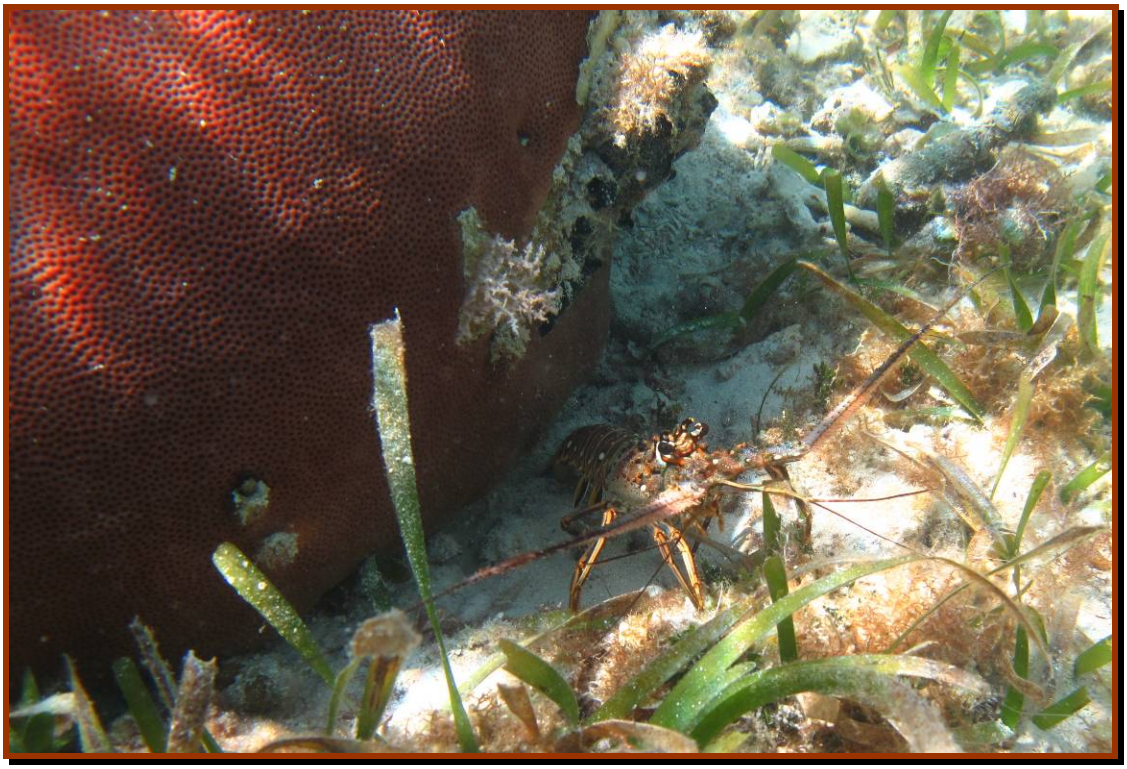
Glover's Reef Marine Reserve
Long-term Atoll Monitoring Program (LAMP)



Report for the period July 2004 – August 2011

February 2012

Wildlife Conservation Society,
Global Conservation Program, Belize
Belize City, Belize

This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID), under the terms of the Cooperative Agreement No. LAG-A-00-99-00047-00. The contents are the responsibility of the Wildlife Conservation Society and do not necessarily reflect the views of USAID or the United States Government.

ACKNOWLEDGEMENTS

The results presented in this report are based on field surveys conducted by WCS Staff with the invaluable assistance of the Belize Fisheries Department's Glover's Reef Marine Reserve Staff. Funding for the study was provided generously by the Oak Foundation and the United States Agency for International Development.

Photo on cover page: Spiny lobster (*Panulirus argus*) on a patch reef in Glover's Reef Marine Reserve (R.Coleman/WCS).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (contd.)

Acronyms

CARICOMP	Caribbean Coastal Marine Productivity
CI	Carapace length
CZ	Conservation Zone
GRMR	Glover's Reef Marine Reserve
GUZ	General Use Zone
LAMP	Long-term Atoll Monitoring Program
MPA	Marine Protected Area
WCS	Wildlife Conservation Society
WZ	Wilderness Zone
YSI	Yellow Springs Instrument

EXECUTIVE 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 2011. 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*).

The results show that the preferred habitat of conch, the sand algal flats and seagrass beds, had healthy populations of juvenile conch in both the Conservation and General Use Zones with each zone having mean densities of 160 conch per ha over all sampling periods. The mean density of adult conch on sand algal flats and seagrass beds was also high with mean densities of 90.3 conch per ha in the CZ and 43.4 conch per ha in the GUZ . These mean densities fall within the healthy population target range of 50 – 300 conch per ha recommended by the Healthy Reefs for Healthy People Initiative (McField, M. and Kramer, P., 2007).

The mean densities of spiny lobsters on patch reef sites remain low with mean densities of 6 lobsters per ha in the CZ and 4 lobsters per ha in the GUZ, over all sampling periods. In terms of life stages the adult spiny lobster had higher mean densities in the CZ than the GUZ, but overall, the size class distribution shows that over the last four years, 2008-2011, there are more individuals in the smaller size classes and fewer individuals in the size classes greater than 110 cm in carapace length.

The hogfish and Nassau grouper were the group of fish most widely distributed occurring in 50% of the patch reef sites, however, fish densities remained low. Hogfish had the highest mean density of 4 fish per ha in the CZ and 2 fish per ha in the GUZ over all sampling periods. In terms of parrotfish as a group, the stoplight parrotfish was present in 75% of the patch reef sites and had mean densities of 10.1 finfish per ha in the CZ and 7.2 finfish per ha in the GUZ with similar mean biomasses of 90 grams recorded in both management zones.

INTRODUCTION

Glover's Reef Marine Reserve

The Glover's Reef Atoll (16º44'N, 87º48'W) is about 32 km long and 12 km wide with an area of 35,876 ha. The atoll lies approximately 45 km east of the Belizean mainland and 25 km to the east of the Belize Barrier Reef (Figure 1). The depth ranges from 300 to 400 m to the north and west of the atoll, while the east side drops to over 1000 m. Water depth in the inner lagoon averages 6-8 m deep with depths up to 18 m (Figure 2). There are three main channels that connect the ocean, reef and lagoon habitats, with the latter containing approximately 850 patch reefs. The entire Glover's Reef Atoll was established as a Marine Protected Area in 1993 (Statutory Instrument 38 of 1993 under the Fisheries Act Chapter 210) and is managed by the Belize Fisheries Department. The Glover's Reef Marine Reserve includes five management zones: General Use Zone, Conservation Zone, Wilderness Zone, Seasonal Closure Zone and Spawning Aggregation Site (Figure 3).

