Glover's Reef Marine Reserve
Long- term Atoll Monitoring Program (LAMP)

Report for the period July 2004 – November 2007

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SUMMARY

Fishing is one of the most important economic activities in Belize, and the Marine Protected Area (MPA) system is expected to contribute to sustainable fisheries by providing refuge areas that allow for species reproduction and ultimately, the replenishment of adjacent fished areas. Long-term monitoring is required to determine the status of these commercially-exploited stocks within MPAs. In 2004, a long term fishery-independent monitoring program was introduced at Glover's Reef Atoll, the third largest marine protected area in Belize with an area of 35,876 hectares. The aim of the Glover's Reef Long-term Atoll Monitoring Program (LAMP) is to collect baseline information and data over time that will be used to determine the current status and monitor trends of commercial fish species (distribution, density, size class structure, reproduction) and habitat quality. The information on the population dynamics of target species will also be used to develop recommendations to guide management decisions on fishing quotas, length of fishing season, size limits and other regulations to ensure profitability and sustainability of the fishery.

This report presents the results of data collected at 33 sample sites located within the atoll's three main management areas: the Wilderness, Conservation and General Use Zones, during eight sampling periods from July 2004 – November 2007. The report focuses on data collected on the spiny lobster (*Panulirus argus*), queen conch (*Strombus gigas*) and five commercial finfish species (Nassau grouper *Epinephelus striatus,* Black grouper *Mycteroperca bonaci,* Hogfish *Lachnolaimus maximus,* Mutton snapper *Lutjanus analis* and Queen triggerfish *Balistes vetula*). The results for six species of parrotfish (Stoplight *Sparisoma viride,* Redtail *Sparisoma chrysopterum*, Yellowtail *Sparisoma rubripinne*, Princess *Scarus taeniopterus*, Striped *Scarus croicensis* and Redband *Sparisoma aurofrenatum*) are also presented in the report.

INTRODUCTION

The Long Term Atoll Monitoring Program (LAMP) is a fishery independent monitoring program designed specifically for the long-term monitoring of physical and biological parameters at the Glover's Reef atoll and for generating data comparable to the existing Caribbean Coastal Marine Productivity (CARICOMP) dataset. The CARICOMP program is a comprehensive, long-term plan for research and monitoring in the Caribbean basin.

Fishery independent monitoring involves sampling of habitats of the target species to get direct estimates of the population in its natural habitat. In Marine Protected Areas, this type of monitoring in conjunction with an appropriate study design also allows for the comparison of the impact in the different management zones and for detecting changes in a fished population (e.g. due to over fishing).

Aim and Objectives of Study

Aim of the study:

To monitor and analyze the viability of a fished population in order to determine trends showing increase, decrease or stability of the population.

Objectives:

1) To gather data on the number of animals in each size class of the population,
2) To gather data on the number of adults that are reproducing
3) To determine any major changes in habitat quality from that required by the species.
4) To compare the effectiveness of the different management zones in the reserve
5) Based on the results of the data gathered make recommendations for management decisions on fishing quotas, length of season, size limits, and other regulations that can be modified to make the fishery both profitable and sustainable.

METHODOLOGY

The LAMP protocol was developed in 1996 to monitor the spiny lobster and queen conch fisheries in the Glover's Reef Marine Reserve. In 2000, it was expanded to include the monitoring of five commercially important finfish species: (Nassau grouper *Epinephelus striatus,* Black grouper *Mycteroperca bonaci,* Hogfish *Lachnolaimus maximus,* Mutton snapper *Lutjanus analis* and Queen triggerfish *Balistes vetula*). The protocol is described in *Field protocol for monitoring coral reef fisheries resources in Belize* (Acosta, 2003) and conforms to the methodology described in the CARICOMP Methods Manual Levels 1 and 2 (CARICOMP, March 2001 edition). In March, 2006, parrotfish species were also included as part of the monitoring program given their importance as herbivores and their increasing importance as a commercially fished species.

This report presents data collected only for the fishery independent component of the protocol[1] from 31 July, 2004 to 15 November, 2007 during 12 sampling periods. The sampling periods are also grouped by year to illustrate data trends on an annual basis:

Year 1: July 2004, October 2004, March 2004 and May 2005
Year 2: November 2005, March 2006, July 2006 and September 2006
Year 3: February 2007, May 2007, August 2007 and November 2007

Sampling Sites

A random sampling design was employed to select the location of the sites. A total of 33 sites were placed in the Glover's Reef Marine Reserve: Conservation Zone (CZ) - 13 sites; General Use Zone (GUZ) – 19 sites[3] and Wilderness Zone (WZ) – one site (Figure 1). GPS readings were taken of all the sites.

Twenty-two sites were located on sand flats and 11 sites were located on lagoon patch reefs. Of the 22 sand algal flat sites, eight were located in the CZ, 13 in the GUZ and one in the WZ. Of the 11 patch reef sites, 5 were located in the CZ and 6 in the GUZ (Table 1). The depth of the sampling sites ranged from 3.3 ft. to 52 ft.

[1] The protocol also includes direct fishery monitoring which involves subsampling the fisher's catch or landings.
[2] Only seven sampling periods of Parrotfish data were analysed since data collection for the six Parrotfish species began on 17 March 2006.
[3] Only a portion of the General Use Zone was surveyed.

Figure 1 *Location of the 33 sampling sites in the Glover's Reef Marine Reserve*.

