

Spawning Aggregation  
at  
Glover's Reef Marine Reserve

Report for the Period  
January 2005 – February 2009

Nassau grouper  
*Epinephelus striatus*

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## PROJECT SUMMARY

Commercially important reef fish such as groupers and snappers migrate to specific places at specific times to reproduce, a phenomenon known as a spawning aggregation, a critical stage in the life cycle of these species. Since reef fish aggregations are spatially and temporally predictable, they have become increasingly vulnerable to fishing pressure with drastic declines in fish populations of some species throughout the Caribbean. In Belize, in an effort to preserve these sites, 11 of the 13 known spawning aggregation sites were granted protected status, however, even with the fishing closure measures, the fish populations are still decreasing within these sites and are at risk of depletion. One species at risk is the Nassau grouper, *Epinephelus striatus*, now considered as Endangered on The World Conservation Union (IUCN) Red List. In Belize, 2001, an assessment of Nassau grouper spawning sites in Belize, determined that only two of the nine sites surveyed were still viable for fishery purposes in Belize, one of which is the Northeast Point site at Glover's Reef Atoll (Paz and Grimshaw, 2001).

In 2005, a monitoring program was implemented at Glover's Reef Atoll with the aim to evaluate the status of Nassau grouper at the atoll. The specific objectives of the monitoring program are to:

### Objectives

- 1) Quantitatively evaluate and monitor the spawning site by species, documenting the time and location of each aggregation with estimates of the number of fish and their sizes using underwater census techniques.
- 2) Describe, monitor and map the biological and physical characteristics of the site including geomorphology, benthic cover and structure, currents, air and water temperature, salinity and other physical measurements etc.
- 3) Share data and information from all sites to promote appropriate management measures both locally and regionally.

The data gathered will be used to determine the sizes, seasonality and number of various species that utilize the spawning sites. This report presents data collected from the 2009 Nassau grouper spawning event season (December 2008, January 2009 and February 2009) at Northeast Point Site at the Glover's Reef Atoll. The data are combined with results from the previous 2005 – 2008 spawning event seasons.

## METHODOLOGY

### Study site

The Glover's Reef Atoll (16°44'N, 87°48'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 Mesoamerican Barrier Reef. 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. The east (windward) side is composed mainly of low-relief spur and groove formations and is better developed than the western (leeward) reefs. 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). The Statutory Instrument (SI) was revised in 2001 (SI 137 of 2001) to include five management zones within the Marine Reserve: General Use Zones I and II, Conservation Zone I, Wilderness Zone I and Seasonal Closure Zone (Figure 1). The Seasonal Closure Zone, covering an area of 1,550 ha encompasses the Nassau grouper spawning bank located on the northeast corner of the atoll. In order to provide protection for the population of spawning Nassau grouper, the zone is closed to fishing from the 1 December to 1 March. This area also encompasses the Spawning Aggregation Site, established in 2003 (SI 161 of 2003) which is closed to fishing all year round. In April 2009 (SI 49 of 2009), the legislation governing Nassau groupers was strengthened by requiring fish caught in the waters of Belize to be no less than 50.8 cm in total length or greater than 76.2 cm in total length and landed whole.

The Nassau grouper spawning aggregation site at Northeast Point was selected for monitoring based on studies conducted by Sala *et al.* (2001) and the 2001 assessment of Nassau grouper spawning sites in Belize (Paz and Grimshaw, 2001). The Northeast Point Site lies within the Spawning Aggregation Site (Figure 1). The site is described by Sala *et al.* (2001) as lying approximately 1 km off the reef crest to the east of the northernmost channel in a spur and groove system at depths of 25.0 m – 45.0 m.

