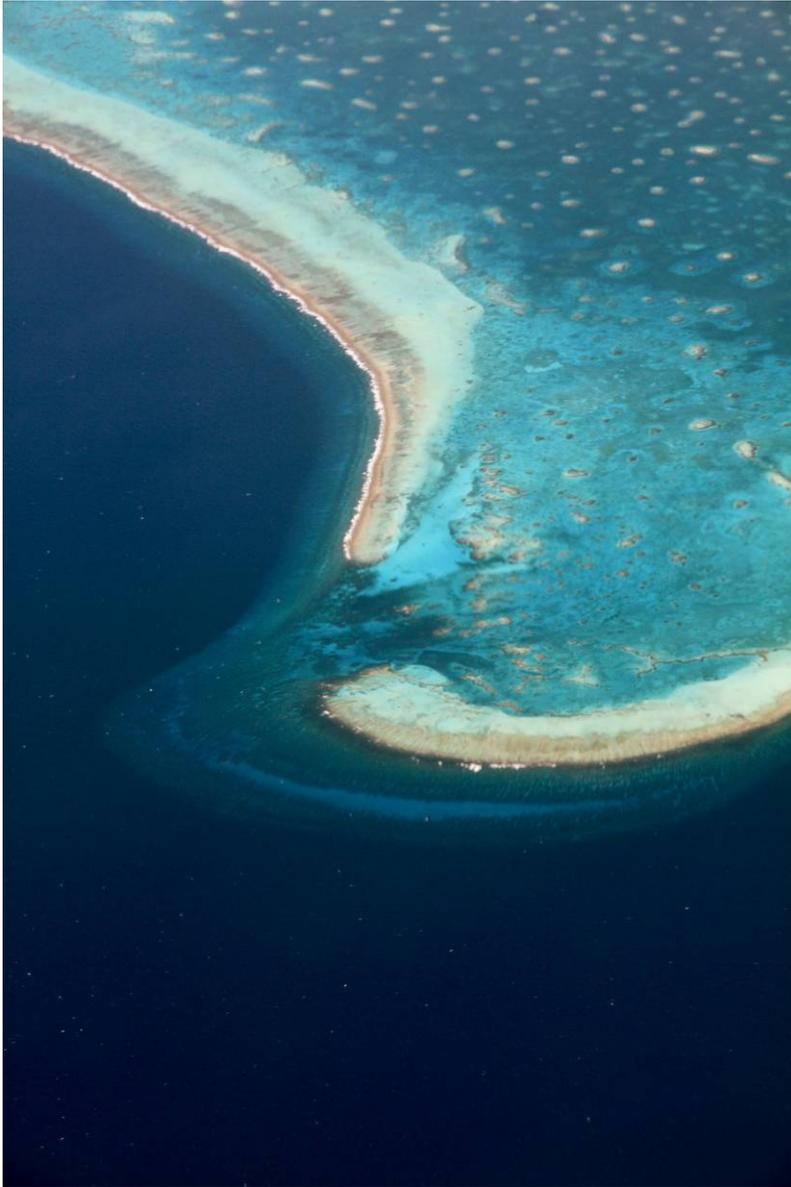


**Nassau grouper Spawning Aggregations  
at  
Northeast Point, Glover's Reef Marine Reserve**



**Report for the 2005 to 2012  
Spawning Aggregation Periods**

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A special thank you to Dr. Yvonne Sadovy, Director for the Society for the Conservation of Reef Fish Aggregations, for participating in the 2011 and 2012 spawning aggregation surveys at Northeast Point.

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*Photo: Aerial photo of Northeast Point Spawning Aggregation Site, Glover's Reef Marine Reserve, Belize (photo: R. Graham)*

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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. One species at risk is the Nassau grouper, *Epinephelus striatus*, now considered as Endangered on The World Conservation Union (IUCN) Red List.

