

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



Report for the period July 2004 – August 2009

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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 the period July 2004 – August, 2009. The report focuses on data collected on the spiny lobster (*Panulirus argus*); queen conch (*Strombus gigas*); five commercial finfish species (Nassau grouper *Epinephelus striatus*, Black grouper *Mycteroperca bonaci*, Hogfish *Lachnolaimus maximus*, Mutton snapper *Lutjanus analis* and Queen triggerfish *Balistes vetula*); and six species of parrotfish (Stoplight *Sparisoma viride*, Redtail *Sparisoma chrysopterum*, Yellowtail *Sparisoma rubripinne*, Princess *Scarus taeniopterus*, Striped *Scarus croicensis* and Redband *Sparisoma aurofrenatum*).

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. changes 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 species¹.

This report presents data collected only for the fishery independent component of the protocol² from 31 July, 2004 to 13 August, 2009 during 19 sampling periods.

Sampling Sites

A stratified 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 sites³ 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.

Table 1: Distribution of sampling sites by habitat and management zone in the Glover’s Reef Marine Reserve

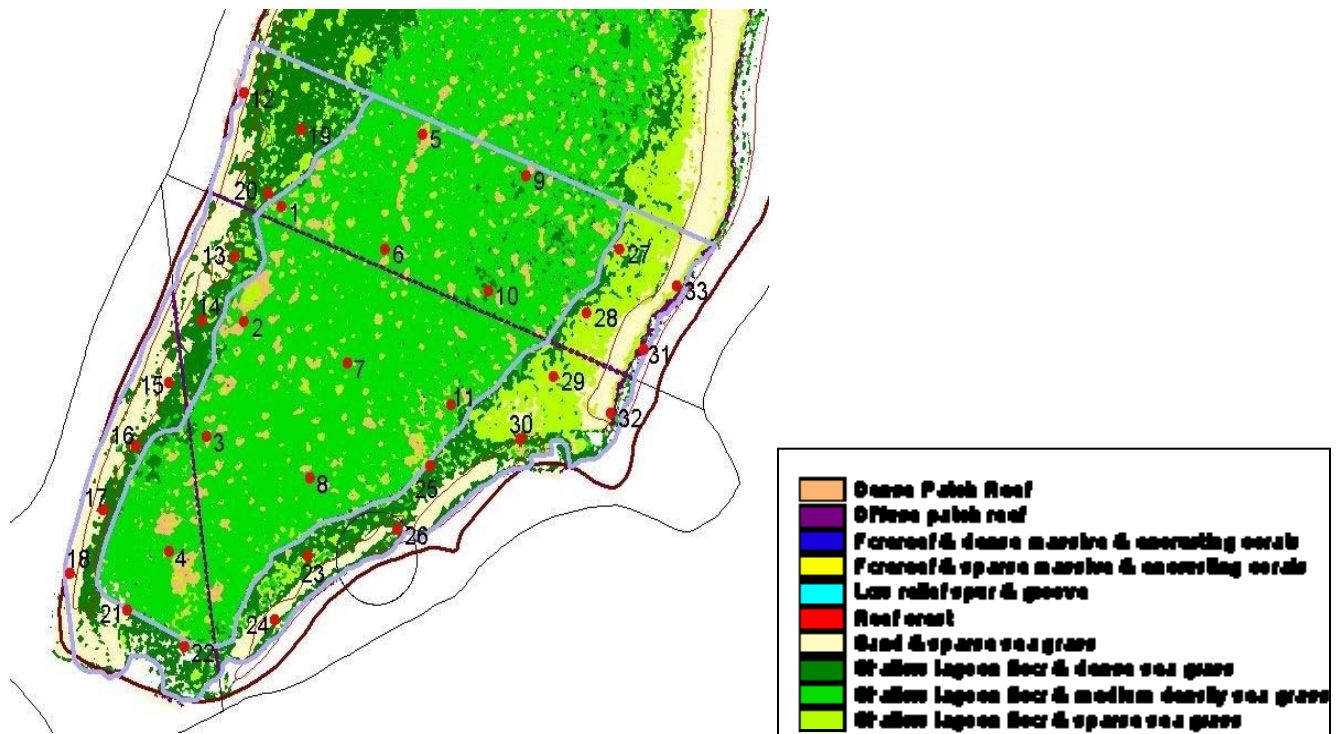
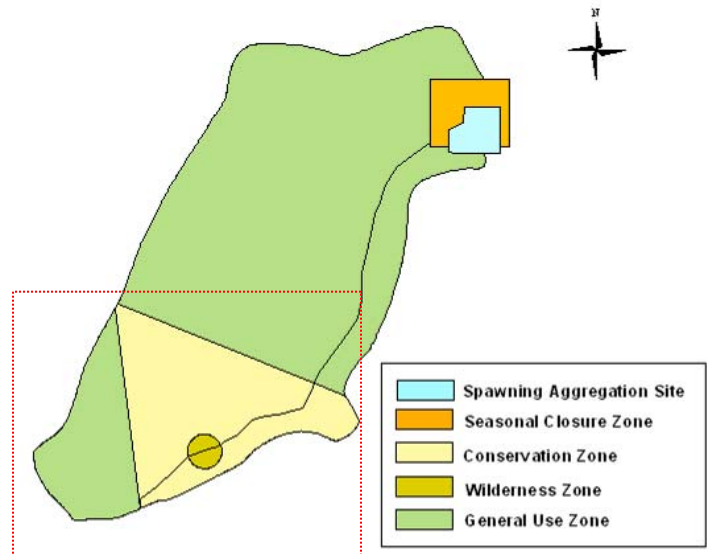
Habitat	Management Area		
	Wilderness	Conservation	General Use
Sand Algal Flats and Seagrass Beds	1	8	13
Patch Reefs	0	5	6
Total No. of Sites	1	13	19