Table 1 *Distribution of sampling sites by habitat and management zone in the Glover's Reef Marine Reserve.*

	Management Area		
Habitat	**Wilderness**	**Conservation**	**General Use**
Sand Algal Flats and Seagrass Beds	1	8	13
Patch Reefs	0	5	6
Total No. of Sites	**1**	**13**	**19**

Each sampling period, a total area of 6 ha was surveyed: 2.99 ha in the CZ, 2.99 ha in the GUZ and 0.02 ha in the WZ (Table 2). Each of the 33 survey sites had one of two distinct types of replicate sampling unit, namely: individual patch reefs or straight line belt transects. The area of each patch reef was estimated by taking GPS points along the perimeter of the patch reef and inputting the information into a Geographic Information System (GIS) to calculate the area. The patch reefs ranged in size from 0.05 ha to 1.43 ha and averaged 0.51 ha. The area of each of the belt transects was 0.02 ha and measured 50 m long by 4 m wide.

Table 2 *Area of sites surveyed in the three management zones in the Glover's Reef Marine Reserve.*

	Management Zone (Area - ha)		
	Wilderness	**Conservation**	**General Use**
Patch Reefs			
prC7AB		1.26	
prC2AB		0.84	
prC11AB		0.44	
prC8AB		0.17	
prC3AB		0.12	
prC6AB			1.43
prC9			0.64
prC4AB			0.25
prC1AB			0.21
prC10AB			0.15
prC19AB			0.05
Total Patch Reef Area	**0.00**	**2.83**	**2.73**
Mean Patch Reef Area		**0.57**	**0.46**
Total Sand Flats Area	**0.02**	**0.16 (0.02 ha x 8 sites)**	**0.26 (0.02 x 13 sites)**
Total Area Surveyed (Patch Reef and Sand Flats)	**0.02**	**2.99**	**2.99**

*The Conservation and Wilderness Zones were combined for all analyses.

Species Surveys

Conch Survey

The queen conch was surveyed on sand algal flats and seagrass beds (i.e. the sand flats areas) as well as near shallow patch reef habitats. In sand-algal and seagrass habitats, density surveys were conducted along straight line belt transects measuring 50 m long by 4 m wide. A 50 m measurement tape was laid along the substrate and conch were counted along 2 m on either side of the tape. Conch were measured for size and checked for egg laying activity or presence of egg masses. To measure size, shell length was measured in mm from the tip of the spire to the notch opening. Mature conch stop increasing in shell length, but the shell lip starts to thicken, therefore, the lip thickness was also measured to estimate the age of mature conch.

Lobster Survey

Spiny lobsters were surveyed on patch reef sites only since large juveniles and adults use patch reef habitat for shelter and feeding and smaller size classes of lobster which use seagrass and macroalgal habitats cannot be visually surveyed accurately by standard methods. Each patch reef was surveyed for 30 or 60 minutes depending on depth and reef size. Patch reefs were surveyed by swimming crossing patterns across the entire reef structure. Lobsters were measured for size by estimating the carapace length to the nearest cm with a marked tickle stick placed over the dorsal side from the posterior end of the carapace to the space between the eyes. The sex was determined by observing external dimorphic characteristics and the lobster was checked for the presence of egg masses.

Finfish Survey

Finfish species were surveyed on patch reef sites, as in the spiny lobster sampling protocol described above. Data for the following species were collected during the survey: Nassau grouper *Epinephelus striatus*; Black grouper *Mycteroperca bonaci*; Hogfish *Lachnolaimus maximus*; Mutton Snapper *Lutjanus analis* and Queen triggerfish *Balistes vetula.* The six species of parrotfish surveyed were: Stoplight *Sparisoma viride,* Redtail *Sparisoma chrysopterum*, Yellowtail *Sparisoma rubripinne*, Princess *Scarus taeniopterus*, Striped *Scarus croicensis* and Redband *Sparisoma aurofrenatum*. The fork length of the target species was estimated in cm from the tip of the snout to the fork of the tail.

Environmental Variables

At each site, the following variables were recorded using a Yellow Springs Instrument (YSI) meter: water temperature, conductivity, salinity and depth. Visibility was measured using a secchi disk.

RESULTS

Queen Conch (*Strombus gigas)*

Species count and density

The mean density of conch surveyed for the period July 2004 to November 2007 was 24.6 conch per ha. The density of conch was highest for the period February 2007 to November 2007 (28.7 conch per ha) when compared to the July 2004 – May 2005 and November 2005 – September 2006 periods (Figure 2). The density of Queen conch was also higher in the CZ (26.1) than the GUZ (23.1) for the July 2004 to November 2007 survey period (Table 3).