In Belize, 11 of the 13 known spawning aggregation sites were granted protected status in an effort to preserve these sites. However, even with the fishing closure measures, the fish populations are still decreasing within these sites and are at risk of depletion. In 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 overall objectives of the monitoring program are to:

### Overall 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 the site 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. To demonstrate that protection works and that more fish are, as a result, coming back to the aggregations, scientifically robust methodology is required. Spawning aggregation (SPAG) surveys are challenging in that it involves counting fish all massing together and moving around in deep waters, strong currents, poor visibility etc. and divers who might change every few years. A consistent and repeatable method that divers can easily be trained to use is needed for counting aggregating fishes. To this end, in 2011, Dr. Yvonne Sadovy, Director for the Society for the Conservation of Reef Fish Aggregations (SCRFA) accompanied the SPAG team during their surveys of the Northeast Point SPAG site to observe and make suggestions for strengthening the current methodology. Her recommendations were tested during the 2012 spawning aggregation surveys.

This report highlights the revisions to the 2005 to 2011 methodology that were made during the 2012 spawning aggregation season at Northeast Point SPAG site and presents results from the data collected from the 2005 to 2012 Nassau grouper spawning event seasons at Northeast Point SPAG site at the Glover's Reef Marine Reserve.

## 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.



*Aerial photo of Glover's Reef Atoll  
(photo by R. Graham)*

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.

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



## **METHODOLOGY**

The methodology used for the 2005 to 2011 SPAG surveys is based on the 'Reef Fish Spawning Aggregation Monitoring Protocol for Belize' (Heyman *et al.*, 2004).

### **Underwater Visual Surveys**

#### **2005 to 2011 Spawning Seasons**

Underwater visual surveys using SCUBA were employed to obtain Nassau grouper spawning aggregation counts. A team of at least six persons conducted the surveys including four SCUBA divers, a boat captain and an assistant boat captain.

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, were also documented.

For the SPAG surveys conducted from January 2005 to February 2011, the type of species, 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. The data were transcribed from the slates to the all weather paper. 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.

#### **2012 Spawning Season**

Dr. Yvonne Sadovy, who participated in the January 2011 surveys, had made the following recommendations for improving the scientific rigor of the current monitoring. These recommendations included: 1) define the survey area for the species by delineating the outer boundary of the aggregation site; 2) survey the entire survey area on each trip and conduct more detailed surveys on the balls of fish; 3) keep data collection to a minimum by focusing on a single fish species since bottom time is limited; 4) reconsider the usefulness of size data, which is time consuming to collect; 5) develop a consistent and repeatable method that divers can use to count fish in three-dimensional balls such as video; and 6) make every effort to retain divers on a regular basis to ensure consistency year to year and across different sites.

Based on these recommendations the methodology for the 2012 Spawning Season (January 2012 and February 2012) surveys were revised based on the following objectives:

1. Verify that the survey site corresponds with the historical coordinates of the known spawning site
2. Sketch the area surveyed by the team and establish points of reference to ensure subsequent monitoring covers the same known area and to assist orientation on site and related discussions
3. Develop and explore census techniques with the aim of standardizing a census protocol for future spawning aggregation monitoring
4. Explore the use of video as an additional census technique to corroborate visual census
5. Foster team building through constructive discussion of techniques and improved confidence of fish number estimates

For the 2012 surveys, the outer boundary of the aggregation site was delineated - this will become the survey area for the species at the site on a long-term basis. GPS readings were taken so that the full extent of the site could be documented (length and breadth) and its area determined. This information is important to make sure that surveys are replicable in the future.

Searches were systematic with multiple divers exploring different parts of the survey area and being in visual contact. Detailed surveys were done of the balls of fish since there may be multiple balls on a single aggregation site. If multiple divers assessed a single ball, the estimates of each diver were used and a mean and standard deviation were calculated to get an idea of the variability of the estimates. Video was also used to verify or calibrate visual counts by estimating the dimension of the 'ball' and the average density.



*2012 Spawning Monitoring Team (l to r – Charles Noralez, Dr. Yvonne Sadovy, Valentine Rosado, Randolph Coleman (standing), Virginia Burns Perez, Mervin Nunez and Alicia Eck) (Photo by: WCS)*

Since the priority is Nassau grouper, all efforts were focused on the Nassau grouper on a single dive. As the dives are relatively deep and therefore require a short bottom time, Sadovy cautioned that if an attempt is made to collect too much information on each dive, the time constraint may result in all data being compromised. Size data, which is time consuming to collect and still yields low level of accuracy, were not collected. Recovery in overall numbers will be the key indicator of aggregation condition.