Figure 1: Location of Glover's Reef Atoll, Belize

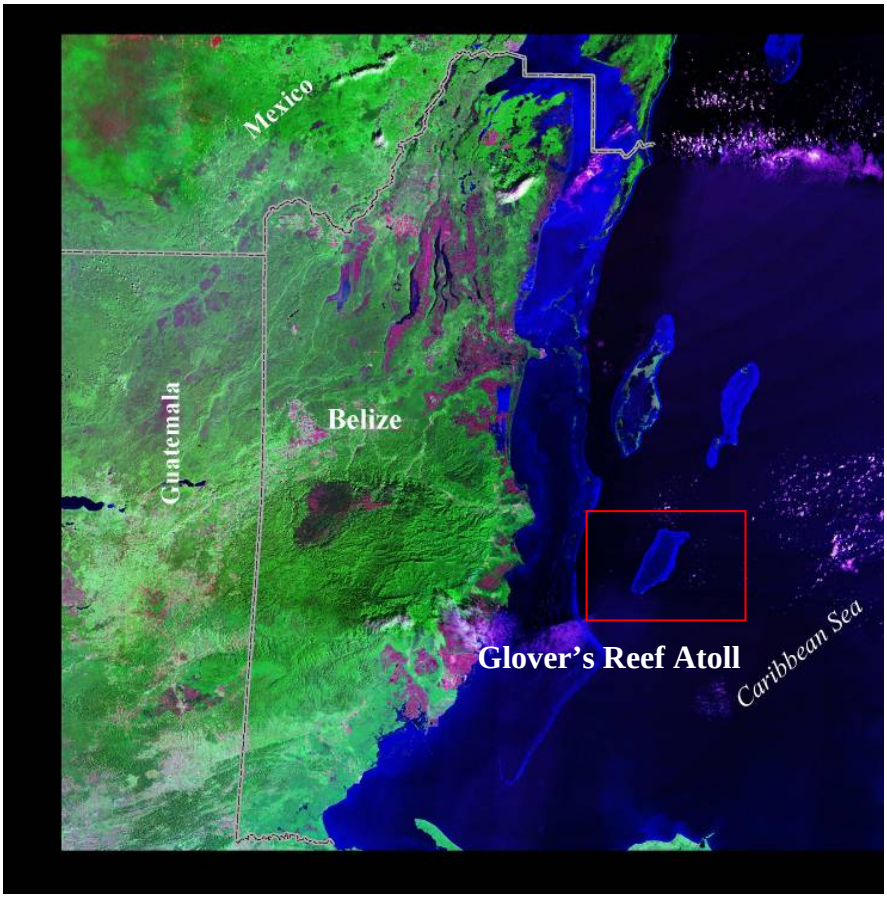


Figure 2: Bathymetry of Glover's Reef Atoll

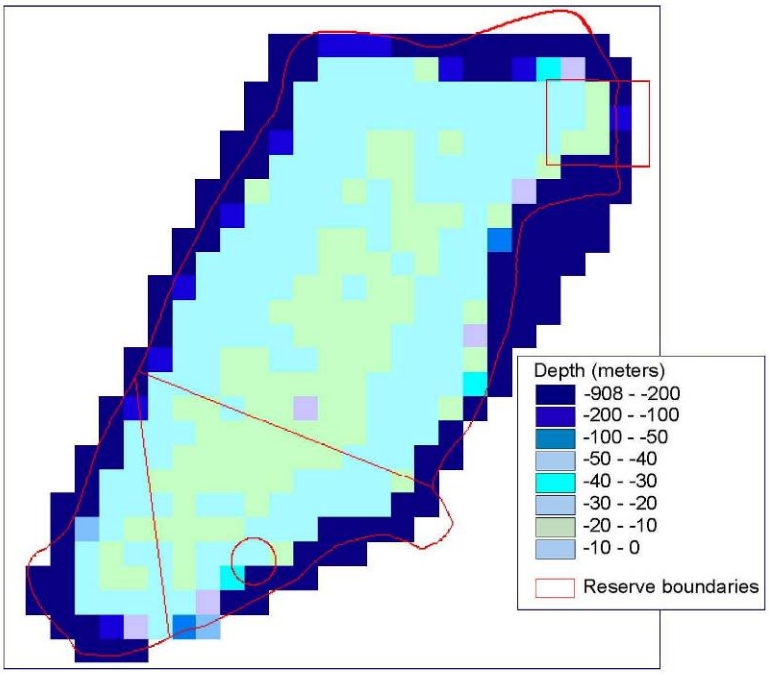
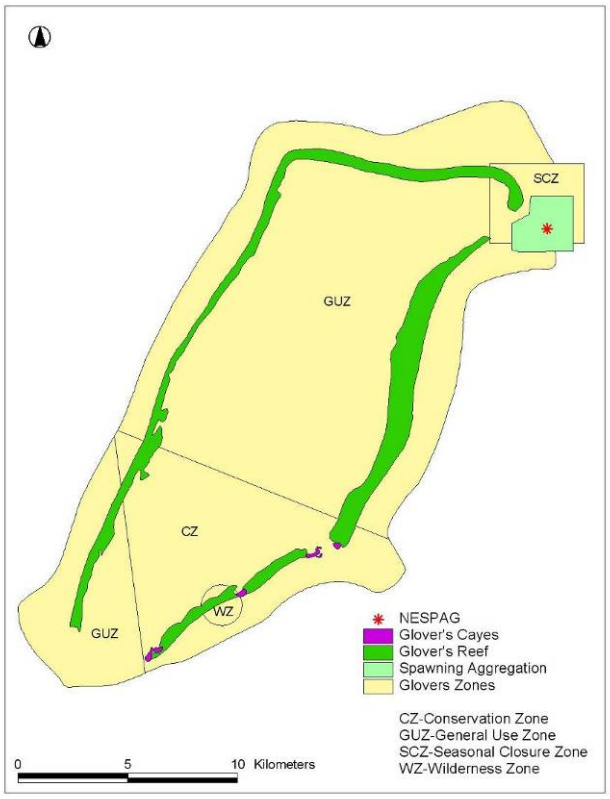


Figure 3: Glover's Reef Marine Reserve: Management Zones



Long Term Atoll Monitoring Program (LAMP)

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 species[1]. In May 2009, the Government of Belize passed new legislation which now bans the harvesting of all species of parrotfish.

This report presents data collected only for the fishery-independent component of the protocol[2] from 31 July, 2004 to 25 August, 2011 during 23 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 sites[3] and Wilderness Zone (WZ) – one site (Figure 1). GPS readings were taken of all the sites.

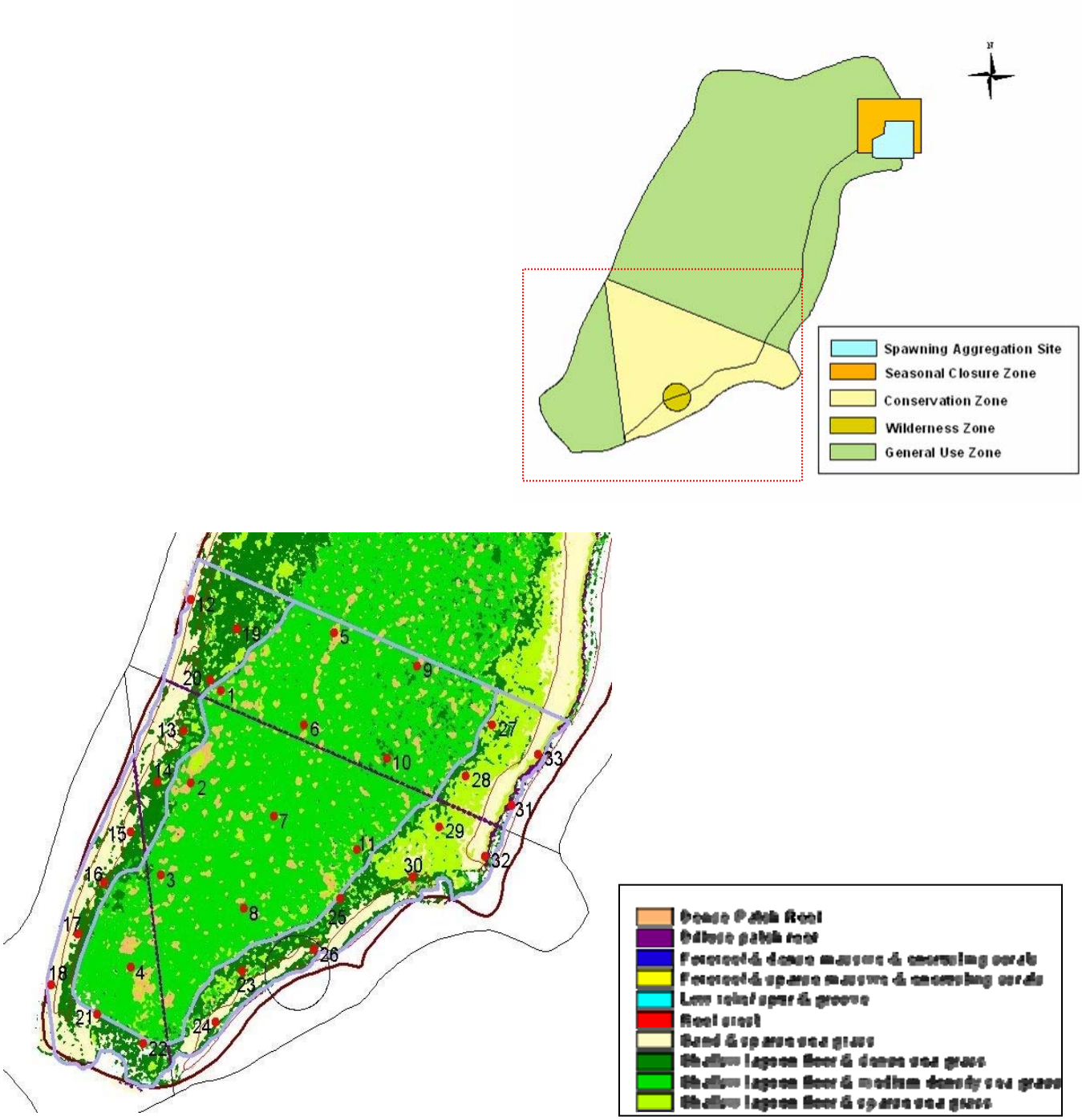
Twenty-two sites were located on sand flats and 11 sites were located on lagoon patch reefs. Of the 22 sand algal flat sites, eight were located in the CZ, 13 in the GUZ and one in the WZ. Of the 11 patch reef sites, 5 were located in the CZ and 6 in the GUZ (Table 1). The average depth of the sampling sites ranged from 1.2 m to 9.0 m.

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**

[1] Only 17 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 4: 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). In May 2009 (sampling period 18), 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 1.34 ha and the total area surveyed reflects this change. In May 2009, two sand flat sites, which were located in deep waters and had poor visibility, were replaced by shallower sites that are closer to the back reef.

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/WCS

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.

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

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.