Figure 2: *Mean density (conch per hectare) of Queen conch* Strombus gigas *surveyed at Glover's Reef Marine Reserve for the period July 2004 to November 2007.*

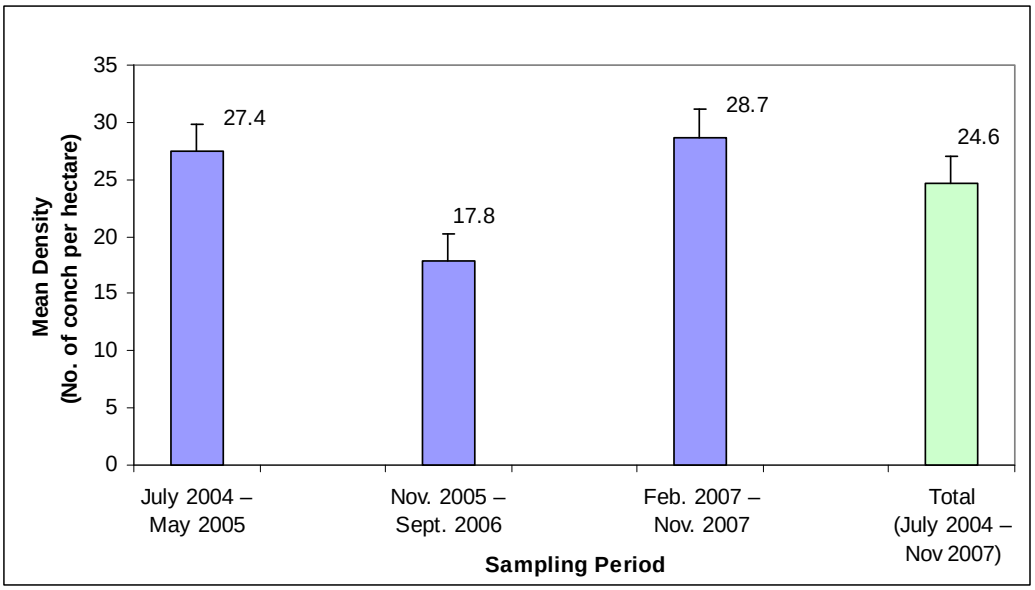


Table 3 Mean *Density (conch ha^{-1}) of queen conch* Strombus gigas *surveyed on patch reef and sand algal flats in Glover's Reef Marine Reserve for the period July 2004 to November 2007. Density per management zone is also shown.*

	Mean Density (#conch ha^{-1})		
Sampling Period	**Total no. of conch (CZ + GUZ)**	**Conservation Zone**	**General Use Zone**
July 2004 – May 2005	27.4	32.7	22.1
Nov. 2005 – Sept. 2006	17.8	15.9	19.6
Feb 2007 – Nov 2007	28.7	30.0	27.4
Total (July 2004 – Nov. 2007)	24.6	26.1	23.1

Shell length

The total sample mean shell length was 173.61 mm (s.d. 55.6 mm). The minimum shell length was 19 mm and the maximum was 300 mm. In analysing the data by sampling period and management zone, the mean shell length in the CZ was higher (185.2 mm) than the GUZ (160.4 mm) for the sampling periods July 2004 to November 2007 (Table 4).

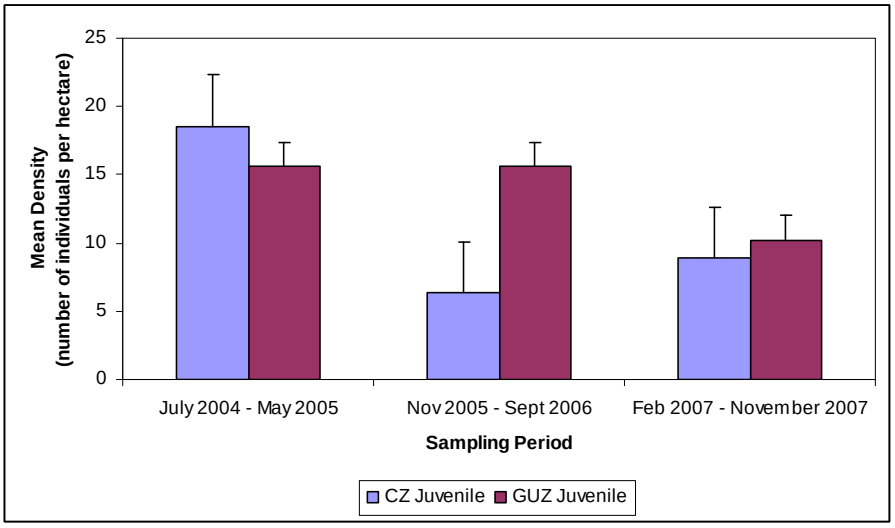
Table 4 *Queen conch* Strombus gigas *shell length according to sampling period and management zone.*

Zone		July 2004 – May 2005	Nov. 2005 – Sept. 2006	Feb 2007 – Nov 2007	July 2004 - Nov 2007
Conservation	**Mean shell length (mm)**	**174.1** (50.7)	**189.6** (51.2)	**195.0** (51.7)	185.2 (52.0)
General Use	**Mean shell length (mm)**	**153.3** (56.2)	**133.8** (52.4)	**185.2** (49.1)	160.4 (56.5)

The standard deviation is in brackets.