## **RESULTS**

### **SECTION A**

#### **Nassau grouper monitoring at Northeast Point (2012 Spawning Season)**

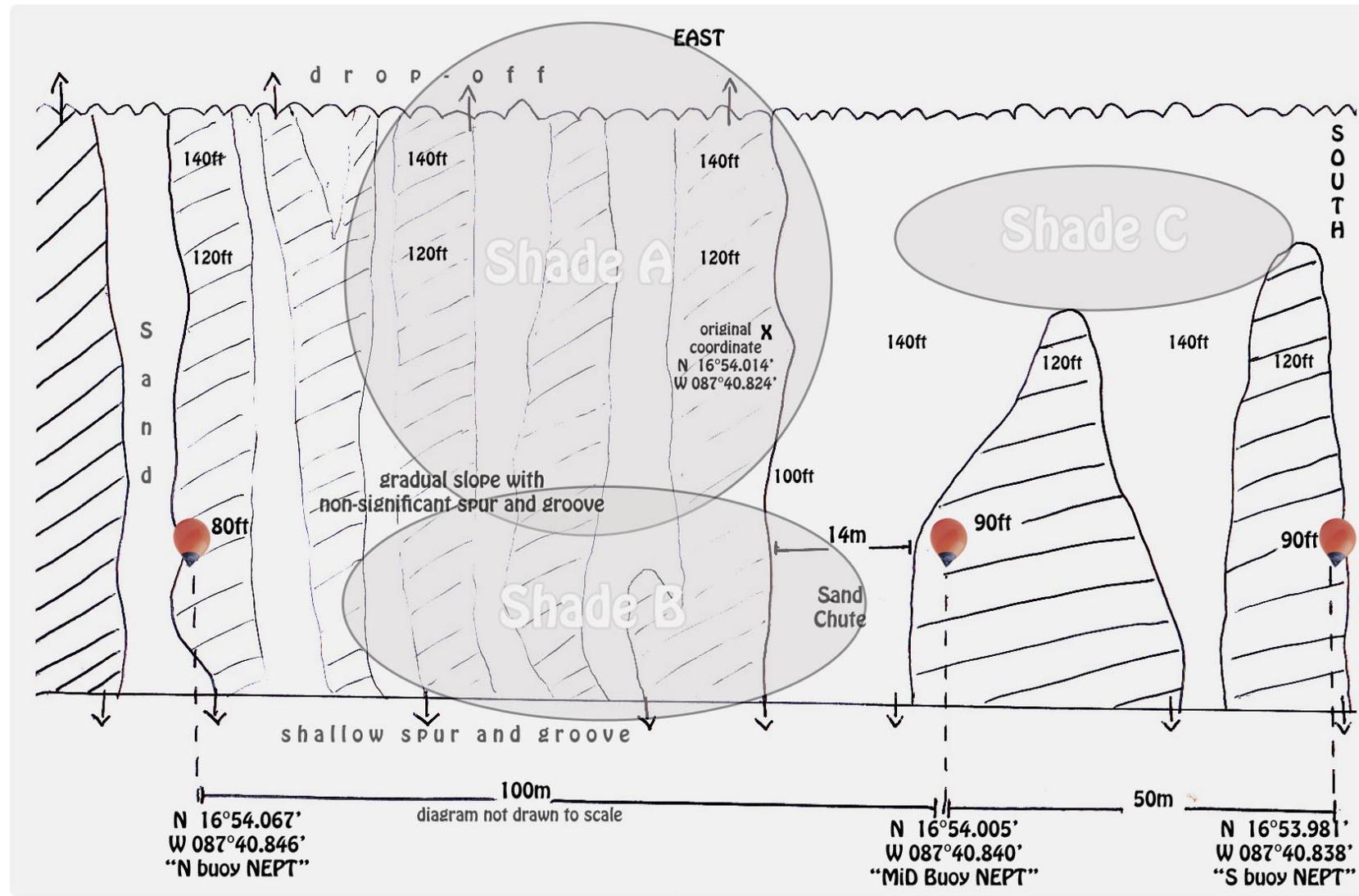
##### **Delineating Survey Area**

On 12 January, the first day of the surveys during the January moon, two preliminary dives were conducted to: 1) confirm the aggregation site at Northeast Point using existing coordinates and 2) practice underwater videoing. To delineate the area, buoys were placed at the northernmost point of the aggregation site (north-buoy), the mid-point (mid-buoy) and the southernmost point (south buoy). The area originates from the shallow reef spurs and grooves at depths of 80 feet and then gradually slopes to depths greater than 140 feet (Figure 2). The linear distance from the north-buoy to the south buoy is approximately 150 meters.