Stoplight parrotfish (*Sparisoma viride*) at Glover's Reef
Photo: R. Coleman/WCS

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)*

Mean density of conch in all sampled habitats

The mean density of conch (all life stages) surveyed for the period July 2004 to August 2011 was 32.4 conch per ha (s.d. = 20.3) in the Conservation Zone (CZ) and 21.3 conch per ha (s.d. = 11.4) in the General Use Zone (GUZ). The last three sampling periods saw the highest mean density of conch recorded in the CZ with 71.1 conch per ha, 93.0 conch per ha and 53.2 conch per ha recorded in Nov 2010, April 2011 and Aug 2011, respectively.

Mean density of conch on patch reef sites

The mean density of conch (all life stages) recorded on patch reef sites for the period July 2004 to August 2011 was 18.3 conch per ha (s.d. = 17.9) in the CZ and 5.3 conch per ha (s.d. = 3.3) in the GUZ.

In terms of life stage, the mean density of adult Queen conch (shell length greater than 177 mm) in the CZ was 15.8 conch per ha (s.d. = 11.7) and in the GUZ was 4.9 conch per ha (s.d. = 3.1). For the period 2004 to 2011, the results show an upward trend in mean density in the CZ (Figure 5). The mean density of juvenile Queen conch was low overall, but the CZ had a higher mean density (2.5 conch per ha; s.d. = 11.7) than the GUZ (0.4 conch per ha; s.d. = 3.1). For all sampling periods the mean densities of juvenile conch remained stable with a spike in April 2011 when a mean density of 36.4 conch per ha (s.d. = 1.8) was recorded (Figure 6).

Mean density of conch on sand algal flats and seagrass beds

On the sand/algal flats and seagrass beds sites, the mean density of conch (all life stages) recorded was 254.6 conch per ha (s.d. = 224.9) in the CZ and 210.4 conch per ha (s.d. = 154.3) in the GUZ.

In terms of life stage, the mean density of adult Queen conch was twice as much in the CZ (90.3 conch per ha; s.d. = 58.6) than in the GUZ (43.4 conch per ha; s.d. = 43.4). The highest recorded mean density was 294.4 conch per ha (s.d. = 19.2) in the CZ in May 2007 (Figure 7).

The mean density of juvenile Queen conch was similar in both the CZ (163.8 conch per ha; s.d. = 202.7) and in the GUZ (166.2 conch per ha; s.d. = 134.3). During November 2011, the highest mean densities of juvenile Queen conch were recorded in the CZ (850 conch per ha) and the GUZ (461.5 conch per ha) (Figure 8).

Both patch reef and sand/algal flat sites had higher mean densities of adult conch in the CZ than the GUZ (Figure 9). On patch reefs, the mean density of juvenile conch was higher in the CZ than the GUZ, but on sand flats, both CZ and GUZ had similar mean densities of juvenile queen conch (Figure 9).

Figure 5: Mean density (conch per hectare) of adult Queen conch *Strombus gigas* surveyed on patch reef sites in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2011

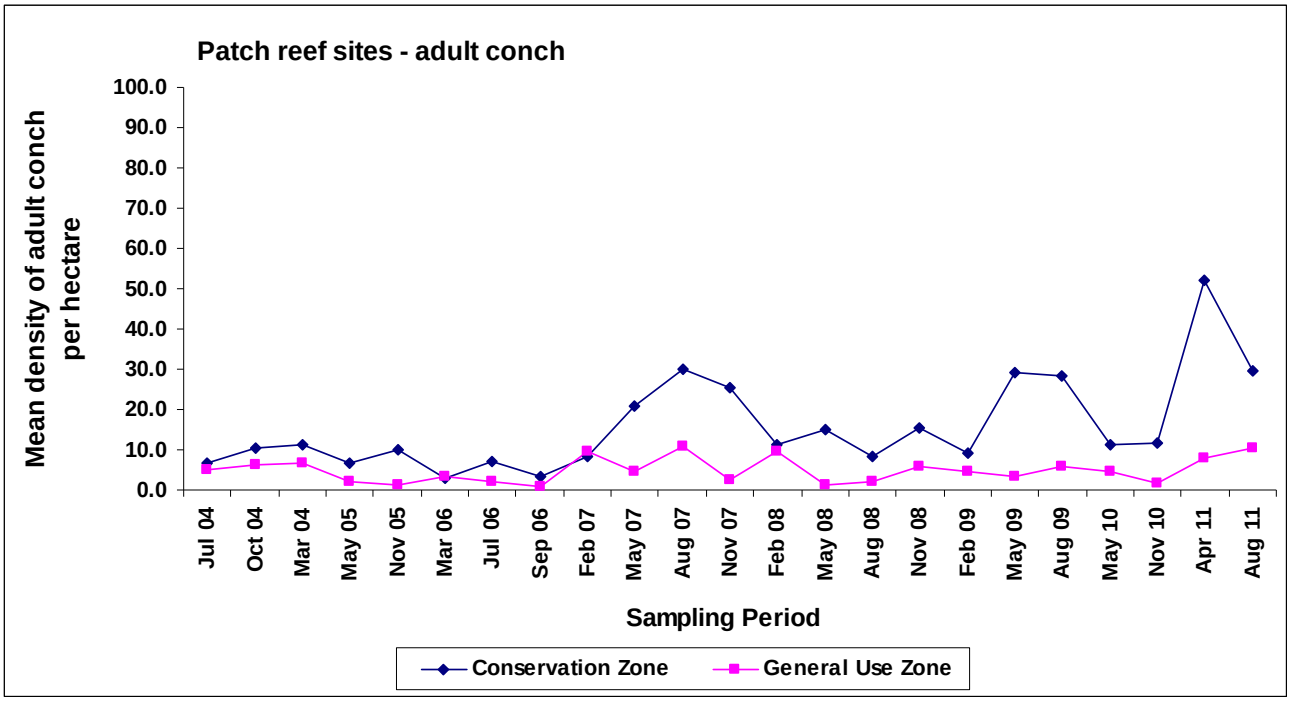


Figure 6: Mean density (conch per hectare) of juvenile Queen conch *Strombus gigas* surveyed on patch reef sites in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2011

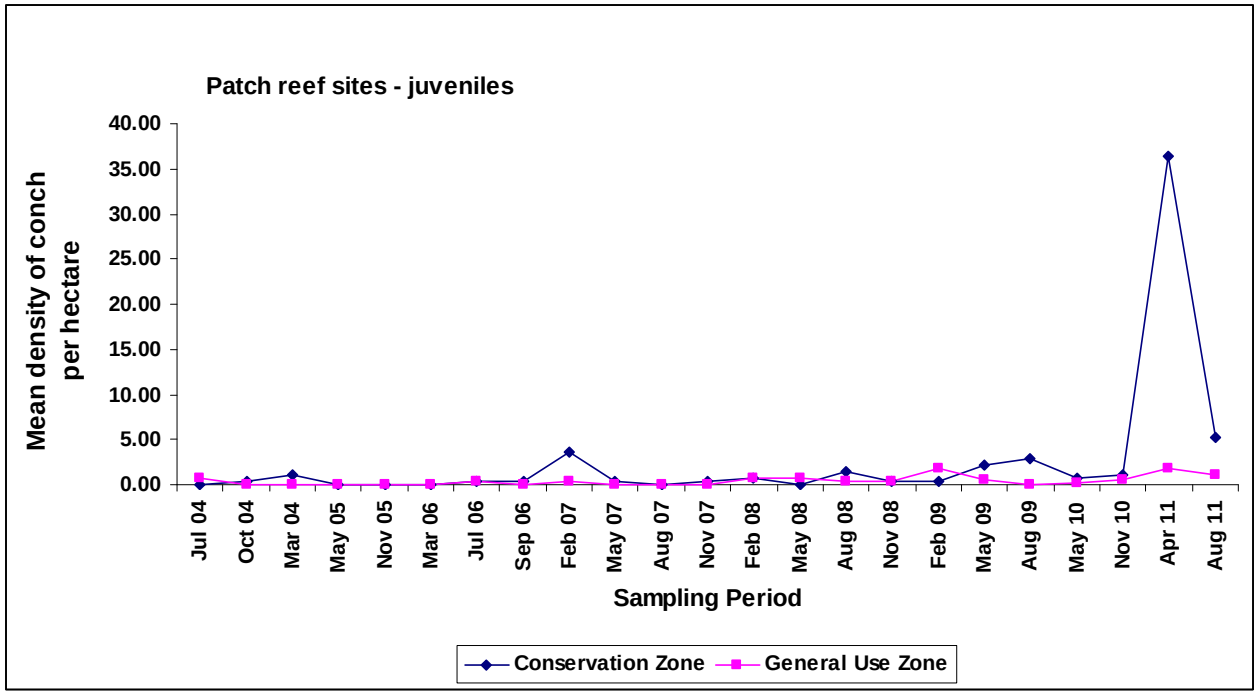


Figure 7: Mean density (conch per hectare) of adult Queen conch *Strombus gigas* surveyed on sand/algal flats and seagrass beds in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2011