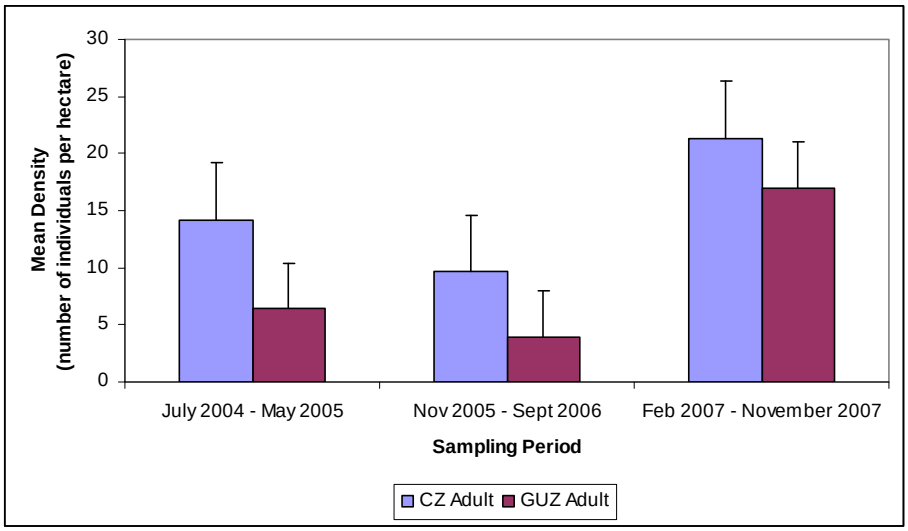
In comparing the periods July 2004 – May 2005, November 2005 – September 2006 and February 2007 to November 2007, the mean density of juvenile Queen conch (shell length less than or equal to 177 mm) was higher in the GUZ than in the CZ for two of the three annual sampling periods (Figure 3).

Figure 3 *Mean Density of juvenile Queen conch in the Conservation and General Use Zones.*



The mean density of adult queen conch (shell length greater than 177 mm) was higher in the CZ than the GUZ for all three sampling periods (Figure 4).

Figure 4 *Density of adult queen conch in the Conservation and General Use Zones.*

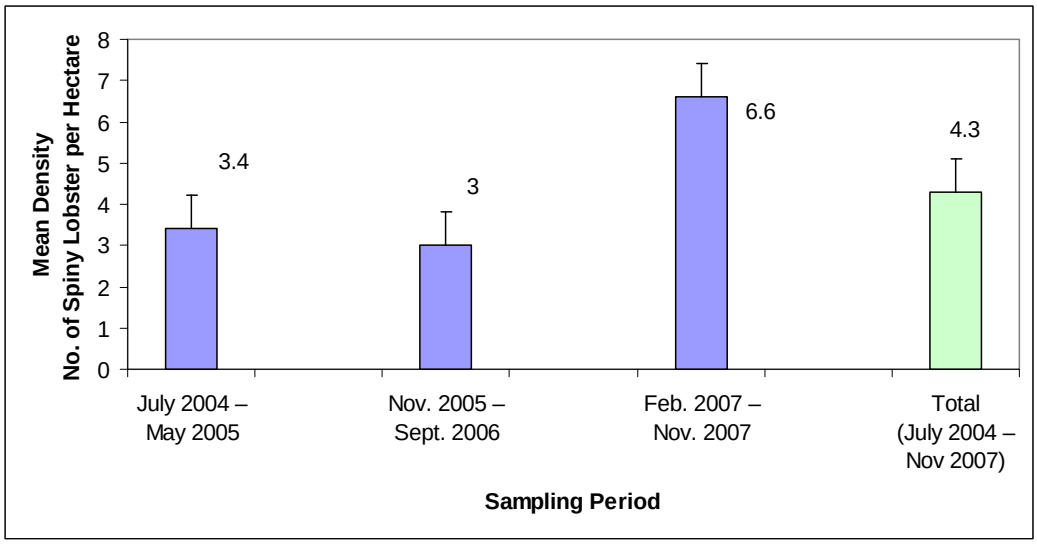


Spiny Lobster *(Panulirus argus)*

Species count and density

A total of 291 lobsters were encountered during the surveys. The total number of lobsters surveyed ranged from 1 individual to 59 individuals per site. Of the 291 lobsters surveyed, 151 were females (51.9%) and 131 were males (45%). Eight lobsters were not sexed. No egg masses were present on any of the female individuals. The total mean density of lobster surveyed for the period July 2004 to November 2007 was 4.3 lobster per ha. The density of lobster was highest for the period February 2007 to November 2007 (6.6 lobster per ha) when compared to the July 2004 – May 2005 and November 2005 – September 2006 periods (Figure 2).

Figure 5: *Mean density (lobster per hectare) of spiny lobster* Panulirus argus *surveyed at Glover's Reef Marine Reserve for the period July 2004 to November 2007.*



The mean density of spiny lobster was higher in the CZ than in the GUZ for all annual sampling periods (Table 5).

Table 5 *Mean Density of spiny lobster* Panulirus argus *within management zones at Glover's Reef Marine Reserve for the period July 2004 – November 2007.*

	Mean Density (# lobster ha^{-1})		
Sampling Period	**Total no. of conch (CZ + GUZ)**	**Conservation Zone (CZ)**	**General Use Zone (GUZ)**
July 2004 – May 2005	3.2	4.5	1.9
Nov. 2005 – Sept. 2006	3.0	3.9	2.2
Feb 2007 – Nov 2007	6.6	7.1	6.2
Total (July 2004 – Nov. 2007)	4.3	5.3	3.5

