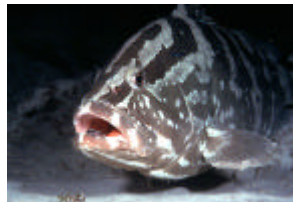
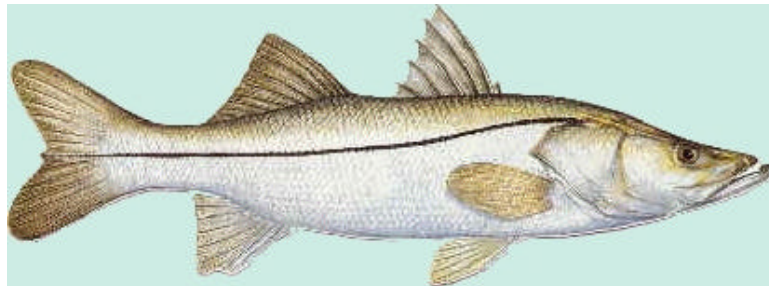


**CRITICAL ANALYSIS OF INFORMATION ON SPAWNING  
AGGREGATION SITES IN MBR'S PROJECT COUNTRIES AND  
RECOMMENDATIONS FOR THEIR MONITORING &  
MANAGEMENT**

*Draft Report*



**Prepared By**

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**11 November, 2002**

## Executive Summary

The Mesoamerican Barrier Reef System (MBRS) is the second longest reef system in the world extending nearly 1,000 kilometers from Isla Contoy in Mexico to the Bay Islands of Honduras. The Belize segment of this system extends for approximately linear 220-250 km but the country's patch, faro and barrier reef complex together comprises approximately 79% of the Mesoamerican Reef System. Many commercially important reef species also use specific promontories located along the margin of the MBRS's complex patch reefs, barrier reefs and atolls to aggregate and spawn at specific times of the year.

A wide range of ethnic groups living along the coast of this region depend on this reef complex for fishing and tourism as their primary economic livelihood. Fishermen belonging to these groups have known of the spawning aggregation sites for generations and have fished them extensively to the point of total collapse of some of the spawning sites. The primary reason for the widespread population decline has been attributed to selective over-fishing of aggregating species' highly synchronized & site specific spawning aggregations throughout most of their range.

The most dramatic example of the level and result of such exploitation at spawning sites have been documented at the Caye Glory spawning bank on Belize's barrier reef. During the 1960's, Nassau Grouper were fished from their December aggregation at a rate of about 2 tons per day (Craig, 1966). Today however, the site no longer supports even recreational catch of Nassau Grouper and underwater survey of the area has further established that less than 25 individuals aggregate at the site during the December spawning period (Paz and Grimshaw, 2001). Similar consequences have been reported elsewhere in Puerto Rico, Cayman Islands, Bermuda, US Virgin Islands, Mexico, Honduras and the Dominican Republic.

The objective of this report is to evaluate the status of select spawning aggregation in the Belize portion of the MBRS region through the collection and analysis of available scientific and anecdotal information. This assessment will focus on five key commercially important species. These include: Nassau Grouper (*Epinephelus striatus*), Mutton Snapper (*Lutjanus analis*), Common Snook (*Centropomus undecimalis*), Hogfish (*Lachnolaimus maximus*), and the Dusky Anchovy or Manjua (*Anchoa lyolepis*). Anecdotal information about other species participating in spawning aggregations in the MBRS region is also included with this report.

## **TASK 1 : PROJECT DESIGN AND ORGANIZATION**

Mr. Mito Paz, Managing Director of Green Reef Environmental Institute attended the project design and organization meeting held in Belize in October of 2002, during which time the project plan, methods goals, expectations, schedule and deliverables for the report were discussed. The primary obligations of the national consultancy were at this time identified as consisting of four primary tasks, which were identified as:

- Task 1: Participation in project planning & organization;
- Task 2: Reporting on the findings of a literature review, interviews and data summarization;
- Task 3: Map identification of reported spawning aggregation sites; and
- Task 4: Analysis of findings.

The following sections of this report address the obligations identified under Tasks 2 – 4 for the plan of work identified during Task 1 of this study.

## **TASK 2 PART I: LITERATURE & ANECDOTAL REPORTS OF SPAWNING AGGREGATIONS IN BELIZE**

Approximately, seven Caribbean families of reef fish are known to form aggregation in the MBRS region.

### **SERRANIDAE: GROUPERS**

#### ***Epinephelus striatus (Nassau Grouper)***

The Nassau Grouper was at one time a very important commercial fish in Belize, with spectacular spawning aggregations. These aggregations have been reported to have consisted of tens of thousands of individuals which migrate to specific sites on the reef. Nassau Groupers have historically aggregated around the full moons in December and January in Belize. These aggregations usually form in 20-40 meters of water at specific locations at the outer reef shelf. Anecdotal information and early literature on Belize's Nassau Grouper spawning aggregations indicate that 10 sites have been recognized historically. These include:

1. ***Rocky Point***
2. ***Cay Caulker***
3. ***St. George's Cay***
4. ***Goff's Cay***
5. ***Cay Glory***
6. ***Gladden Spit***
7. ***Sapodilla Cays***
8. ***Mauger Cay, Turneffe Reef***
9. ***Northern Two Cay, Lighthouse Reef***
10. ***North-Glovers Reef***

The earliest record of spawning aggregation sites in Belize identified Cay Glory as the single largest aggregation site, followed by Goff Cay Bank and the Sapodilla Cays (The Fisheries of British Honduras, 1944).