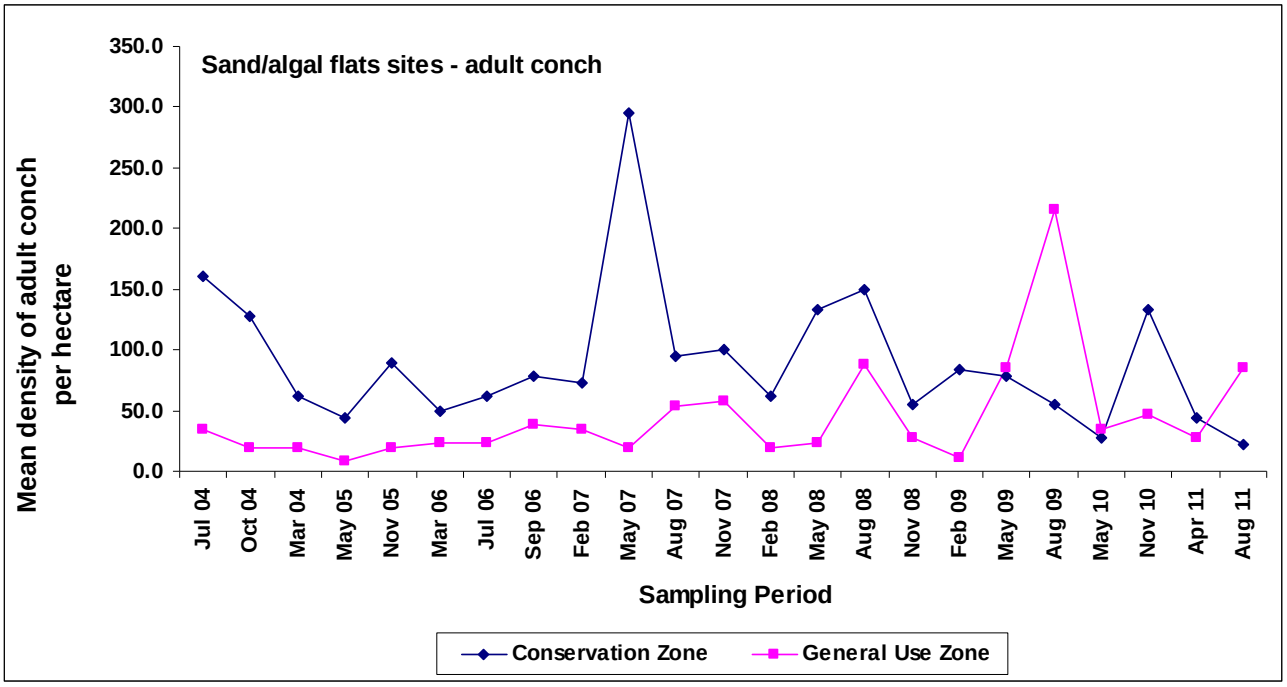


Figure 8: Mean density (conch per hectare) of juvenile Queen conch *Strombus gigas* surveyed on sand/algal flats and seagrass beds in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2011

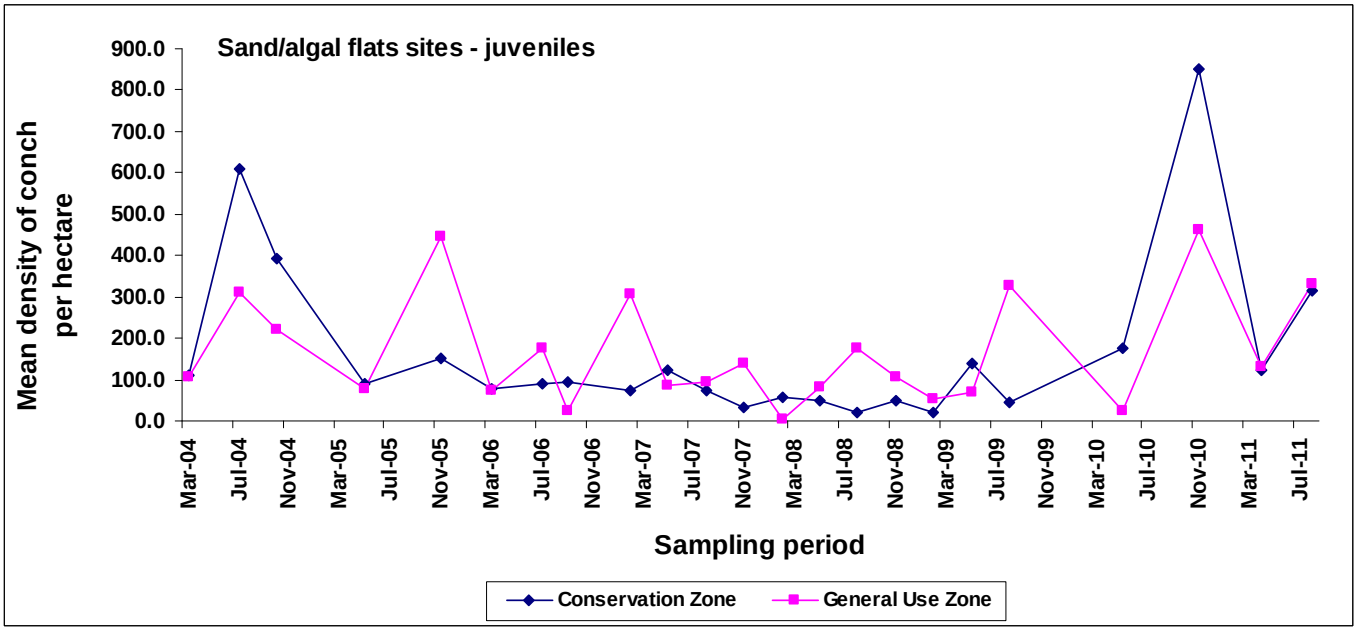
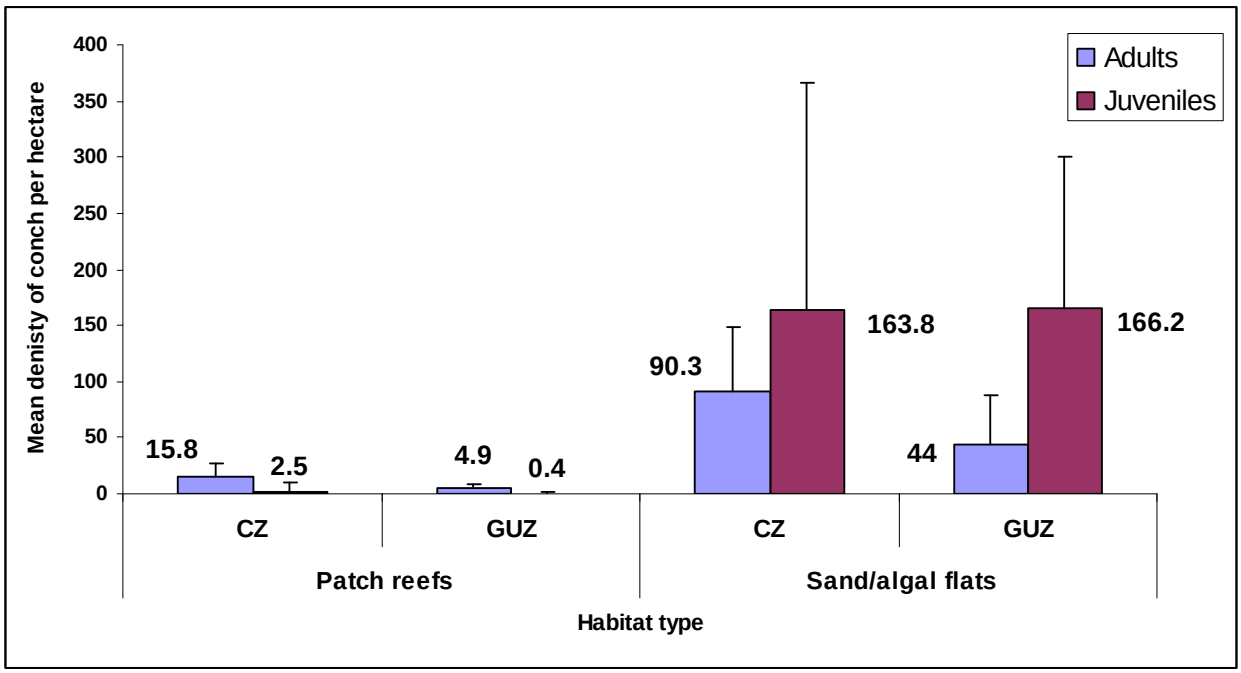


Figure 9: Mean density (conch per hectare) by life stage of Queen conch *Strombus gigas* surveyed on patch reef sites and sand/algal flats and seagrass beds sites in the Conservation and General Use Zones at Glover's Reef Marine Reserve for the period July 2004 to August 2011