¹ Only 14 sampling periods of Parrotfish data were analysed since data collection for the six Parrotfish species began on 17 March 2006.

² The protocol also includes direct fishery monitoring which involves subsampling the fisher’s catch or landings.

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



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. 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). For the last two sampling periods, one of the sites, Patch Reef 4, was replaced by a new site due to low visibility on the majority of the surveys. The area of this new patch reef site was estimated to be 1.34ha which was reflected in the analyses for the last two sampling periods.

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			
Pr7		1.26	
Pr2		0.84	
Pr11		0.44	
Pr8		0.17	
Pr3		0.12	
Pr6			1.43
Pr9			0.64
Pr4			0.25
Pr1			0.21
Pr10			0.15
Pr19			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.



Laying 50 m measurement tape for conch survey
Photo: R. Coleman

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.



Estimating the carapace length of a lobster using a marked tickle stick
Photo: R. Coleman

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.



Collecting water quality parameters using a Yellow Springs Instrument (YSI) meter

Photo: S. Hoare

RESULTS

Queen Conch (*Strombus gigas*)

The mean density of conch surveyed for the period July 2004 to August 2009 was 25.0 conch per ha (s.d. = 13.1) in the Conservation Zone (CZ) and 20.3 conch per ha (s.d. = 10.4) in the General Use Zone (GUZ). In terms of size class, the mean density of adult Queen conch (shell length greater than 177 mm) was higher in the CZ - 17.2 conch per ha (s.d. = 9.7) than in the GUZ - 7.3 conch per ha (s.d. = 3.6). However, the mean density of juvenile Queen conch was higher in the GUZ - 13.5 conch per ha (s.d. = 7.9) than in the CZ - 7.8 conch per ha (s.d. = 8.5).



Queen conch (*Strombus gigas*)
Photo: D. Garbutt

The mean density of adult Queen conch was higher in the CZ than the GUZ for all

sampling periods except the last period (Figure 2) and the mean density of juvenile Queen conch was higher in the GUZ than the CZ in 13 of the 19 sampling periods (Figure 3).

Figure 2: Mean density (conch per hectare) of adult Queen conch *Strombus gigas* surveyed in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2009