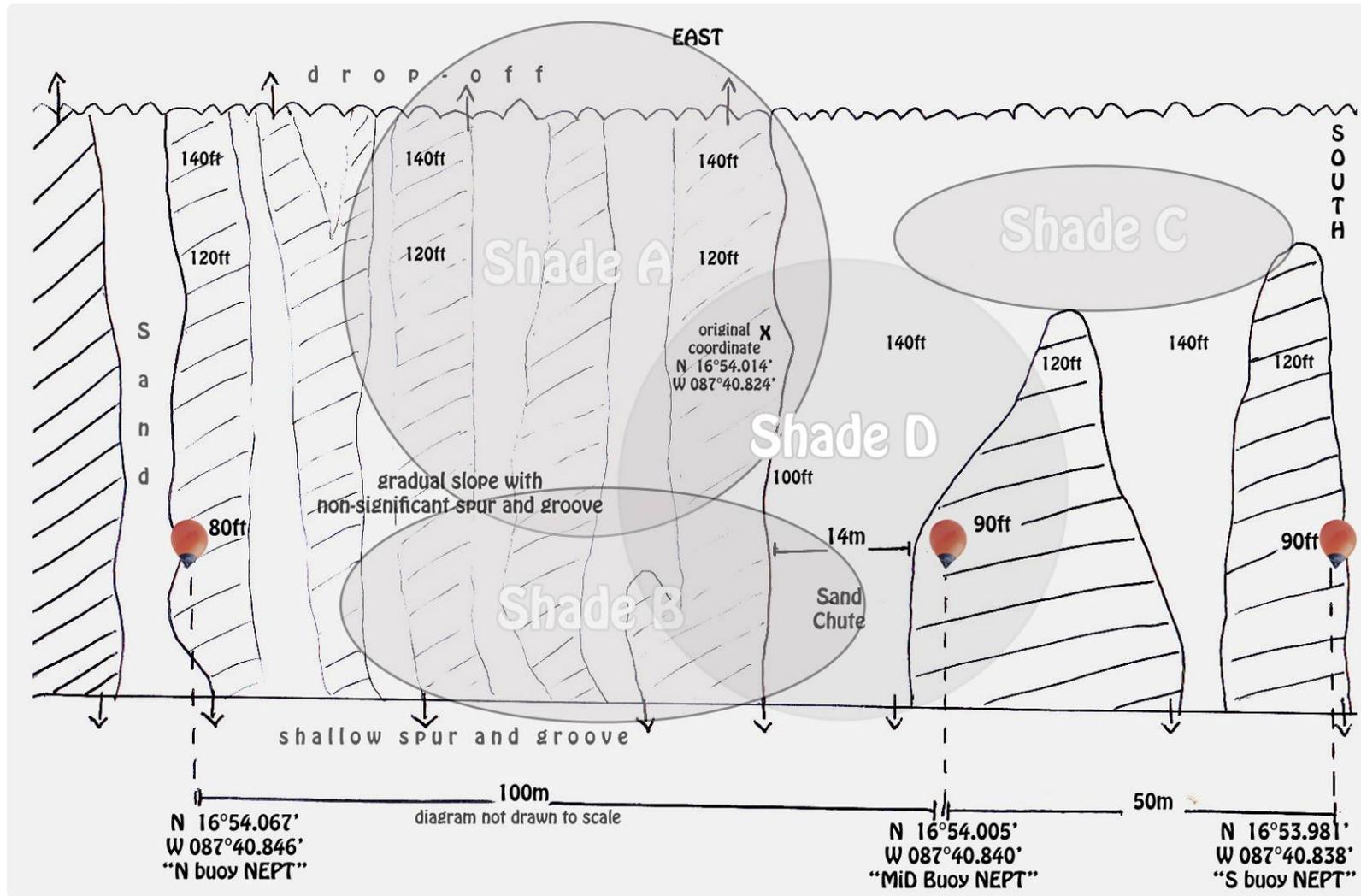
The establishment of a designated north-buoy and south-buoy will also serve as an important drop-point for the diving team. Subsequent monitoring can use the south-buoy as the descent point when the water current is flowing north and the north-buoy can be used as the descent point when the water current is flowing towards the south. This method ensures the survey of the entire known aggregation area on any given dive by the field team.