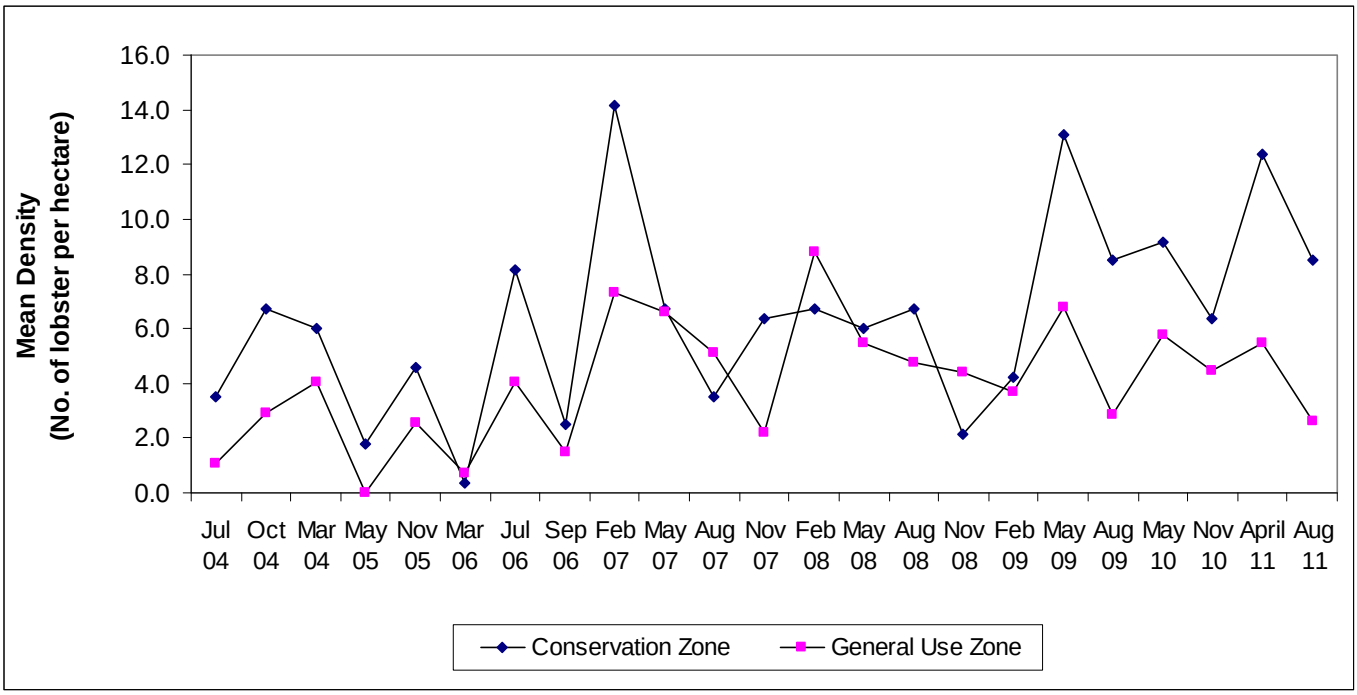


Spiny Lobster *(Panulirus argus)*

Mean density of spiny lobsters on patch reef sites

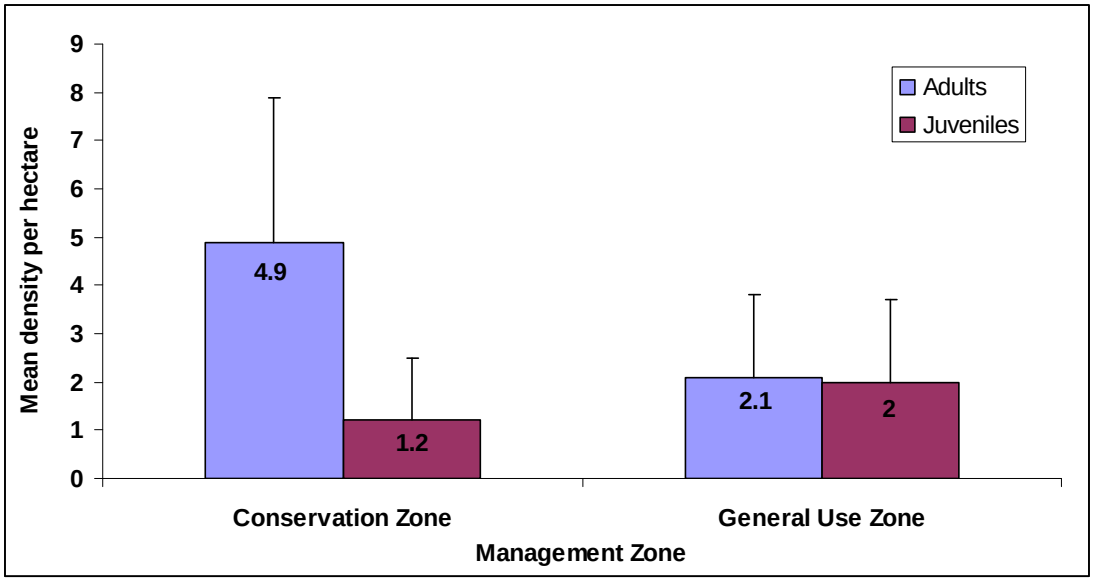
A total of 704 spiny lobsters were encountered during the surveys. The mean density was 6.4 lobsters per ha (s.d. = 3.5) in the CZ and 4.1 lobsters per ha (s.d. = 2.2) in the GUZ. The mean density of spiny lobster was higher in the CZ than the GUZ for 19 of the 23 (82.6%) sampling periods (Figure 10).

Figure 10: Mean density (lobster per hectare) of 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 2011.



The mean density of adult spiny lobster (greater than 70 mm carapace length) was greater in the CZ (4.9 lobsters per ha; s.d. = 3.0) than in the GUZ (2.1 lobsters per ha; s.d. = 1.7) (Figure 11). The mean density of juvenile spiny lobster was slightly greater in the GUZ (2.0 lobsters per ha; s.d. = 1.7) than in the CZ (1.2 lobsters per ha; s.d. = 1.3).

Figure 11: Mean density (lobster per hectare) of 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 2011.



Size Class Frequency Distribution

The size class frequency distribution of spiny lobsters (N=672) by years show a more normal distribution during the first four years of surveys (2004-2007) compared to the latter four years (2008-2011) (Figure 12). The latter four years show a positively skewed distribution with more individuals in the smaller size classes (less than 70 cm carapace length) and fewer individuals in the size classes greater than 110 cm carapace (Figure 13). The minimum size that can be harvested is 72.6 mm carapace length.

Figure 12: Size class frequency distribution of 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 November 2007, showing frequency of 10 cm size classes for each year.

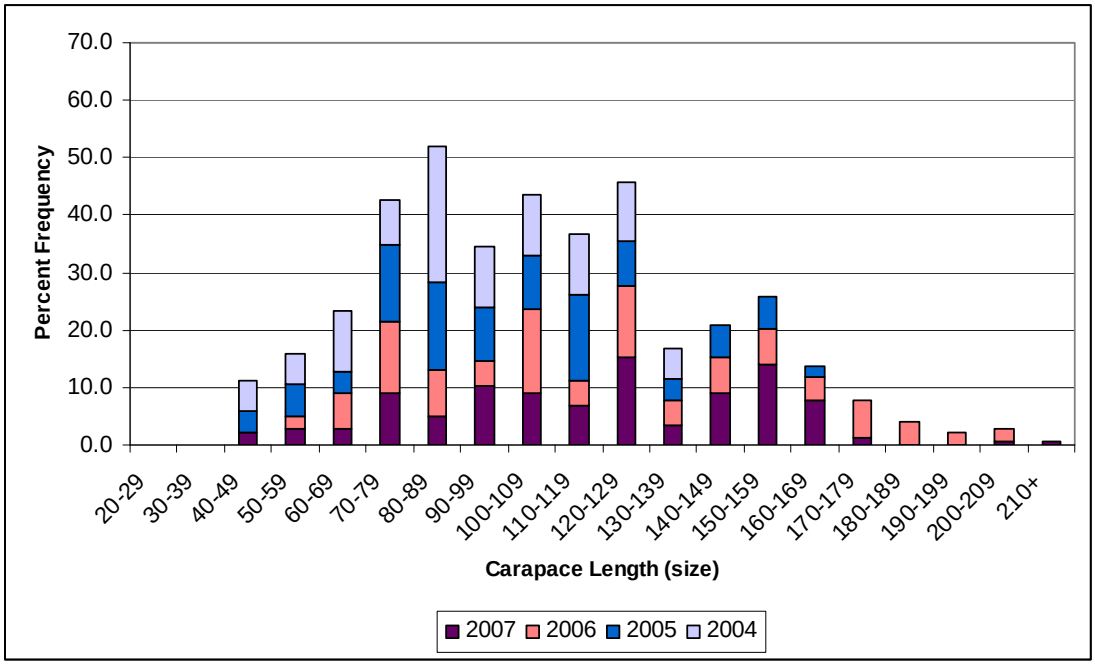
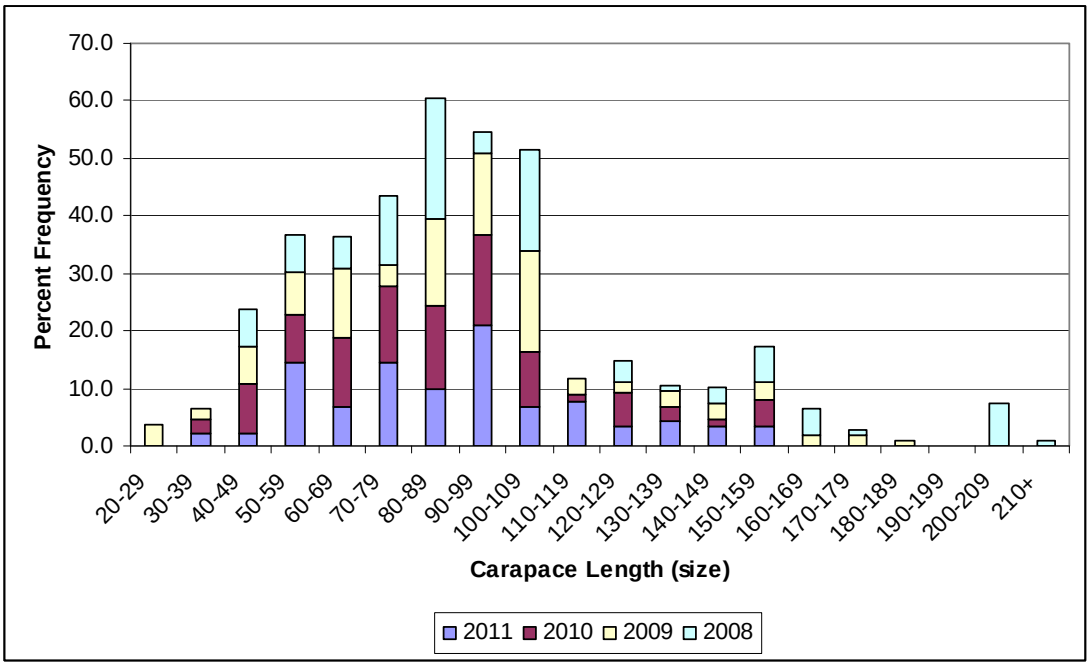