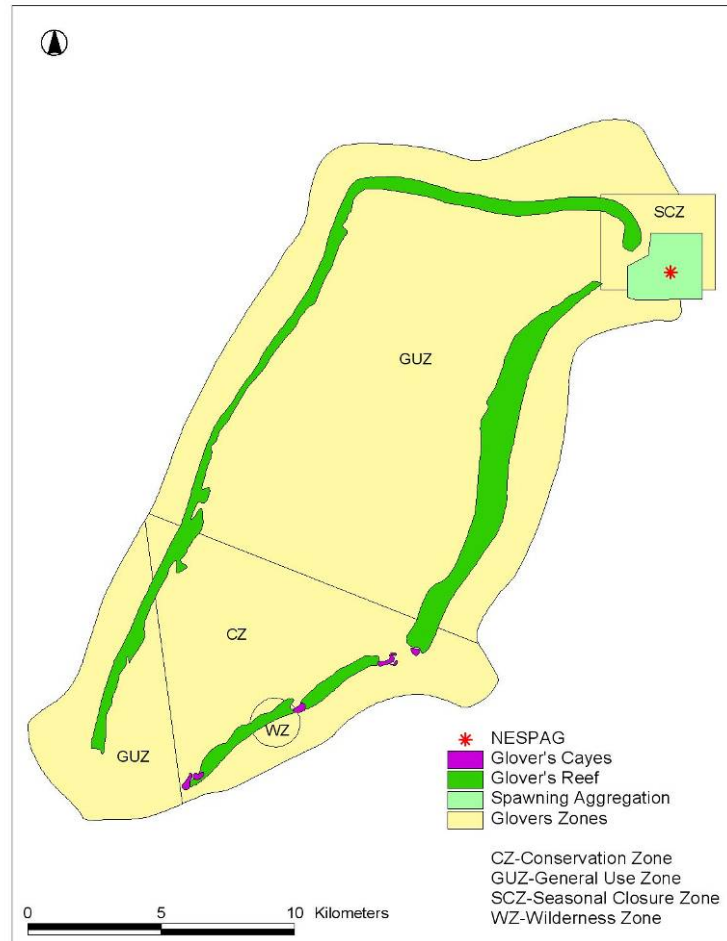
### Underwater Visual Surveys

Underwater visual surveys using SCUBA were employed to obtain Nassau grouper spawning aggregation counts. The methodology is based on the 'Reef Fish Spawning Aggregation Monitoring Protocol for Belize' (Heyman *et al.*, 2004).

A team of at least three persons conducted the surveys – two SCUBA divers and a boat captain. The sites were located using a Global Positioning System (GPS). Upon arrival at the site, information such as survey date, location, GPS coordinates, team members and surface conditions were recorded on data sheets. The surface conditions noted were: air and water temperature, surface current speed and direction, sea state, wind speed and direction and number of fishing

boats nearby. The time the dive started and finished were also recorded. The dives usually lasted between 30 to 45 minutes. Upon the divers' return to the boat, underwater conditions such as depth, temperature, visibility and estimate of current at spawning depth as well as type of species, size class and spawning behaviour were transcribed from the slates to the all weather paper. The numbers and sizes of all aggregating fish were estimated visually. The fish sizes were recorded in 10 cm increments. The spawning behavior observed was also recorded and classified as: grouping, fighting, color changes, bite wounds, gravid, courtship and spawning. Dives were conducted during the months of December, January and February in the morning, afternoon and evening, however, most of the dives were conducted in the evening after four o'clock, about 30-60 minutes before sunset. The data were entered in the Belize National Spawning Aggregation Working Group Online Database and then exported to Microsoft Excel for analyses.

**Figure 1** *Location of Northeast Point spawning aggregation monitoring site at Glover's Reef Marine Reserve.*



## RESULTS

### Nassau grouper Monitoring at Northeast Point

A total of 18 underwater visual surveys over 13 days were conducted during the 2009 spawning season (Dec. 2008, Jan. and Feb. 2009). Since 2005, a total of 61 underwater visual surveys over 42 days have been conducted during the spawning events. The surveys were conducted two to ten days after the full moon (Table 1). Nassau groupers were encountered on 57 of the 61 visual surveys. The majority of the dives (26 dives or 43%) were conducted after 4:00 p.m. (late p.m.) (Table 2). The survey depths ranged from 27.3 m to 45.7 m with an average depth of 28.7 m (standard deviation (s.d.) = 3.3).