At the start of the February 2012 surveys, the survey area was re-sketched reflecting a different composition of Nassau grouper aggregation activity classified as 'Shades' (Figure 3).

**Figure 2** Diagram of spawning aggregation area (January 2012) showing the GPS location of the three points of reference and the groupings (Shades) of spawning aggregation activity (done by V. Rosado)



**Figure 3** Diagram of spawning aggregation area (February 2012) showing the GPS location of the three points of reference and the groupings (Shades) of spawning aggregation activity (done by V. Rosado)



## Maximum Counts

A total of 13 underwater visual surveys over a seven day period were conducted during the 2012 spawning season. In January 2012, the seven surveys were conducted from the 12 -14 January corresponding to three to five days after the full moon. Due to inclement weather, dives were not conducted on the 15 and 16 January and 12 February. The maximum count of Nassau grouper was 1050 and 600 in January 2012 and February 2012, respectively. The 1050 count was recorded during a late evening dive on 13 January, four days after the full-moon. Table 1 shows the counts (visual and video) recorded for each dive. Dives which also incorporated video counts showed for the 14 January count, a video count of 850 which is lower than the maximum mean visual count of 1010 (standard deviation (s.d.)- 220). All other video counts were slightly higher than the visual mean counts but within the standard deviation.

**Table 1** Counts of Nassau grouper recorded during the 2012 Spawning Aggregation (January 2012 and February 2012) surveys at Northeast Point, Glover’s Reef Marine Reserve.

Survey Date	Survey Start Time	Visual Count (mean numbers and standard deviation (s.d.) of Nassau groupers)	Video count (numbers of Nassau groupers)
12 Jan. 2012	4:50 p.m.	742 (s.d.-177.3)	No count
13 Jan. 2012	4:25 p.m.	1050 Two 'balls' of fish 300 (s.d. -40.8) 750 (1 estimate only)	No count
14 Jan. 2012	4:13 p.m.	1010 (s.d. – 220)	850
10 Feb 2012	3:20 p.m.	343 (s.d. -49.2)	No count
11 Feb 2012	2:33 p.m.	300 (s.d.-100)	360
11 Feb 2012	4:12 p.m.	377 (s.d.-75.9)	430
13 Feb 2012	3:22 p.m.	320 (s.d.-20)	No count
14 Feb 2012	2:15 p.m.	430 (s.d.-80.4)	450
14 Feb 2012	4:12 p.m.	600 (s.d.-100)	630

## Spawning Behaviour

During the January 2012 visual survey dives, no spawning or fighting behaviors were observed by the team. On Day 1 and Day 2 of the January surveys, three and four days after the full moon, respectively, grouping, colour changes, bite wounds, gravid and courtship spawning behaviors were observed. For the maximum count of 1050 groupers, the approximate ratio of color phases was: 5 bi-color: 3 dark phase: 2 normal.

During the February 2012 surveys, the team observed only bite wounds, gravid and a few incidences of bi-color and dark phases. No spawning, fighting, grouping or courtship behaviors were observed.

## Other species recorded at Northeast Point Site

While not the focus of the surveys, the following species were also recorded at Northeast Point during the 2012 spawning season. These included: the white margate (*Haemulon album*) which had the greatest maximum count of 200 individuals followed by horse-eye jacks (*Caranx latus*) – 110 individuals, tiger groupers (*Mycteroperca tigris*) - 100 individuals and permit (*Trachinotus falcatus*) with a maximum count of 70. These maximum counts were recorded in February 2012. The black grouper (*Mycteroperca bonaci*) and Caribbean Reef shark (*Carcharhinus perizi*) were also recorded. The tiger groupers were observed displaying color changes, bite wounds and gravid behaviors during the February 2012 surveys.