Figure 13: Size class frequency distribution of spiny lobster *Panulirus argus* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period February 2008 to August 2011, showing frequency of 10 cm size classes for each year.



Finfish

Nassau grouper *Epinephelus striatus,* **Black grouper** *Mycteroperca bonaci,* **Hogfish** *Lachnolaimus maximus,* **Mutton snapper** *Lutjanus analis* and **Queen triggerfish** *Balistes vetula*

Species distribution

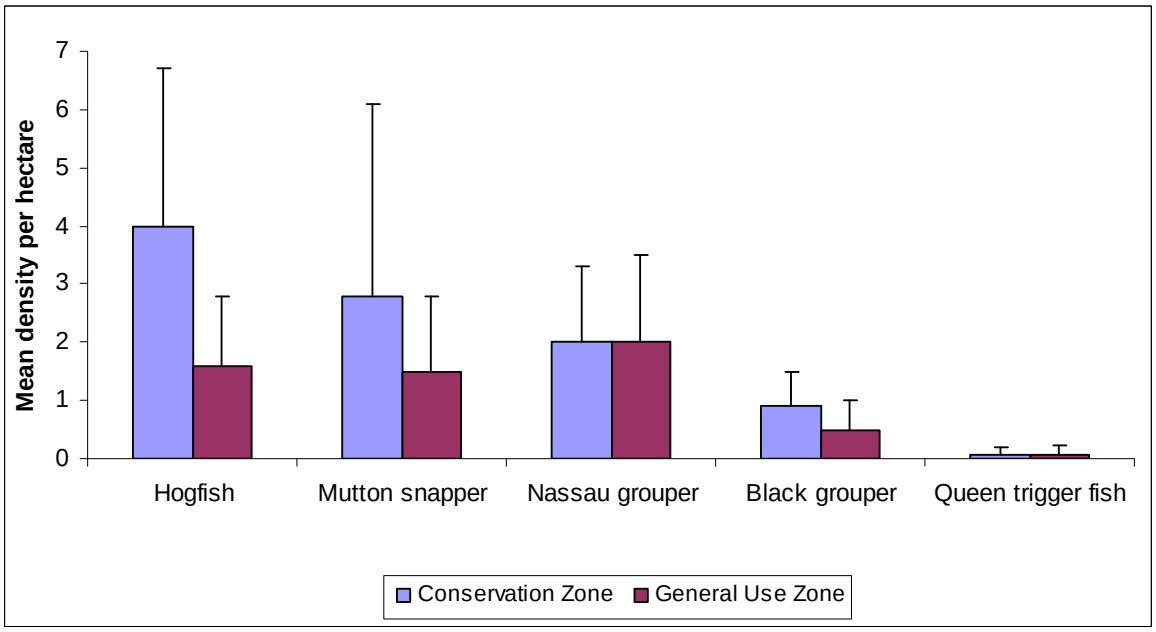
A total of 1003 individuals were recorded for the five commercial finfish species. Hogfish made up the largest (35.8%) proportion of finfish sample. The mutton snapper comprised 28.0% of the sample, Nassau grouper 25.8%, black grouper 9.6% and queen triggerfish 0.8%.

For the period 2004 – 2011, on average, the Nassau grouper and the hogfish had the highest distribution across patch reef sites (5.5 of 11 patch reefs) occurring in 49.8% and 49.4%, respectively. The mutton snapper occurred in 39.1%, the black grouper in 26.5% and the queen triggerfish in only 2.8%.

Mean density

Hogfish had the highest mean density of the five finfish species with 4.0 fish per ha (s.d. = 2.7) in the CZ and 1.6 fish per ha (s.d. = 1.2) in the GUZ (Figure 14). The mutton snapper had the second highest mean density with 2.8 fish per ha (s.d. = 3.3) in the CZ and 1.5 fish per ha in the GUZ (s.d. = 1.3). The mean density of Nassau grouper was 2.0 fish per ha in both the CZ (s.d. = 1.3) and the GUZ (s.d. = 1.5). The mean density of black grouper and queen trigger fish was less than 1.0 fish per hectare in both the CZ and GUZ.

Figure 14: Mean density of 5 finfish species (**Hogfish** *Lachnolaimus maximus,* **Mutton snapper** *Lutjanus analis,* **Nassau grouper** *Epinephelus striatus,* **Black grouper** *Mycteroperca bonaci* and **Queen triggerfish** *Balistes vetula*) on 11 patch reef sites at Glover's Reef Marine Reserve for the period July 2004 to August 2011.



Mean length and biomass

The mean total length for hogfish for all sampling periods ranged from 23.4 cm (s.d. = 10.3 cm) in 2010 to 30.6 cm (s.d. = 17.2 cm) in 2005. The mean total length for mutton snapper ranged from 17.4 cm (s.d. = 5.5 cm) in 2011 to 38.2 cm (s.d. = 6.9 cm) in 2009. The mean fork length for Nassau grouper ranged from 19.7 cm (s.d. = 8.7 cm) in 2008 to 28.8 cm (s.d. = 10.3 cm) in 2004 and 2009.

Overall, the mean biomass per ha for hogfish was lower in the CZ (229.5 g; s.d. = 156.7 g) than in the GUZ (267.0 g; s.d. = 137.8) with the last three sampling periods (Nov 2010 – Aug 2011) being below the overall biomass average (Figure 15).

The mean biomass per ha for mutton snapper was 238.3 g (s.d. = 177.2 g) in the CZ and 188.1 g (s.d. = 230.4 g) in the GUZ. The mean biomass per ha of Nassau grouper was slightly higher in the CZ (110.7 g; s.d. = 76.5 g) than in the GUZ (99.7 g; s.d. = 99.1 g). No clear trends could be established for any of the species across the sampling periods (Figure 15, Figure 16 and Figure 17).