**Table 1** *Dates underwater visual surveys were conducted at Northeast Point spawning aggregation site at Glover’s Reef Marine Reserve for the period January 2005 to February 2009.*

Spawning Event	Number of Days Following the Full Moon										
	0 (FM)	1	2	3	4	5	6	7	8	9	10
<b>2005 Season</b>											
Jan 05				X		X	X	X	X		
<b>2006 Season</b>											
Dec 05			X	X	X		X				
Jan 06							X	X	X		X
Feb 06				X	X						
<b>2007 Season</b>											
Jan 07							X				
Feb 07		X		X	X		X				
<b>2008 Season</b>											
Jan 08				X	X	X	X	X			
Feb 08					X	X	X	X	X		
<b>2009 Season</b>											
Dec 2008				X	X	X	X	X			
Jan 09			X	X	X						
Feb 09				X	X	X	X	X			

**Table 2** *Time of day underwater visual surveys were conducted at Northeast Point spawning aggregation site for the period January 2005 to February 2009.*

Time of Day	Classification	No. of underwater visual surveys
8:00 a.m. to 9:59 a.m.	early am	1
10:00 a.m. to 11:59 a.m.	late am	4
12:00 p.m. to 1:59 p.m	early p.m	5
2:00 p.m. to 3:59 p.m	mid p.m	21
4:00 p.m. -	late p.m.	26
No time provided		4


### Maximum Counts

During the 2009 spawning season, a maximum Nassau grouper count of 1100 was recorded in Feb 2009. The maximum counts during the 2005, 2006, 2007 and 2008 spawning event seasons were 2,240, 3000, 800 and 1190, respectively. The peaks for each of the seasons occurred four to seven days after the full moon (Table 3).

**Table 3** *Maximum counts recorded at Northeast Point spawning aggregation site, Glover's Reef Marine Reserve during the January 2005 – February 2009 spawning events.*

Spawning Event	Survey Date	Maximum Counts	Time	Lunar Phase (FM- full moon)	Depth (m)
<b>2005 Season</b>	29-Jan-05	2240	early p.m.	4 days after FM	30.0
<b>2006 Season</b>	19-Dec-05	8	mid p.m.	4 days after FM	31.2
	21-Jan-06	3000	late p.m.	7 days after FM	35.5
	17-Feb-06	1200	late p.m.	4 days after FM	38.1
<b>2007 Season</b>	9 Jan-07	570		5 days before FM	
	6-Feb-07	800	late p.m.	4 days after FM	30.0
<b>2008 Season</b>	27 Jan 2008	950	late p.m.	5 days after the FM	28.2
	28 Feb 2008	1190	late p.m.	7 days after the FM	39.4
<b>2009 Season</b>	18 Dec 2008	130	mid p.m.	5 days after the FM	45.7
	15 Jan 2009	900	late a.m.	5 days after FM	31.4
	14 Feb 2009	1100	late p.m.	5 days after FM	27.4
	15 Feb 2009	1100	late p.m.	6 days after FM	30.5

\*(Early p.m. – 12:00 – 2:00 p.m.; mid p.m. – 2:01 – 4:00 p.m.; late p.m. – 4:01 – 6:00 p.m.)

Maximum Count for each season 

## Size Class Frequency Distributions

The size class distribution for the maximum counts recorded during the 2005, 2006, 2007 and 2008 spawning seasons showed that the Nassau grouper ranged in size from 31 to 90 cm total fork length (Figure 2). During the 2009 spawning season, the maximum total fork length recorded was 80 cm and unlike the previous spawning seasons, individuals were recorded in the 21 to 30 cm total fork length range (Figure 2). The 2009 spawning season's size class distributions also showed that unlike the previous spawning seasons, the majority of individuals occurred in the smaller 31 – 50 cm total length size class range indicating less mature fish (mature > 50 cm).