## SECTION B

### Nassau grouper monitoring at Northeast Point (2005 to 2012 Spawning Seasons)

Since 2005, a total of 101 underwater visual surveys over 67 days have been conducted during the spawning events. The surveys were conducted one to ten days after the full moon (Table 2). The majority of the dives (41 dives or 45.5%) were conducted after 4:00 p.m. (late p.m.) (Table 3). The survey depths ranged from 26.5 m to 45.7 m with an average depth of 30.4 m (s.d.-4.3).

**Table 2** 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 2012

Spawning Event	Number of Days Following the Full Moon (FM)										
	0	1	2	3	4	5	6	7	8	9	10
<b>2005 Season</b>											
Jan 2005				X		X	X	X	X		
<b>2006 Season</b>											
Dec 2005			X	X	X		X				
Jan 2006							X	X	X		X
Feb 2006				X	X						
<b>2007 Season</b>											
Jan 2007							X				
Feb 2007		X		X	X		X				
<b>2008 Season</b>											
Jan 2008				X	X	X	X	X			
Feb 2008					X	X	X	X	X		
<b>2009 Season</b>											
Dec 2008				X	X	X	X	X			
Jan 2009			X	X	X						
Feb 2009				X	X	X	X	X			
<b>2010 Season</b>											
Jan 2010					X		X	X			
Feb 2010			X	X		X	X				
March 2010				X	X	X					
<b>2011 Season</b>											
Jan 2011				X	X	X	X				
Feb 2011				X	X			X			
<b>2012 Season</b>											
Jan 2012				X	X	X					
Feb 2012				X	X		X	X			

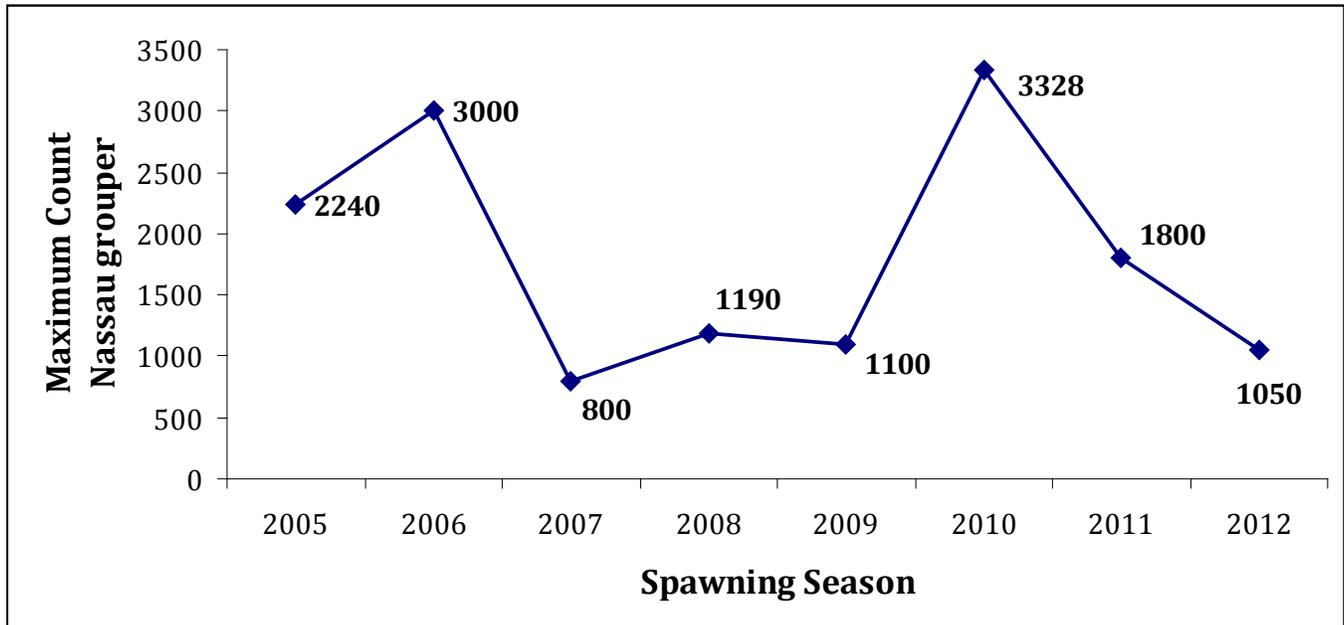
**Table 3** Time of day underwater visual surveys were conducted at Northeast Point spawning aggregation site for the period January 2005 to February 2012

Time of Day	Classification	No. of underwater visual surveys
8:00 a.m. to 9:59 a.m.	early a.m.	2
10:00 a.m. to 11:59 a.m.	late a.m.	5
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.	39
4:00 p.m. -	late p.m.	46
No time provided		4
		101

**Maximum Counts**

The maximum counts during the 2005 to 2012 spawning event seasons ranged from 800 to 3328 in 2007 and 2010, respectively (Figure 4). The peaks for each of the seasons occurred three to seven days after the full moon (Table 4).