Carapace length

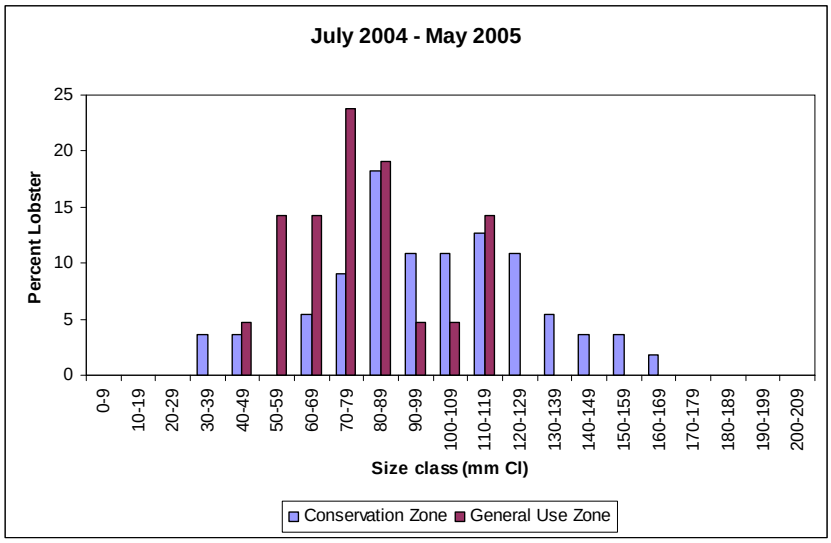
The mean carapace length of the sample was 106.0 mm (36.7 mm S.D.). In analyzing the data by zone, the mean carapace length was higher in the CZ (110.1 mm, S.D. = 35) than in the GUZ (98.8 mm, S.D. = 38.3 mm) overall (Table 6).

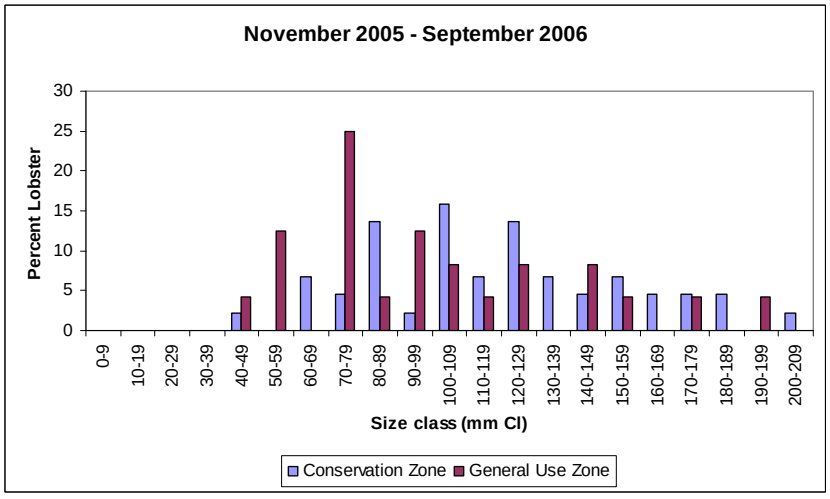
Table 6 *Distribution of spiny lobster* Panulirus argus *carapace length (in mm) by management zone.*

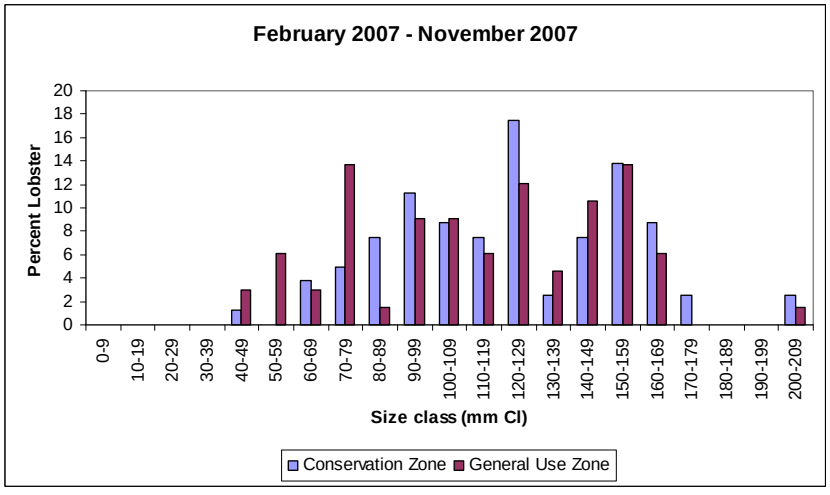
Zone		July 2004 – May 2005	Nov. 2005 – Sept. 2006	Feb 2007 – Nov 2007	July 2004 - Nov 2007
Conservation	**Mean carapace length (mm)**	95.1 (29.6)	114.1(37.3)	118.3 (34.3)	110.1 (35.0)
General Use	**Mean carapace length (mm)**	74.3 (20.6)	95.8 (39.8)	107.6 (38.9)	98.8 (38.3)

The population size class structure of spiny lobster in the GUZ for the period July 2004 to May 2005 showed that the majority of the individuals fell within the small to mid size class ranges and there were no individuals larger than 120 mm carapace length. For the same period, the spiny lobster in the CZ showed a normal distribution with a small number of individuals in the smaller and larger size classes with the majority of individuals in the midrange (Figure 6). For the period November 2005 to September 2006, the majority of individuals fell within the mid size class range of 70 mm to 129 mm carapace length in both the CZ (57%) and GUZ (63%). For the period February 2007 to November 2007, the majority of individuals fell within the mid and upper size class range between 90 mm to 169 mm carapace length in both the CZ (79%) and the GUZ (71%) (Figure 6)

Figure 6 *Population size class structure of spiny lobster (carapace length in mm) in the Conservation Zone (CZ) and General Use Zones (GUZ) for the survey periods July 2004 to May 2005, Nov. 2005 to Sept. 2006 and Feb. 2007 to Nov. 2007.*







The mean densities of the juvenile lobsters (less than or equal to 70 mm carapace length) were low in both the CZ and GUZ with mean densities between 1 and 2 individuals per hectare (Figure 7). The mean densities of adult lobsters were higher in the CZ (range 3 to 6 individuals per hectare) than the GUZ for all three sampling periods (Figure 8).