**Figure 2** *Size class frequency distributions of Nassau grouper for maximum counts recorded at Northeast Point Site, Glover's Reef Marine Reserve during the 2005 to 2009 spawning events.*

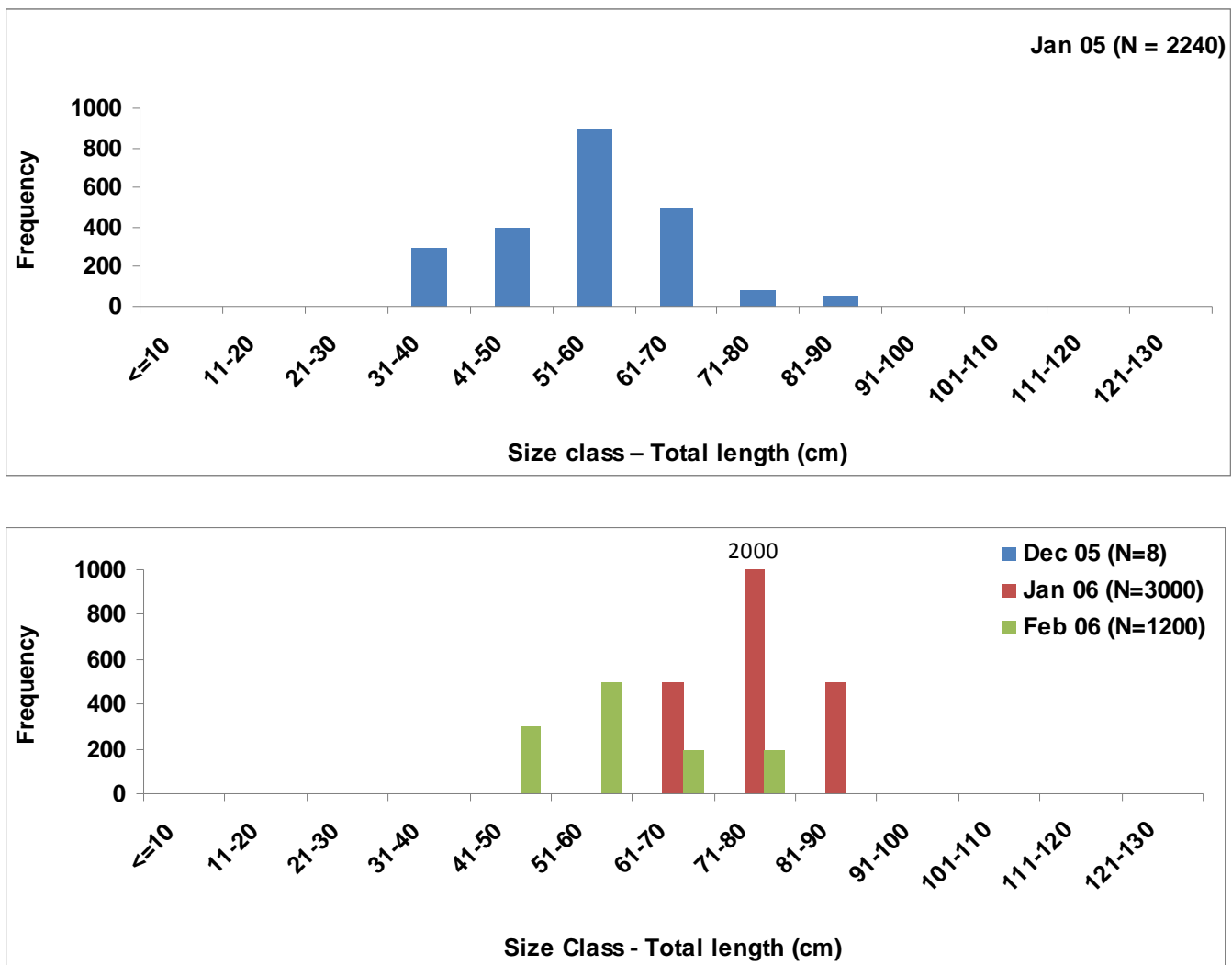