**Figure 4** Maximum counts of Nassau grouper recorded at Northeast Point Site, Glover’s Reef Marine Reserve during the 2005 to 2012 spawning events



**Table 4** Maximum counts recorded at Northeast Point spawning aggregation site, Glover’s Reef Marine Reserve during the January 2005 – February 2012 spawning events

Spawning Event	Survey Date	Maximum Counts	Time	Lunar Phase (FM- full moon)	Depth (m)
<b>2005 Season</b>	29-Jan-05	<b>2240</b>	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	<b>3000</b>	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	<b>800</b>	late p.m.	4 days after FM	30.0
<b>2008 Season</b>	27-Jan-08	950	late p.m.	5 days after the FM	28.2
	28-Feb-08	<b>1190</b>	late p.m.	7 days after the FM	39.4
<b>2009 Season</b>	18-Dec-08	130	mid p.m.	5 days after the FM	45.7
	15-Jan-09	900	late a.m.	5 days after FM	31.4
	14-Feb-09	<b>1100</b>	late p.m.	5 days after FM	27.4
	15-Feb-09	<b>1100</b>	late p.m.	6 days after FM	30.5
<b>2010 Season</b>	4-Jan-10	307	late p.m.	4 days after FM	30.3
	2-Feb-10	<b>3328</b>	late p.m.	3 days after FM	37.9
	4-Mar-10	470	mid p.m.	4 days after FM	36.4
<b>2011 Season</b>	24-Jan-11	<b>1800</b>	mid p.m.	5 days after FM	33.6
	25-Feb-11	1000	late p.m.	7 days after FM	34.8
<b>2012 Season</b>	13-Jan-12	<b>1050</b>	late p.m.	3 days after FM	36.4
	14-Feb-12	600	late p.m.	7 days after FM	39.4

\*(Early p.m. – 12:00 – 1:59 p.m.; mid p.m. – 2:00 – 3:59 p.m.; late p.m. – 4:00 – 6:00 p.m.)

Maximum Count for each season

## **SUMMARY AND RECOMMENDATIONS**

The maximum count recorded during the 2012 Spawning Season is the second lowest recorded since the implementation of the monitoring program in 2005. The lowest maximum count recorded was 800 in 2007; however, the maximum counts in 2006 and 2010 of 3000 and 3328, respectively, represent a threefold increase of the lowest count recorded. The variability in the maximum counts makes it difficult to detect a trend in abundance. The effort being made by the spawning aggregation team to employ a scientifically robust method will help to ensure that any claims of an increase or decrease in the abundance of Nassau groupers are defensible. Many of the recommendations to improve the protocol made by Dr. Sadovy have also been incorporated into a revised version of the 2004 Spawning Aggregation Monitoring Protocol approved by the Spawning Aggregation Working Group, of which WCS is a member. The effort to conduct robust surveys is being done on a national level at the various spawning aggregation sites.

Tremendous strides were made during the 2012 Spawning Season surveys such as 1) delineating and sketching the survey area, 2) working with video to calibrate visual counts and 3) using multiple observers to determine a mean estimate count which has led to greater confidence by the entire team in their visual count estimates, and, greater team spirit. The team also recognized various areas for improvement and made the following recommendations: 1) improve underwater video technique as it pertains to the collection and analysis of the data, 2) calculate the breadth of the survey area, 3) use a more reliable means of calculating current and wind speed and direction and 4) establish a standardized protocol for recording ratio of color phases.

Unfortunately, illegal activities are still occurring at the site, as evidenced by a fishing line and anchor recovered from a depth of 30.3 m just south of the north buoy in February 2012. The objects did not have any algal growth suggesting fairly recent fishing activity.

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