Figure 7 *Densities of juvenile spiny lobster in the Conservation Zone (CZ) and General Use Zones (GUZ).*

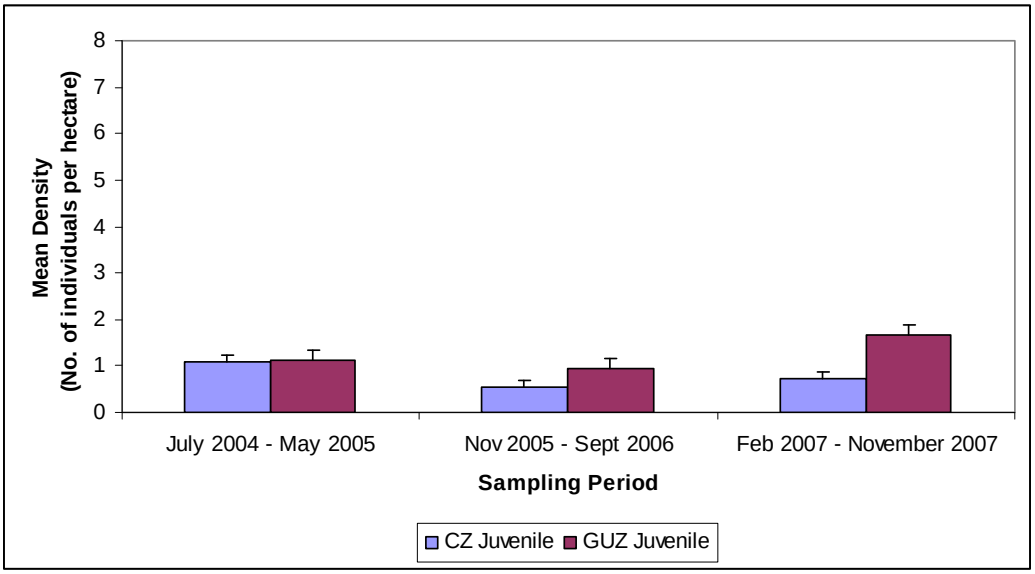
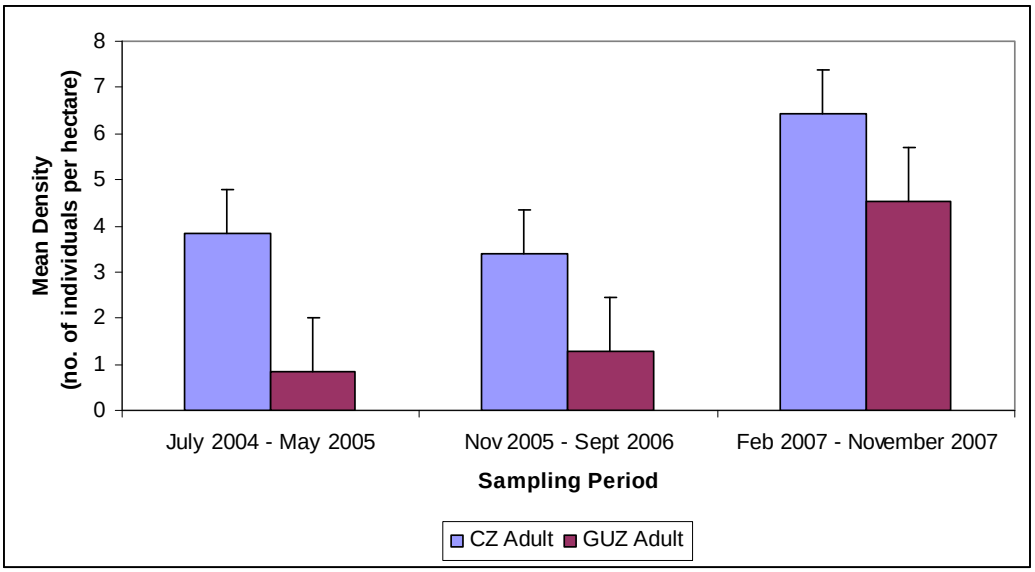


Figure 8 *Mean Densities of adult spiny lobster in the Conservation Zone (CZ) and General Use Zones (GUZ).*



Finfish

Species counts and density

A total of 574 individuals were recorded for the finfish species. Hogfish made up the largest (43.7%) proportion of the finfish sample. The mutton snapper comprised 24.6%; Nassau grouper 22.3%, black grouper 7.8% and queen trigger fish 1.6% (Table 7). The mean densities for the five finfish species per sampling period ranged from a minimum of 0.1 individuals per ha to a maximum of 3.7 individuals per ha (Hogfish) (Table 8).