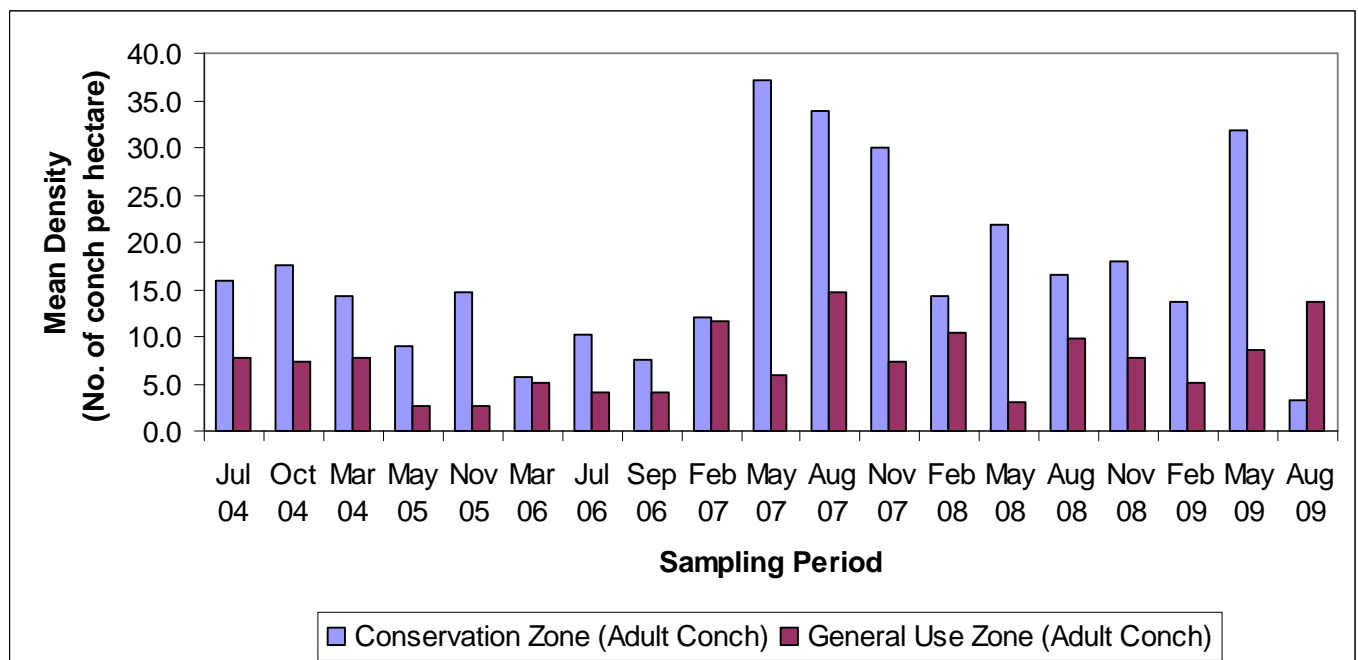
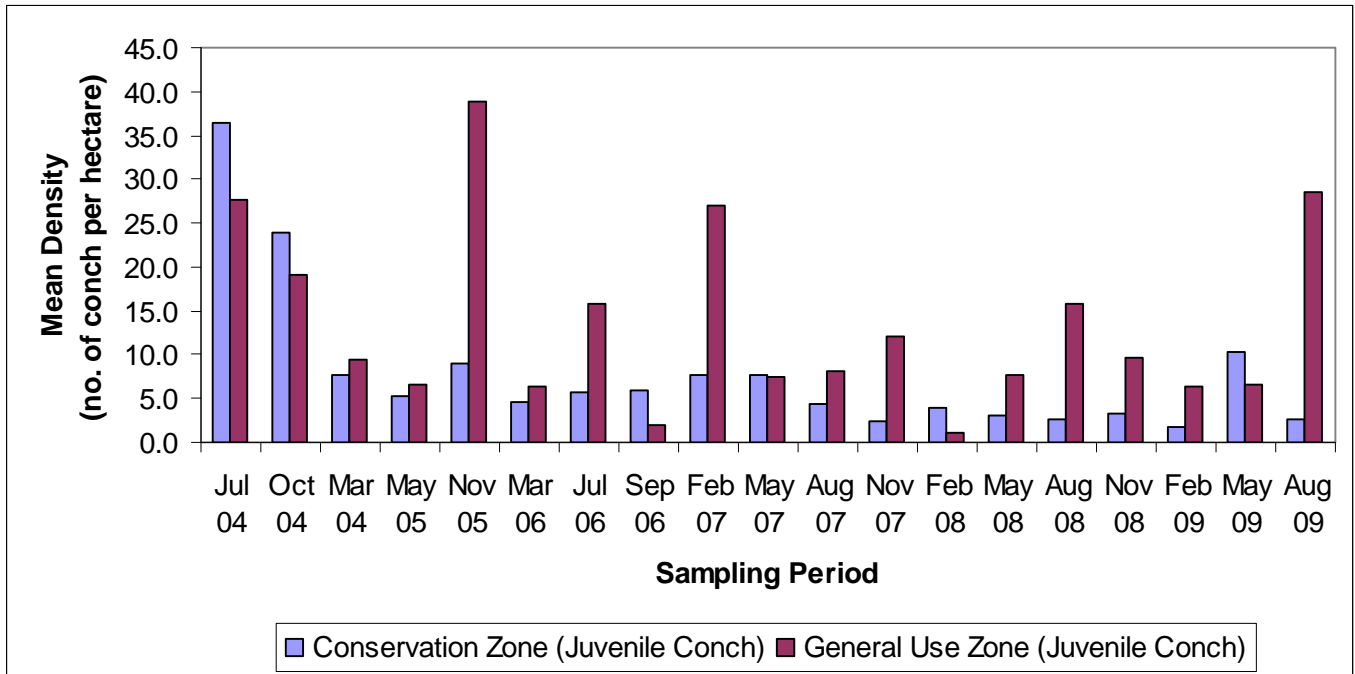
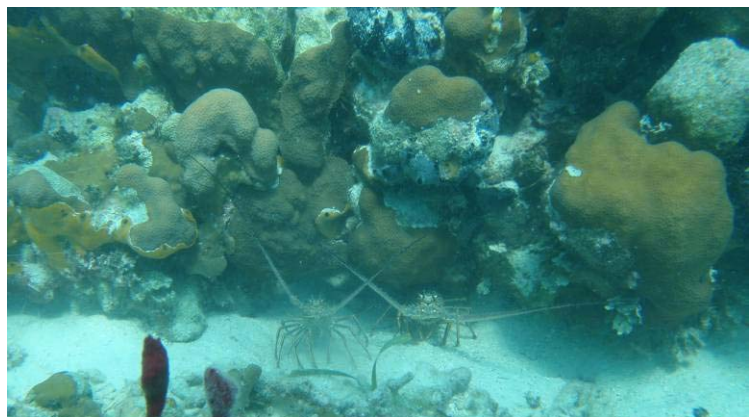