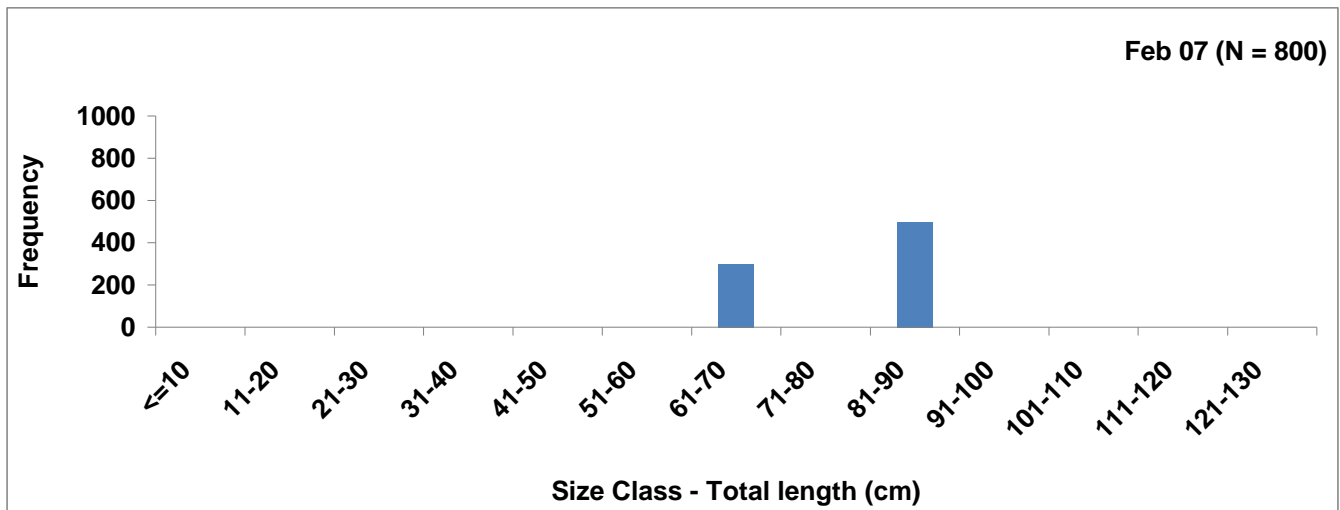
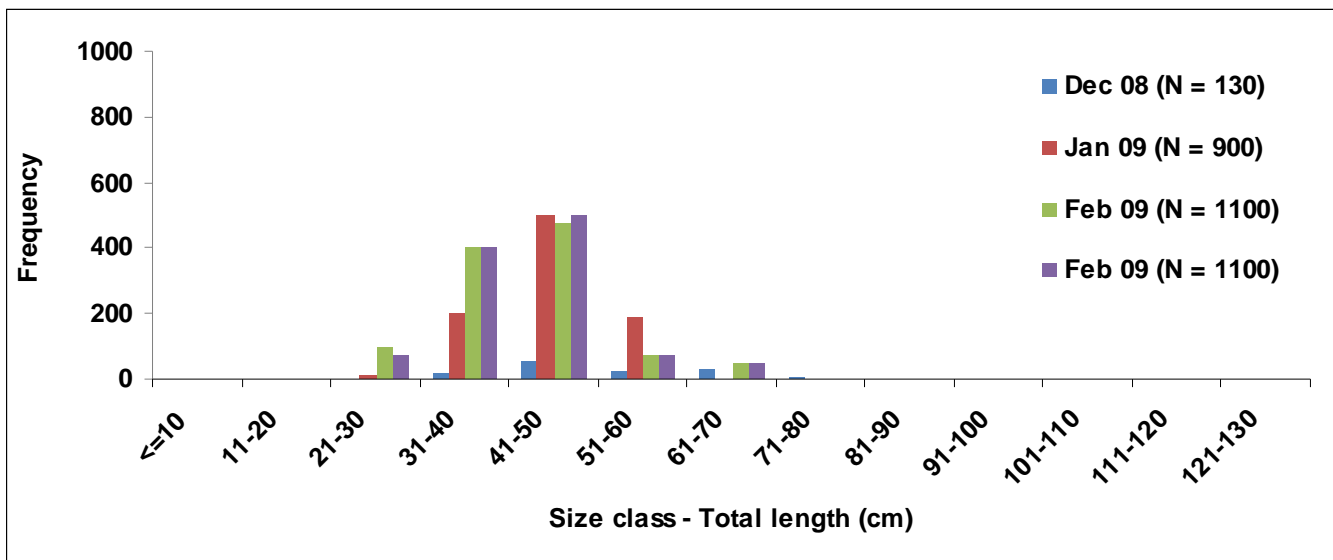
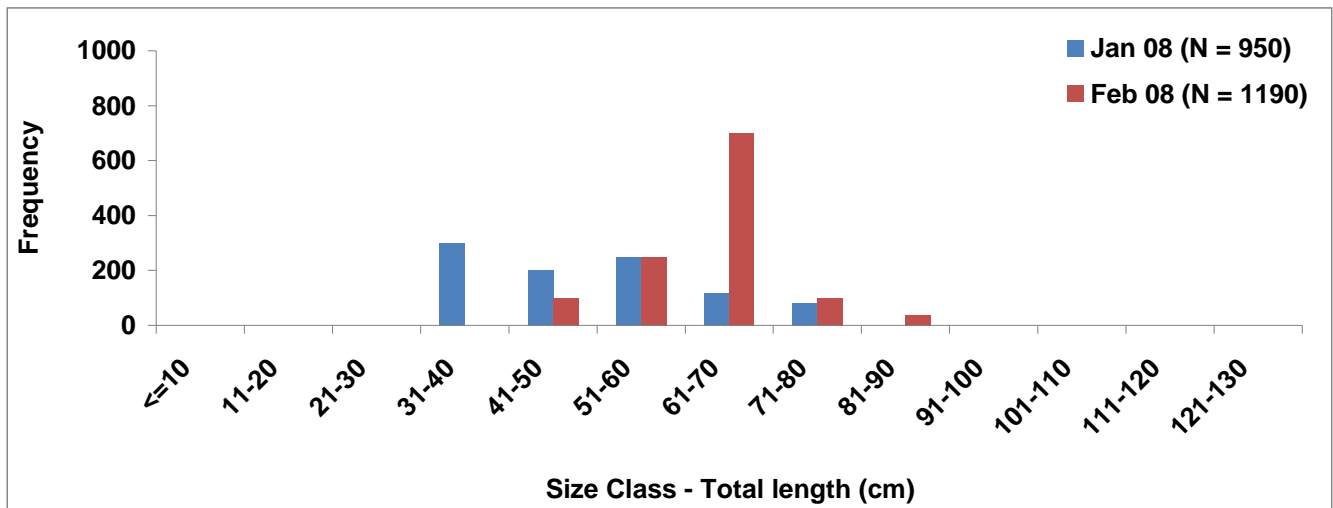