Table 7 *Counts of five commercial finfish species in the Glover's Reef Marine Reserve during the period July 2004 to November 2007.*

Species	Percentage of Individuals % July 2004 – Nov 2007 N=574
Hogfish	43.7
Mutton Snapper	24.6
Nassau Grouper	22.3
Black Grouper	7.8
Queen Trigger Fish	1.6

Table 8 Mean Density *of five commercial finfish species in the Glover's Reef Marine Reserve surveyed during the period July 2004 to November 2007.*

Species	Mean Density No. of individuals per ha Standard Deviation in Brackets
Hogfish	3.7 (2.0)
Mutton Snapper	2.1 (1.5)
Nassau Grouper	1.9 (0.8)
Black Grouper	0.7 (0.4)
Queen Trigger Fish	0.1 (0.2)

For only two of the finfish sampled, Hogfish and Black grouper, the densities observed in the CZ were higher than that observed in the GUZ for the three sampling periods (Table 9). The mean fork length for none of the species was consistently higher in the CZ than in the GUZ (Table 11).

Table 9 *Mean density of five species of finfish in the Conservation and General Use Zones for the period July 2004 – November, 2007.*

	Mean Density (individuals ha^{-1})		
Density (#fish)	**July 2004 – May 2005**	**Nov. 2005 – Sept. 2006**	**Feb. 2007 – Nov. 2007**
Hogfish			
Conservation Zone	8.4 (94)	3.6 (40)	3.4 (38)
General Use Zone	3.2 (35)	1.9 (20)	1.9 (21)
Total (CZ + GUZ)	5.8 (129)	2.7 (60)	2.7 (59)
Mutton Snapper			
Conservation Zone	4.7 (53)	1.7 (19)	1.1 (12)
General Use Zone	2.7 (29)	1.0 (11)	1.6 (17)
Total (CZ + GUZ)	3.7 (82)	1.3 (30)	1.3 (29)
Nassau grouper			
Conservation Zone	2.6 (29)	1.0 (11)	2.0 (22)
General Use Zone	1.3 (14)	1.2 (13)	3.1 (34)
Total (CZ + GUZ)	1.9 (43)	1.1 (24)	2.5 (56)
Black grouper			
Conservation Zone	0.7 (8)	0.4 (5)	1.1 (12)
General Use Zone	0.6 (6)	0.3 (3)	0.9 (10)
Total (CZ + GUZ)	0.6 (14)	0.4 (8)	1.0 (22)
Queen trigger fish			
Conservation Zone	(0)	(0)	0.3 (3)
General Use Zone	0.3 (3)	0.1 (1)	0.1 (1)
Total (CZ + GUZ)	0.1 (3)	0.04 (1)	0.2 (4)

*numbers in brackets are the total number of individuals counted

Fork Length

The mean fork length in the total sample for mutton snapper, black grouper, hog fish, Nassau grouper and queen trigger fish were 32.9, 29.2 cm, 28.8 cm, 25.6 cm and 22.7 cm, respectively.

Table 10 *Distribution of mean fork length (in cm) by five commercial finfish species.*

	N	Mean	Standard Deviation	Minimum	Maximum
Mutton snapper	141	32.9	14.2	12	80
Black grouper	45	29.2	12.8	8	65
Hog fish	251	28.8	14.3	6	80
Nassau grouper	128	25.6	10.8	7	60
Queen Trigger Fish	9	22.7	8.3	12	40

Table 11 *Distribution of mean fork length (in cm) of finfish per management zone and sampling period.*

	July 2004 – May 2005		Nov. 2005 – Sept. 2006		Feb. 2007 – Nov. 2007	
	CZ	**GZ**	**CZ**	**GZ**	**CZ**	**GZ**
Hogfish						
N	94	35	40	20	38	21
Mean Fork Length (cm)	**28.06** (15.0)	**28.40** (15.1)	**29.05** (15.0)	**35.60** (11.9)	**23.4** (7.5)	**35.8** (16.8)
Mutton Snapper						
N	53	29	19	11	12	17
Mean Fork Length (cm)	**33.42** (14.1)	**32.45** (17.0)	**34.53** (13.4)	**32.27** (8.8)	**35.7** (10.1)	**28.4** (16.2)
Nassau Grouper						
N	29	14	11	13	22	34
Mean Fork Length (cm)	**26.17** (11.7)	**25.50** (11.9)	**27.0** (5.4)	**24.77** (12.3)	**25.1** (9.6)	**26.3** (11.7)
Black Grouper						
N	8	6	5	3	12	10
Mean Fork Length (cm)	**31.88** (16.4)	**19.83** (6.2)	**25.60** (5.2)	**23.33** (7.6)	**29.0** (11.2)	**37.2** (15.0)