Figure 3: Mean density (conch per hectare) of juvenile Queen conch *Strombus gigas* surveyed in the Conservation and General Use Zones at Glover’s Reef Marine Reserve for the period July 2004 to August 2009



Spiny Lobster (*Panulirus argus*)

A total of 531 spiny lobsters were encountered during the surveys. The mean density was 6.0 lobsters per ha (s.d. = 3.8) in the CZ and 3.8 lobsters per ha (s.d. = 2.3) in the GUZ. The mean density of adult spiny lobster (greater than 70 mm carapace length) was greater in the CZ - 12.1 lobster per ha (s.d. = 9.8) than in the GUZ - 5.0 lobster per ha (s.d. = 4.5). The mean density of juvenile spiny lobster was slightly higher in the GUZ - 5.3 lobster per ha (s.d. = 4.9) than the CZ - 3.9 lobster per ha (s.d. = 4.9).



Spiny Lobster (*Panulirus argus*)
Photo: R. Coleman

The mean density of adult spiny lobsters was higher in the CZ than the GUZ for 16 of the 19 sampling periods (Figure 4) and for the juvenile spiny lobsters, the mean density was higher in the GUZ than the CZ for 10 of the 19 sampling periods (Figure 5).

Figure 4: Mean density (lobster per hectare) of adult spiny lobster *Panulirus argus* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2009