Figure 2 (continued)



\*No size class data available for the Jan 2007 count.



## Spawning Behaviour

During the December 2008 surveys, a maximum count of 130 Nassau groupers was observed at a depth of 45.7m five days after the full moon. While dark and bicolor phases were noted there were no gravid or courtship behaviour. By the sixth day after the full moon, only 56 groupers were observed suggesting that no spawning may be observed for this moon. Spawning behaviour was not observed during the 2009 January moon (surveys done only 3 to 5 days after FM due to inclement weather) but was observed five and six days after the FM during the 2009 February moon. Since the 2005 spawning season, all types of behavioural changes have been recorded during the surveys. Color changes had the most occurrence and were recorded in 48 of the 61 underwater visual surveys (78.7%); while spawning behaviour had the lowest occurrence, 13.1% of the surveys (Table 4).



Photo: Colour change observed during the January and February 2009 underwater visual surveys at Northeast Point, Glover's Reef Marine Reserve.

**Table 4** *Behaviour observed during the January 2005 – February 2009 Nassau grouper surveys at Northeast Point spawning aggregation site, Glover's Reef Marine Reserve.*

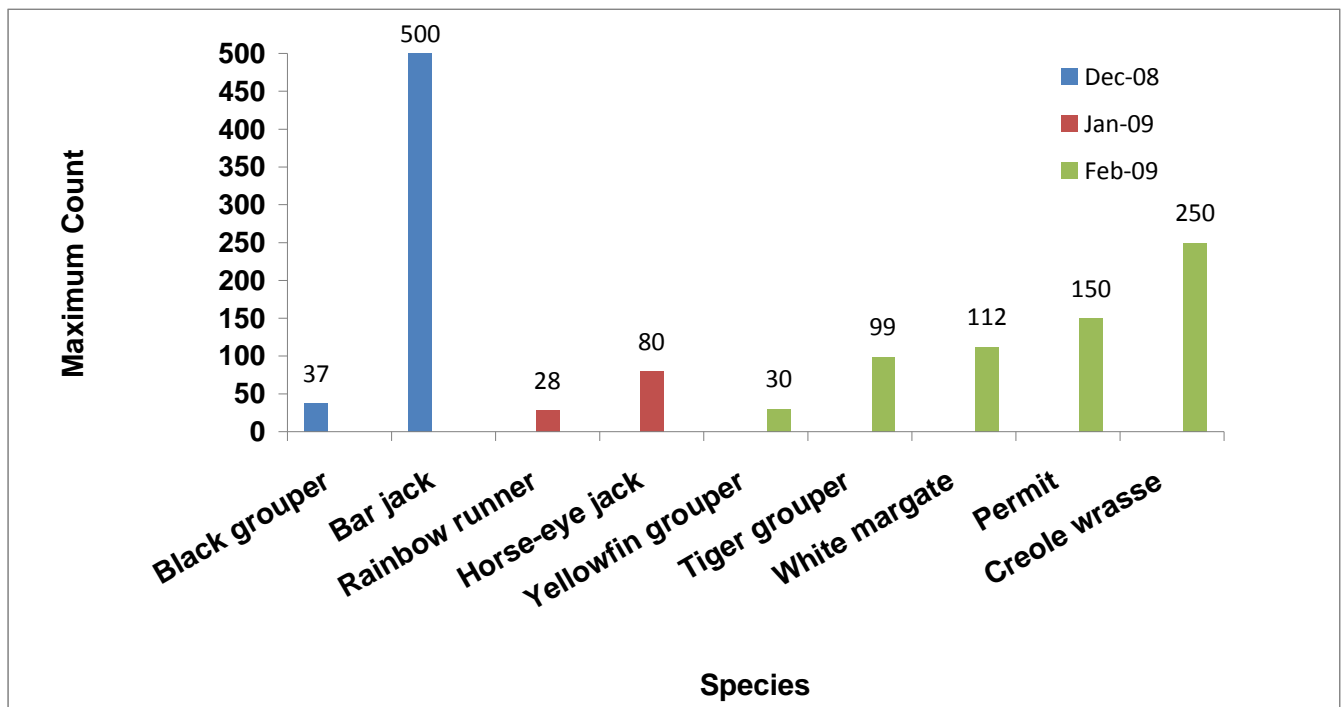
Behaviour	A.M.		P.M.		P.M. Late	Total no. of observations	Percentage of dives behaviour observed (%) N=61
	Early	Late	Early	Mid			
Grouping	0	4	0	10	14	28	45.9
Fighting	0	1	0	4	7	12	19.7
Color changes	1	4	4	17	22	48	78.7
Gravid	0	3	0	9	14	26	42.6
Bite Wounds	0	0	0	4	5	9	14.8
Courtship	0	3	0	7	12	22	36.1
Spawning	0	0	0	1	7	8	13.1

\*(Early pm – 12:00 – 2:00 pm; mid pm – 2:01 – 4:00 pm; late pm – 4:01 – 6:00 p.m.)