Parrotfish

Species count and density

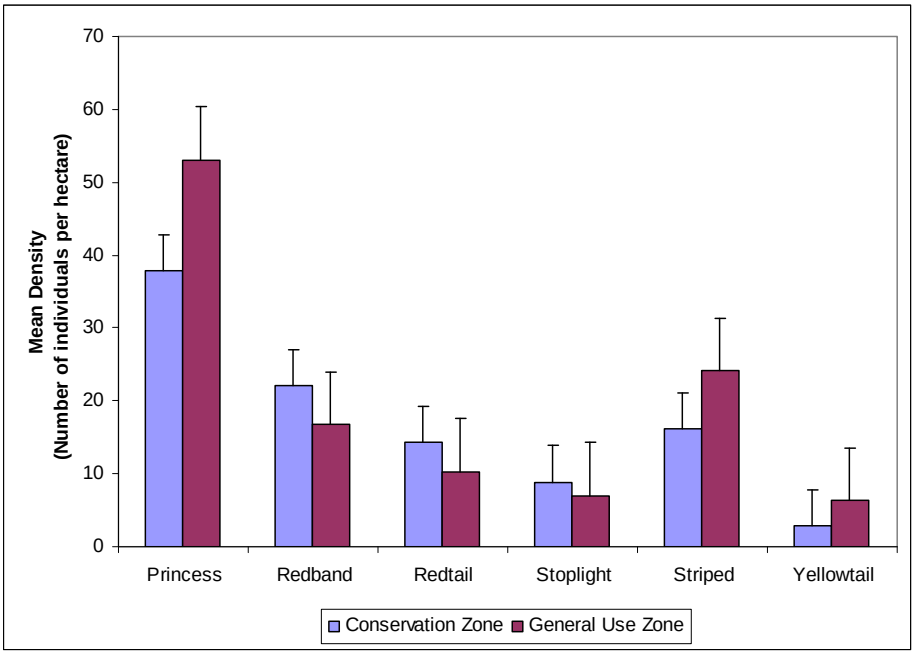
A total of 4228 individuals representing 6 species of parrotfish was recorded during the period March 2006 to November 2007. The princess parrotfish comprised the largest proportion (41.3%) of the parrotfish sampled (Table 12).

Table 12 *Percentage of parrotfish species surveyed in the Glover's Reef Marine Reserve for the period March 2006 to November 2007*

Species	Percentage of individuals (%) March 2006 – Nov 2007 N=4228
Princess	41.3
Striped	18.3
Redband	17.7
Redtail	11.3
Stoplight	7.2
Yellowtail	4.1

The mean parrotfish density in the CZ (102 finfish ha^{-1}) was lower than that in the GUZ (117 finfish ha^{-1}) for the period March 2006 to November 2007. The density of parrotfish species was higher in the CZ than the GUZ for three of the six species: redband, redtail and stoplight (Figure 9).

Figure 9 Mean density of parrotfish species in the Conservation and General Use Zones for the period March 2006 to November 2007.



Fork Length

The mean fork length in the total sample for stoplight, yellowtail, striped, redband, redtail and princess were 21.1, 14.5, 9.5, 12, 9.9 and 7.1, respectively (Table 13).

Table 13 *Distribution of mean fork length by parrotfish species.*

Species	N	Mean Fork length (cm)	Standard Deviation	Minimum (cm)	Maximum (cm)
Stoplight	306	21.1	9.4	4	45
Yellowtail	175	14.5	5.8	3	30
Striped	773	9.5	4.7	3	22
Redband	749	12	6.8	21	21
Redtail	476	9.9	6.3	3	30
Princess	1745	7.1	4.1	1	25

Summary and Conclusions

The average queen conch density for the period July 2004 to November 2007 was 24.6 conch per ha. For all sampling periods, the queen conch adult density in the CZ was higher than the density in the GUZ, however the juvenile queen conch density was higher in the GUZ than the CZ. The highest mean density of 28.7 conch per ha (February 2007 to November 2007) for the CZ and GUZ combined or the mean density of 30 conch per ha in the CZ only, is significantly lower than the 5 to 10 year target of 50-300 conch per ha recommended by the Healthy Reefs for Healthy People Initiative (McField, M. and Kramer, P., 2007). The analyses also showed that the mean shell length of conch was higher in the CZ (185.2 mm) than the GUZ (160.4 mm).

The average lobster density for the period July 2004 to November 2007 was 4.3 lobster per ha, however, the sampling period for only February to November 2007 showed a mean density of 6.6 lobsters per ha. There were low mean densities of juvenile lobsters in both the CZ and the GUZ ranging from 1 to 2 lobsters per ha. The adult mean densities were higher in the CZ than in the GUZ ranging from 3 to 6 lobsters per ha, suggesting that the CZ is serving as a refuge for this species given the higher mean densities and larger size classes found in this zone. The higher mean density of lobster in the last sampling period, February to November 2007, is probably a result of the recent improvement in enforcement by the reserve staff. The mean carapace length was higher in the CZ (110.1 mm) than the GUZ (98.8 mm).

The densities of the five commercial fish species remain low with the hogfish having the highest mean density of 3.7 individuals per hectare. Only two of the finfish, Hogfish and Black Grouper, had mean densities that were consistently higher in the CZ than in the GUZ, however, none of the five finfish species had mean fork length that were consistently larger in the CZ than the GUZ over the annual sampling periods. The effectiveness of the CZ in protecting the more mobile finfish species is less clear. The mean size of the Nassau groupers observed at 25.6 cm showed that they are juveniles. The size of mature Nassau grouper is approximately 36.8 cm.

The mean parrotfish density in the CZ (102 finfish ha^{-1}) was lower than that in the GUZ (117 finfish ha^{-1}) for the period March 2006 to November 2007.

During the period March 2006 to November 2007, the results showed that the princess parrotfish accounted for 41.3 % of the parrotfish sampled with a mean density of 45 individuals per hectare. The princess parrotfish had a higher mean density in the GUZ (53 individuals per hectare) than in the CZ (38 Individuals per hectare). The mean density was also higher in the GUZ than the CZ for striped and yellowtail parrot fishes.

The data were collected over a period of three years and following successive years of data collection it will be more likely to detect trends, particularly in comparing the different management zones.

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