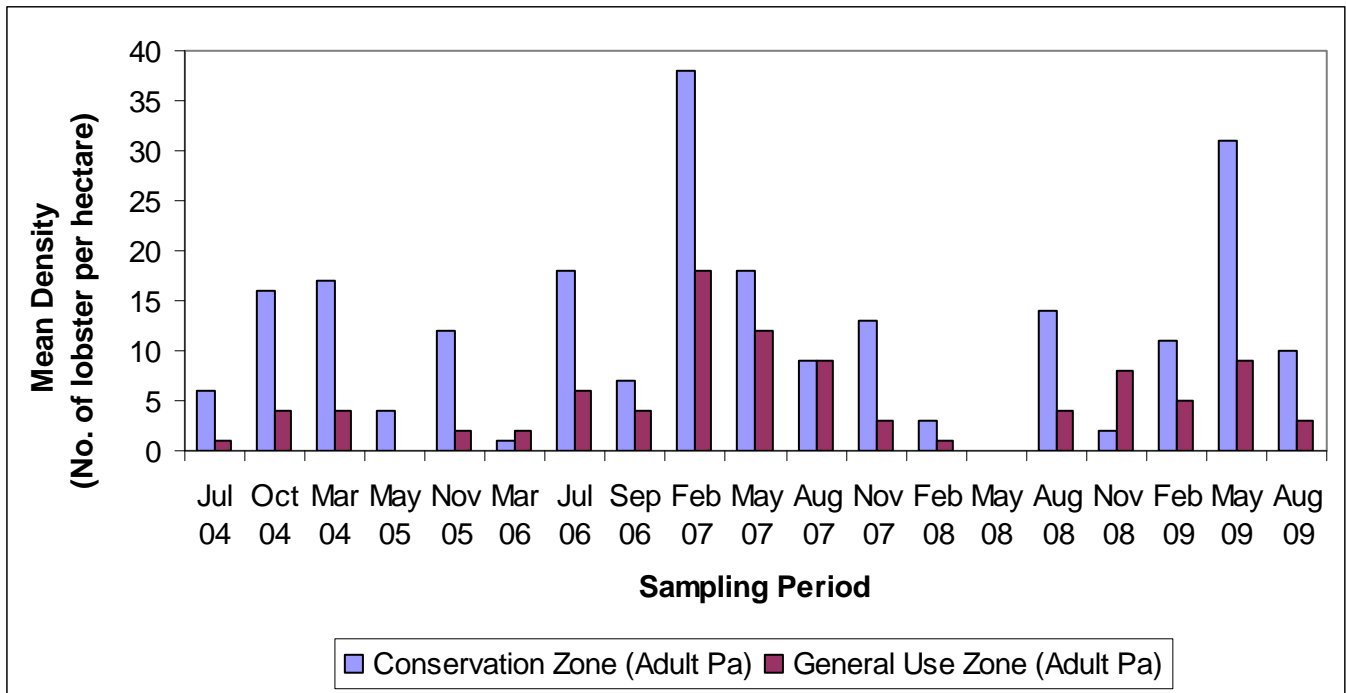
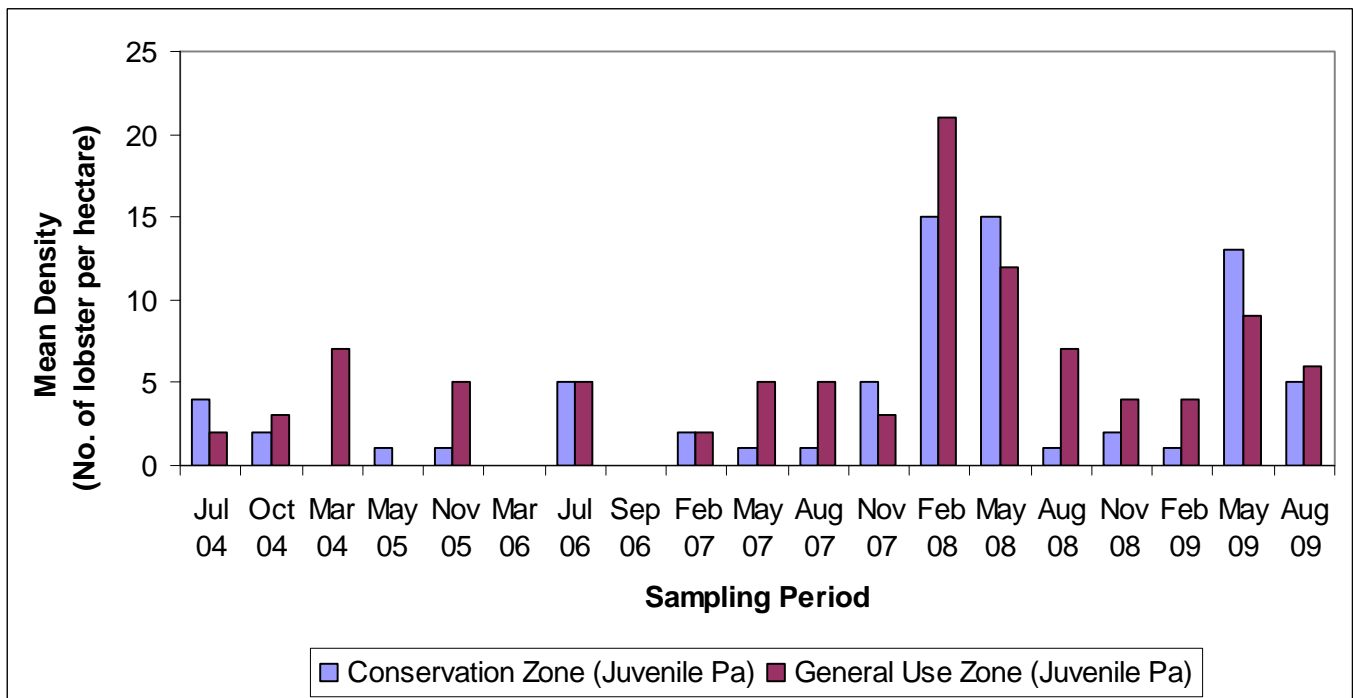