### Other species recorded at Northeast Point Site

A total of 16 species representing seven species types were recorded at Northeast Point during the 2009 spawning season. These types were groupers, snappers, triggerfishes, trunkfishes, grunts, jacks and wrasses. The maximum counts recorded for these species ranged from 5 individuals to 1424 individuals with the most abundant, the bar jacks, recorded in December 2008 (Figure 3). Grouping, fighting, color changes, bite wounds, gravid and courtship behaviours were also noted in 8 of the 16 species including four species of groupers (black (*Mycteroperca bonaci*), tiger (*M. tigris*), yellowfin (*M. venenosa*) and yellowmouth (*M. interstitialis*) and the mutton snapper (*Lutjanus analis*) (Table 5).

**Figure 3** Maximum counts of non-Nassau grouper species observed at Northeast Point Site, Glover’s Reef Marine Reserve during the December 2008 – February 2009 spawning events ( $n > 25$ ).



**Table 5** *Behaviour of non-Nassau grouper species observed during the 2009 spawning season at Northeast Point spawning aggregation site, Glover’s Reef Marine Reserve.*

Species Type	Grouping	Fighting	Color Changes	Bite Wounds	Gravid	Courtship	Spawning
Black grouper	3	4	4	0	4	2	0
Tiger grouper	10	9	8	0	7	7	0
Yellowfin grouper	8	7	9	0	6	6	0
Yellow mouth grouper	1	1	1	0	1	1	0
Mutton snapper	1	0	0	0	0	0	0
Horse-eye jack	3	3	3	1	2	3	0
Ocean triggerfish	1	0	1	0	0	1	0
White margate	4	0	0	0	0	0	0
Total number of observations	31	24	26	1	20	20	0

## SUMMARY AND RECOMMENDATIONS

Despite inclement weather during the 2009 spawning season, the underwater visual survey team completed a total of 18 surveys over 13 days. A maximum count of 1,100 Nassau groupers were recorded during these surveys with spawning observed during the February 2009 surveys. Compared to the previous 2008 spawning season’s peak count of 1190 individuals, this peak count suggests that the relative abundance of Nassau grouper has not changed significantly and remains low. One possible factor contributing to this low count may be the continued occurrence



of illegal activities at the spawning site as evidenced by the presence of Nassau groupers caught on long lines at the Northeast spawning site during the January and February 2009 surveys. The recently implemented April 2009 legislation that stipulates that the Nassau grouper caught in Belize waters must be landed whole and is governed by size restrictions signifies further management efforts to increase the Nassau grouper population. However, the effects of management efforts will only be seen with effective enforcement.

Photo of monitoring team members removing a Nassau grouper caught on a long line at the Northeast Spawning Aggregation Site (February 2009).

The size class frequency distributions for the 2009 spawning season showed that the majority of the Nassau grouper individuals were immature (<50 cm total length) which is now less than the legal minimum size limit of 50.8 cm total length. The size class frequency distributions for the previous spawning seasons (2005 to 2008) showed that the individuals occurred in larger size class ranges of greater than 50 cm total length.

It is recommended that due to the increased likelihood of inclement weather during the Nassau grouper spawning moons of December to March, effort should be focused on the peak moons in January and February, with sampling occurring 3 days after the full moon and lasting for at least 5 days. To calibrate abundance counts and verify fish behaviour, it is also recommended that a video camera, following proper training, be used during the surveys. Future analysis of the data should explore possible correlations between species counts and physical measurements reported during the surveys such as water temperature. The data collected from the long term deployment of HOBO temperature loggers at the Northeast Spawning site should also be used in these analyses.

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