Figure 15: 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 2011

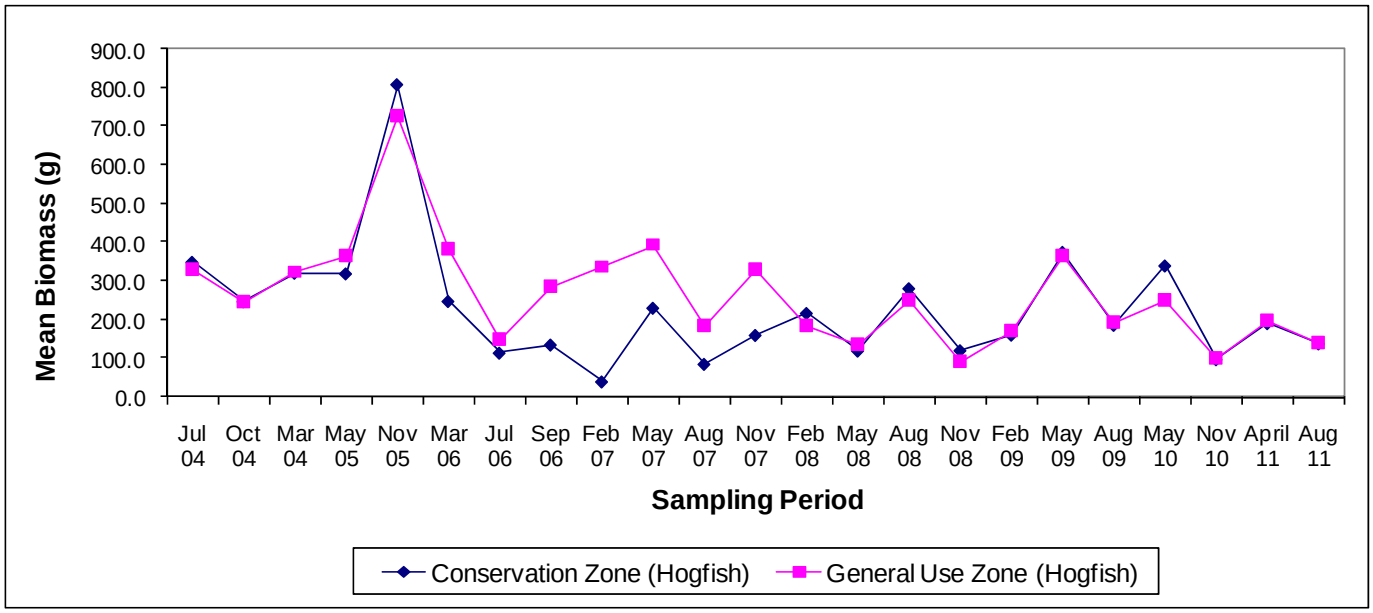


Figure 16: Mean biomass of Mutton snapper *Lutjanus analis* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2011.

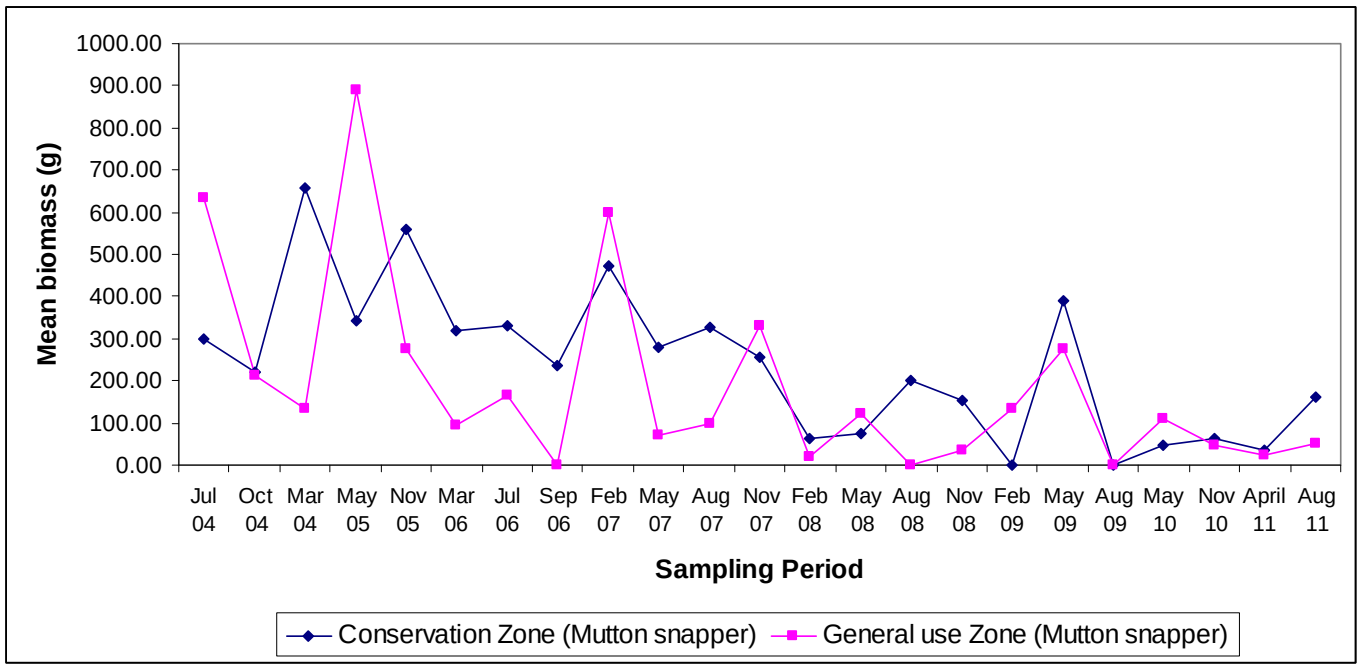
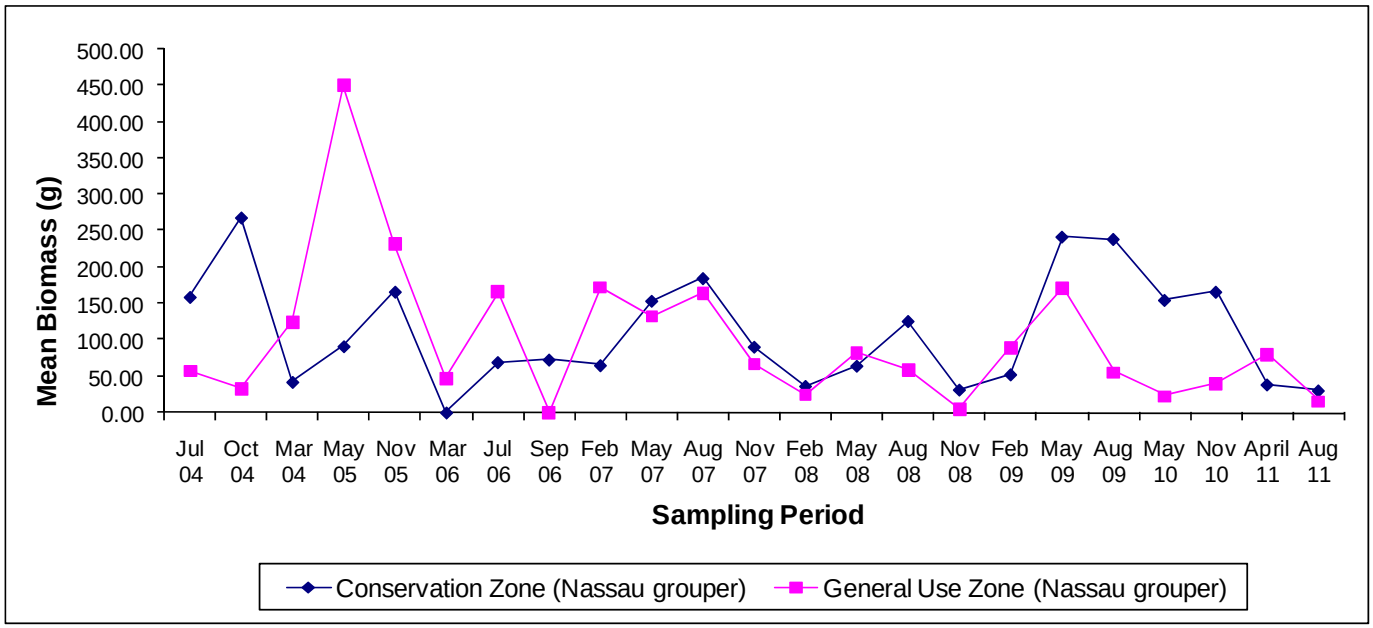


Figure 17: Mean biomass of Nassau grouper *Epinephelus striatus* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2011.



Parrotfish

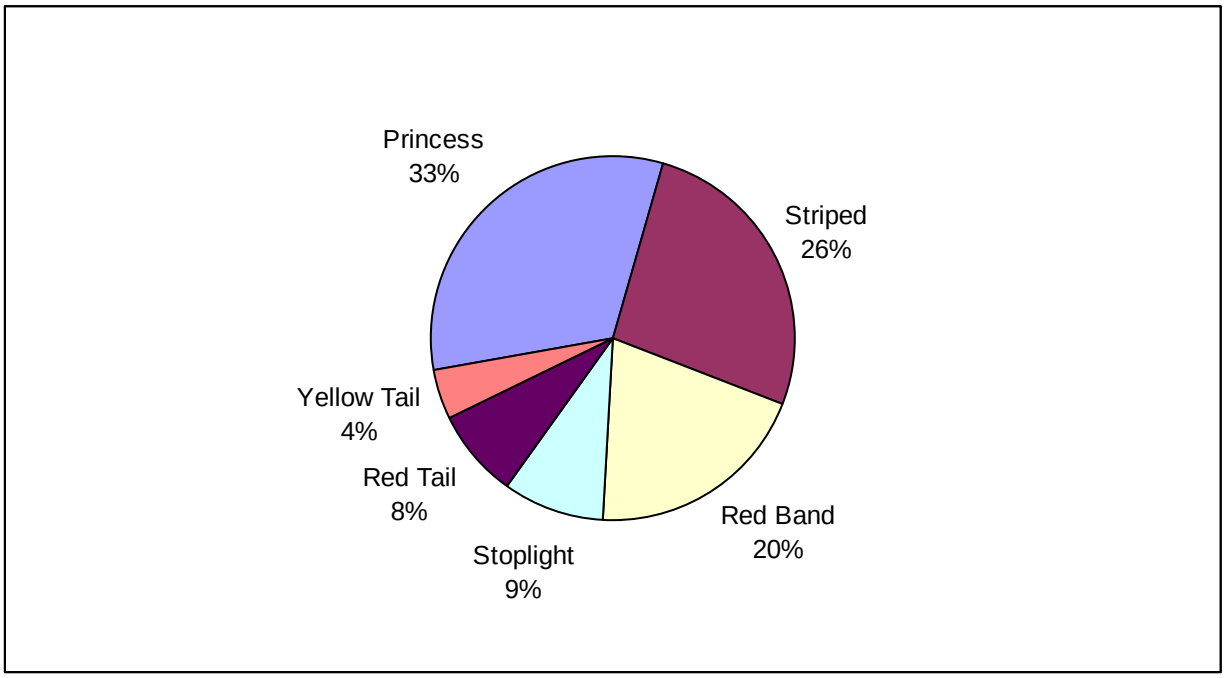
Stoplight *Sparisoma viride,* **Redtail** *Sparisoma chrysopterum*, **Yellowtail** *Sparisoma rubripinne*, **Princess** *Scarus taeniopterus*, **Striped** *Scarus croicensis* and **Redband** *Sparisoma aurofrenatum*).