Figure 5: Mean density (lobster per hectare) of juvenile spiny lobster *Panulirus argus* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2009



Finfish

Hogfish, Nassau grouper, Mutton snapper, Black grouper and Queen Trigger Fish

A total of 799 individuals were recorded for the five commercial finfish species. Hogfish made up the largest (37.9%) proportion of the finfish sample. The Nassau grouper comprised 27.3%; mutton snapper 24.5%, black grouper 9.6% and queen trigger fish 0.6% (Table 3).

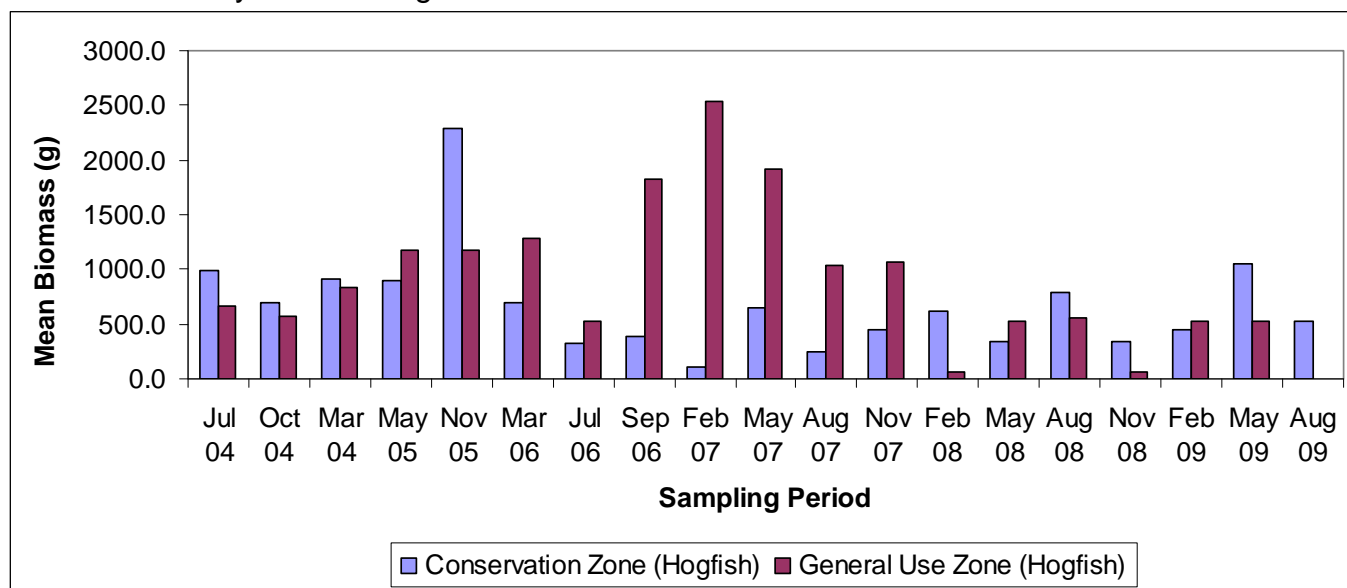
Table 3: Counts of five commercial finfish species in the Glover's Reef Marine Reserve during the period July 2004 to August 2009

Species	Percentage of Individuals % N=799
Hogfish	37.9
Nassau Grouper	27.3
Mutton Snapper	24.5
Black Grouper	9.6
Queen Trigger Fish	0.6

Hogfish

The mean density of hogfish was 3.9 fish per ha (s.d. = 2.9) in the CZ and 1.8 fish per ha (s.d. = 1.2) in the GUZ. However, the hogfish mean biomass was higher in the GUZ - 888.9 g (s.d. = 664.4 g) than in the CZ - 672.1 g (s.d. = 471.6). The mean biomass of hogfish in the GUZ appears to be lower in 2008 and 2009 compared to previous years (Figure 6).

