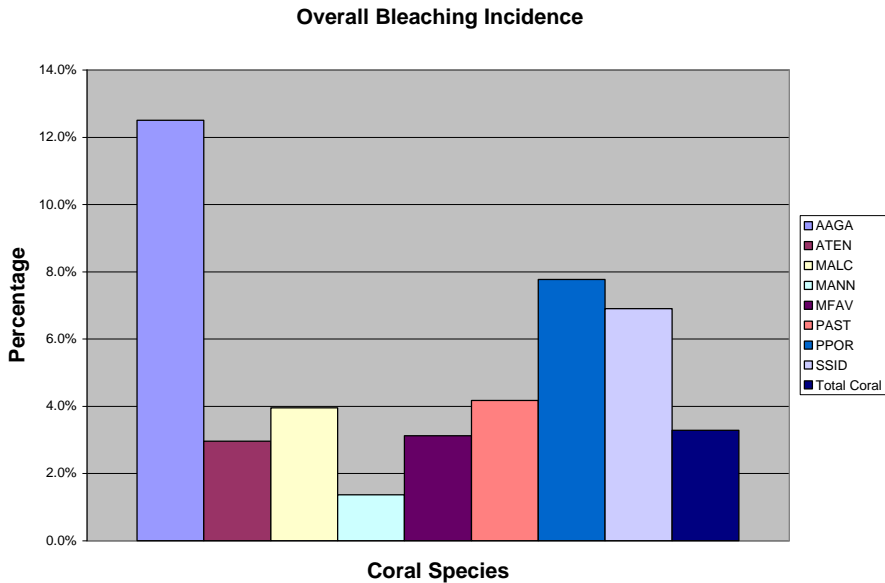
Overall coral mortality at the SCMR was around 17%. The vast majority of this mortality was old mortality attributed to algal overgrowth. As expected the large major reef builders *Montastrea spp.* exhibited high amounts of mortality, as shown in Table 2. As would be expected with the focus of sampling 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 10**



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 10 shows mortality at these five sites appears to be directly related to the percent coverage in a fairly predictable way.

**Figure 11**



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 monitored (3.3%) showed any signs of bleaching. Of these colonies seven coral species were observed with some form of bleaching. Figure 11 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*

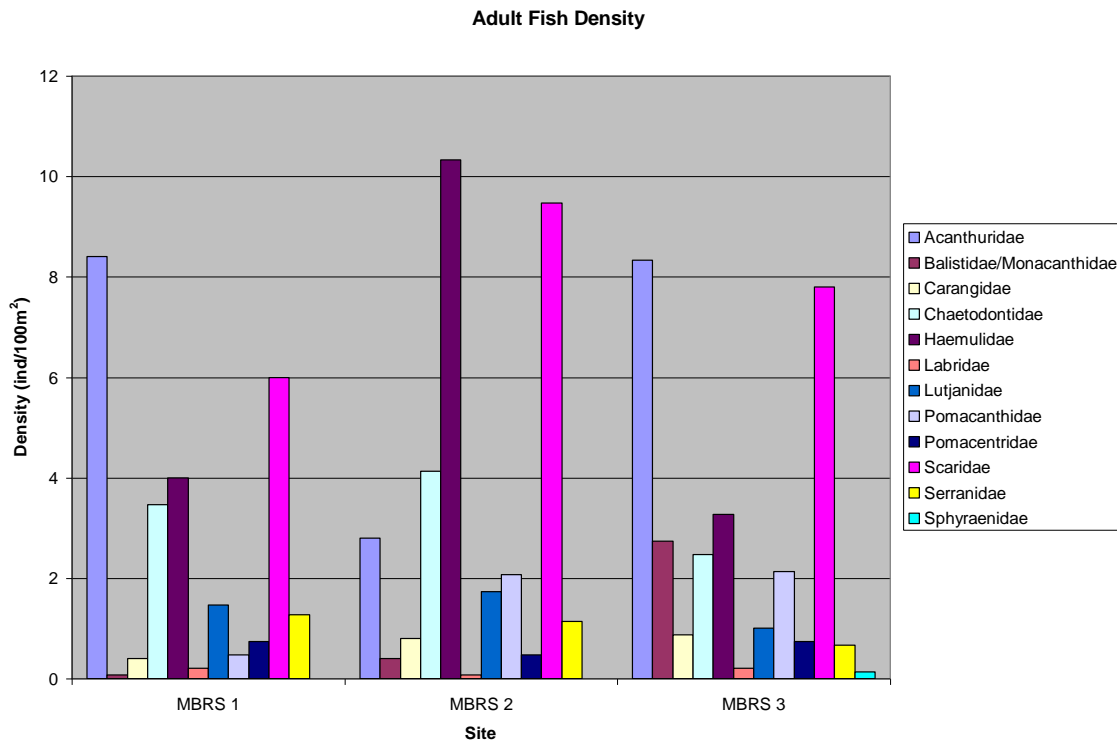
#### Overview of Monitoring Activities-

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 12 shows the average density for each family monitored at each MBRS site from 2005-2007. Figure 12 shows the number of individuals for each family that would be encountered in a 100 m<sup>2</sup> area. 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 12**



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 which 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. Continued monitoring is necessary to monitor these effects. 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 SCMR, 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 3 m 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.

- 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.