The Princess parrotfish comprised the largest proportion (32.3%) of the parrotfish sampled (N=10191) (Figure 18). The Striped and Red Band comprised the second and third largest proportion of fish sampled with 26% and 20%, respectively.

The mean density of the six parrotfish species in the CZ (99.6 finfish per ha, s.d = 70.5) was slightly higher than that in the GUZ (92.2 finfish per ha; s.d. = 66.7) for the period March 2006 to August 2011.

The mean biomass was also slightly higher in the CZ (89.4 g; s.d. = 50.8 g) than in the GUZ (74.2 g; s.d. = 50.8 g).

Figure 18: Percentage of six species of parrotfish surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period July 2004 to August 2011 (N=10191).



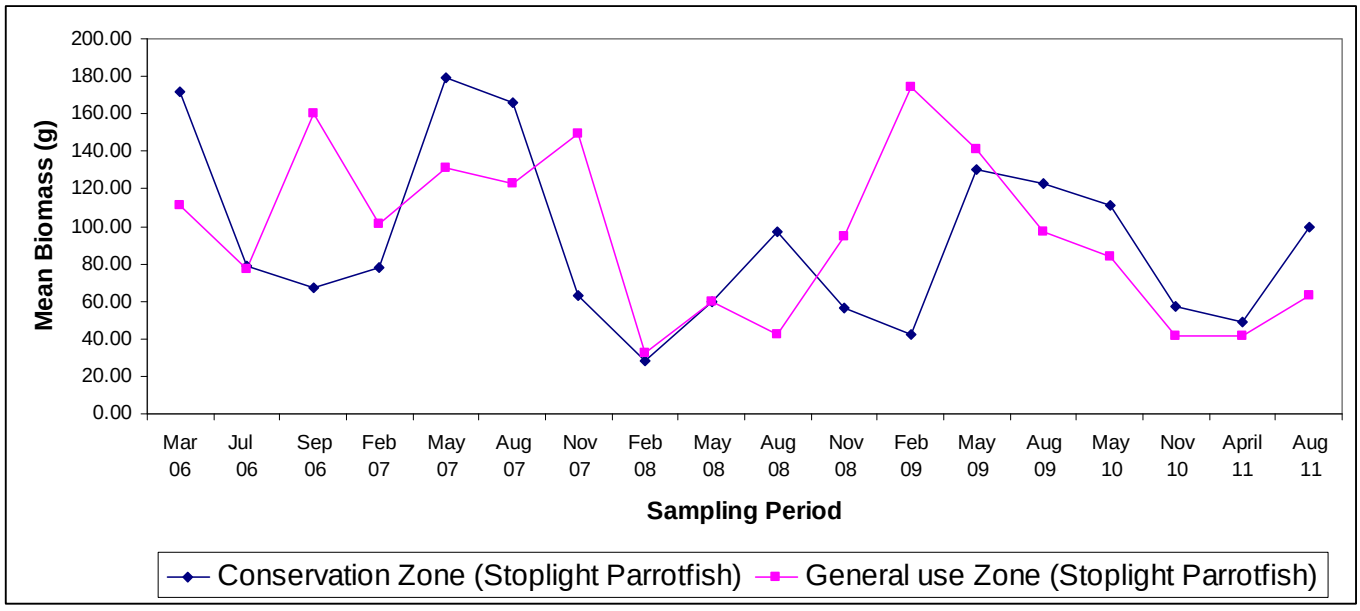
Stoplight *Sparisoma viride*

The stoplight parrotfish was one of the most commonly fished species at Glover's during the period 2005 to 2008 as determined by the Glover's Reef Marine Reserve's Fisheries Catch Data Collection Program (WCS, 2010) up until May 2009 when new Fisheries regulations prohibited the harvesting of parrotfish. This group of species, in particular the stoplight parrotfish, is therefore closely monitored.

Stoplight parrotfish (*Sparisoma viride*) at Glover's Reef
Photo: R. Coleman/WCS

The stoplight parrotfish was present in 75.8% of the sites on average between the period March 2006 to August 2011. The mean density of stoplight in the CZ was 10.1 finfish per ha (s.d = 4.6) and 7.2 finfish per ha (s.d = 4.1) in the GUZ. Mean biomass was similar in both the CZ (92.1 g, s.d. = 46.1g) and GUZ (95.8 g, s.d. = 44.2g). The average fork length was also similar in both the CZ - 19.9 cm (s.d. = 8.9) and the GUZ - 21.1 cm (s.d. = 9.4). For the first sampling periods after the May 2009 ban, the biomass continued to decrease but a slight increase was seen in August 2011 (Figure 19).

Figure 19: Mean biomass of Stoplight parrotfish *Sparisoma viride* surveyed in the Conservation Zone and the General Use Zone at Glover's Reef Marine Reserve for the period March 2006 to August 2011



Summary and Conclusions

The preferred habitat of conch, the sand algal flats and seagrass beds, had healthy populations of juvenile conch in both the Conservation and General Use Zones each with mean densities of 160 conch per ha over all sampling periods, and reaching as high as 850 conch per ha in the CZ in the November 2010 sampling period. The mean density of adult conch on sand algal flats and seagrass beds was also high with mean densities of 90.3 conch per ha in the CZ and 43.4 conch per ha in the GUZ over all sampling periods. The densities do fall within the healthy population target range of 50 – 300 conch per ha recommended by the Healthy Reefs for Healthy People Initiative (McField, M. and Kramer, P., 2007). It should be noted, that these densities have been scaled up from a .02 hectare to a per hectare basis and therefore, may be an overestimation given the patchy distribution of conch in some areas (personal obs.).

The mean densities of spiny lobsters on patch reef sites remain low with mean densities of 6 lobsters per ha in the CZ and slightly lower in the GUZ with 4 lobsters per ha, over all sampling periods. These densities may be an underestimate as one of the limitations of these data is that the entire patch reef is used to estimate the area surveyed, and this includes not only preferred lobster habitat such as near corals or crevices in rocks, but also open sandy areas on the patch reef. In terms of life stages the adult spiny lobster had higher mean densities in the CZ than the GUZ, but overall, the size class distribution shows that over the last four years, 2008-2011, there are more individuals in the smaller size classes and fewer individuals in the size classes greater than 110 cm in carapace length. It may be that the fisheries regulation which requires a minimum harvest size of 72.6 mm carapace length is being adhered to by fishers and hence more individuals in the smaller size classes; however, once the lobsters reach the minimum required size they are harvested before they are able to reproduce and replenish the population. This is of importance since larger sizes of fish, the mega-spawners, are significantly more fecund than smaller sizes of fish.

The hogfish and Nassau grouper were the group of fish most widely distributed occurring in 50% of the patch reef sites, however, fish densities remained low. Hogfish had the highest mean density of 4 fish per ha in the CZ and 2 fish per ha in the GUZ over all sampling periods. In terms of parrotfish as a group, the stoplight parrotfish, which could have been harvested up until May 2009 when the ban on parrotfish was implemented, was present in 75% of the patch reef sites but only made up 9% of the total individuals of parrotfish sampled. The mean densities of stoplight parrotfish were 10.1 finfish per ha in the CZ and 7.2 finfish per ha in the GUZ with similar mean biomasses of 90 grams recorded in both management zones. In 2010, the Glover's Reef Catch Data Collection monitoring program showed that no parrotfish species were sampled as part of the 2009 catch (WCS, 2010), so it appears that there is compliance with the new regulations. There was a small increase in mean density during the last sampling period from the LAMP surveys and it is hoped that this will be the start of an upward trend as a result of the ban on parrotfish.

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