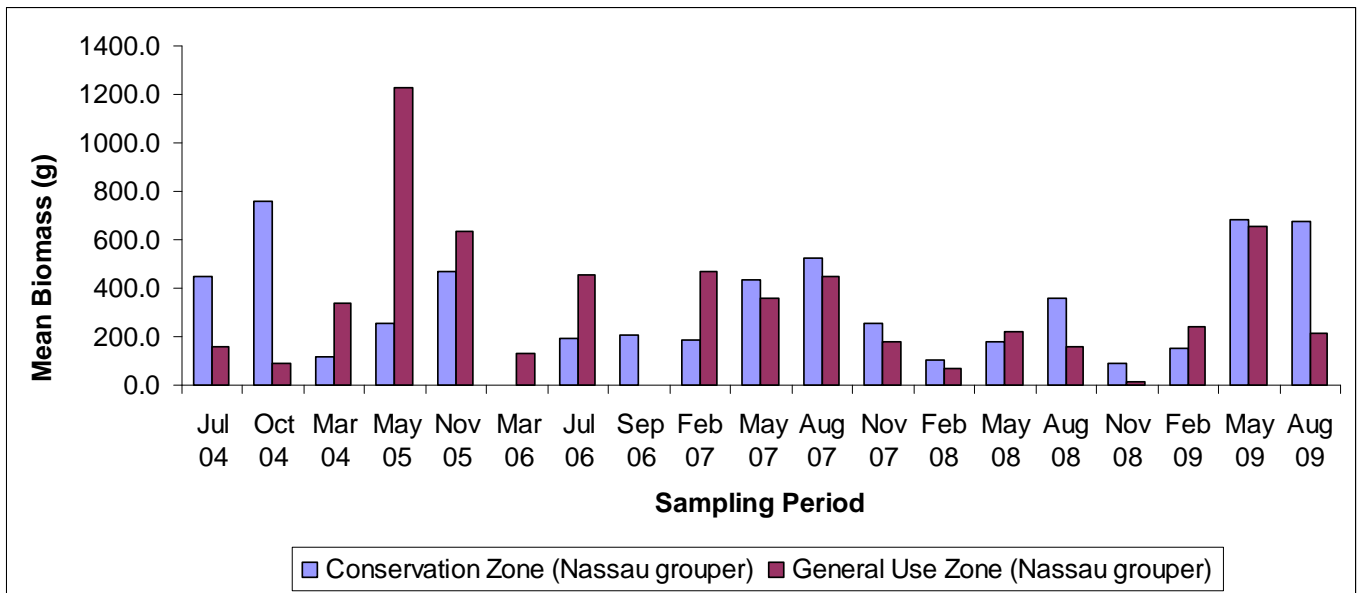
Figure 6: Mean biomass of hogfish (*Lachnolaimus maximus*) surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2009



Nassau grouper

The mean density of Nassau grouper was similar in both the CZ - 2.0 fish per ha (s.d. = 1.3) and the GUZ - 2.1 fish per ha (s.d. = 1.5). The mean biomass of Nassau grouper was also similar in the CZ - 321.1 g (s.d. = 223.0 g) and the GUZ - 319.6 g (s.d. = 292.4 g). The mean biomass of Nassau grouper showed an increase during the last two sampling periods (Figure 7).

Figure 7: Mean biomass of Nassau grouper *Epinephelus striatus* surveyed in the Conservation Zone and the General Use Zone at Glover’s Reef Marine Reserve for the period July 2004 to August 2009



Mutton snapper

The mutton snapper mean density was 2.3 fish per ha (s.d. = 2.1) in the CZ and 1.4 fish per ha in the GUZ (s.d. = 1.2). The mean biomass was 771.1 g (s.d. = 496.3) in the CZ and 579.3 g (s.d. = 668.5 g) in the GUZ.

Parrotfish

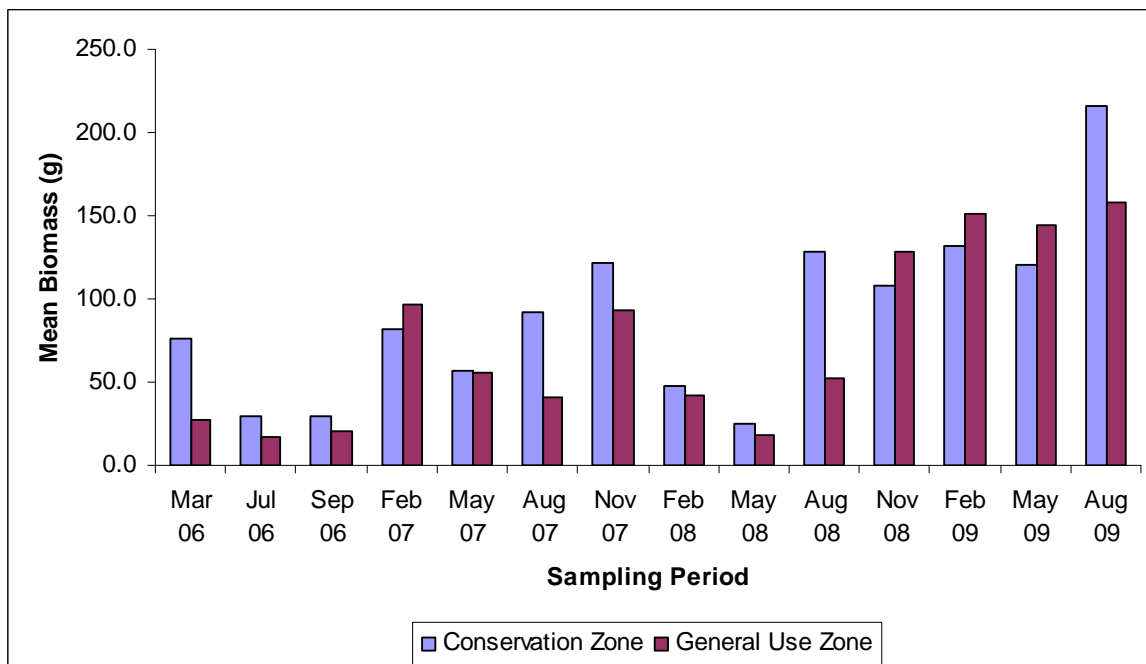
A total of 8030 individuals representing 6 species of parrotfish was recorded during the period March 2006 to August 2009. The princess parrotfish comprised the largest proportion (36.7%) of the parrotfish sampled (Table 4).

Table 4: Percentage of parrotfish species surveyed in the Glover’s Reef Marine Reserve for the period March 2006 to August 2009

Species	Percentage of individuals (%) March 2006 – August 2009 N=8030
Princess	36.7
Striped	22.7
Redband	21.0
Redtail	8.2
Stoplight	7.9
Yellowtail	3.4

The mean density of the six parrotfish species in the CZ (95.4 finfish per ha, s.d = 68.4) was lower than that in the GUZ (102.4 finfish per ha; s.d. = 69.2) for the period March 2006 to August 2009. However, the mean biomass was higher in the CZ (90.3 g; s.d. = 52.6 g) than in the GUZ (74.4 g; s.d. = 52.7 g). The histogram shows that the mean biomass of the six parrotfish species are increasing in both the GUZ and CZ from August 2008 onward (Figure 8).

Figure 8: Mean biomass of the six parrotfish species surveyed in the Conservation Zone and the General Use Zone at Glover’s Reef Marine Reserve for the period March 2006 to August 2009



Summary and Conclusions

The mean density of queen conch for the period July 2004 to August 2009 was higher in the CZ than the GUZ. In terms of size class, the mean density of adult queen conch was higher in the CZ - 17.2 conch per ha (s.d. = 9.7) than in the GUZ - 7.3 conch per ha (s.d. = 3.6); however, the juvenile queen conch mean density was higher in the GUZ than the CZ. The higher mean density of adult queen conch in the CZ than the GUZ suggests that the CZ is providing a haven for the adult queen conch, however, even the highest recorded mean density of 37.2 conch per ha remains well below 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 mean density of the adult spiny lobster was also greater in the CZ with 12.1 lobsters per ha (s.d. = 9.8) than in the GUZ with 5.0 lobsters per ha (s.d. = 4.5). The mean density of juvenile spiny lobster was slightly higher in the GUZ with 5.3 lobsters per ha (s.d. = 4.9) than the CZ with 3.9 lobsters per ha (s.d. = 4.9). Again this suggests that the CZ is providing a haven for the adult spiny lobster.

Of the five commercial finfish species, the hogfish made up the largest (37.9%) proportion of the finfish sample followed by the Nassau grouper (27.3%) and the mutton snapper (24.5%). The mean biomass of hogfish was higher in the GUZ than the CZ, however, the mean biomass appears to have decreased in the GUZ when comparing 2008 and 2009 to previous years. The mean biomass for the Nassau grouper was only slightly greater in the CZ than the GUZ.

During the period March 2006 to August 2009, the results showed that the princess parrotfish accounted for 36.7% of the parrotfish sampled. While the mean density of the six parrotfish species was lower in the CZ than the GUZ, the mean biomass was higher in the CZ than the GUZ. It also appeared that the mean biomass of the six parrotfish species was increasing from August 2008 onward.

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