Carter (1986 & 1988) and Carter *et al* (1994) reported the presence of Nassau Grouper aggregation sites at Northern Two Cay at Lighthouse Reef; North Glovers Reef Atoll, Mauger Cay at Turneffe Island Atoll, Gladden Spit and Rocky Point. Wade (1999) further reported that Nassau Grouper also historically used to aggregate in the reefs in front of St. George's Cay and Cay Caulker. More recently, Paz and Grimshaw (2001) described a previously unreported Nassau Grouper aggregation at Dog Flea Cay, and Cay Bokel, Turneffe Reef; and Heyman and Requena (2002) described a previously unreported Nassau Grouper aggregation at Nicholas Caye on Belize's southern Barrier Reef.

In general, Nassau Groupers are considered in Belize to have been fished to extinction from 6 of their 10 historically-recognized spawning sites; and they appear to have been recently extirpated from the site at Dog Flea Cay (Paz, personal communication). The four historical sites presently regarded as being intact include Northern Two Caye, Lighthouse Reef, Northern Glovers Reef, and Gladden Spit. During the National Grouper Survey of 2001, approximately 4,000 Nassau Groupers aggregated at the Northern Two Cay site, Lighthouse Reef; approximately 100 Nassau Grouper aggregated at Dog Flea Cay, and approximately 100 Nassau Grouper aggregated at Gladden Spit (Paz and Grimshaw 2001). In 2002, 350 Nassau Groupers were observed to aggregate at Gladden Spit, and approximately 75 Nassau Grouper were observed to aggregating at Nicholas Cay (Heyman and Requena, 2002). Wildlife Conservation Society's 2002 survey of the Glovers Reef Nassau Grouper aggregation site has indicated a population of 4,000 to 5,000 individuals was present at the annual aggregation event. The site at St. Georges Caye remains unsurveyed to date.

### ***Epinephelus guttatus (Red Hind)***

Red Hind form spawning aggregations during the full moon of January or February for about two weeks. Red Hinds have been reported as utilizing the Cay Glory bank as an annual spawning aggregation site during February and March by Carter and Perrine (1994); and Domeier *et al* (1997) reported observations of a previously unrecognized, and apparently un-fished spawning aggregation of *Ephinephelus gutattus* at Lighthouse Reef during the full moon of January 1990. More recently, Heyman (2001) reported on a spawning aggregation of *Epinephelus guttatus* at Gladden Spit during the full moons of January and February.

### ***Epinephelus itajara* (Goliath Grouper, formerly Jewfish)**

Local fishermen have reported fishing a spawning aggregation of *Epinephelus itajara* at Goff's Cay during June to October (Jack Barrows, Johnny Eiley, Carl Cabral, pers. com.); and local fishers from San Pedro have reported fishing Goliath Grouper with mature roe at Cay Glory during the annual spawning aggregation in December, January and February (Ernesto Gomez, Florencio Acosta, pers. Comm.). However, this aggregation was not found during two subsequent survey trips to nearby English in July and August, 1992; and during numerous survey trips to both cays by Paz in June, July, August and September of 2001 and September and October of 2002.

### ***Mycteroperca bonaci* (Black Grouper)**

Black Grouper form spawning aggregations during the full moon of January and February. Black Grouper reportedly aggregate to spawn at some of the same sites used by *E. striatus* (i.e. Cay Glory, Northern Two Cay, Glovers Reef, Rocky Point, Gladden Spit, Mauger Cay), during the same months of January and February (Carter, 1989; Carter and Perrine, 1994), however they have also been encountered at sites where Nassau Grouper do not (presently) aggregate. Sala *et al* (2002) reported observing 60 Black Groupers during the 2002 Grouper survey.

Other sites reported to have spawning aggregations of *Mycteroperca bonaci* include Calabash Cay, Turneffe Reef, Gladden Spit, Halfmoon Cay Lighthouse Reef, Sandbore Lighthouse Reef, Cay Glory, and Cay Bokel Turneffe Reef (Paz and Grimshaw, 2001); Middle Cay at Glovers Reef, West Glovers, El Nic at Lighthouse Reef and Soldier Cay at Turneffe Islands (Heyman and Requena 2002); and at Northern Glovers Reef (Salas and Ballesteros, 2000 – 2002).

### ***Mycteroperca tigris* (Tiger Grouper)**

Tiger Grouper are reported to form spawning aggregations during the full moon of January and February. Only two aggregation sites of *M. tigris* have been described for Belize, both of which are located at Glovers Reef. Salas and Ballesteros (2000-2002) reported that approximately 300 Tiger Grouper aggregated to spawn at the North Glovers Site, and another 200 individuals aggregated to spawn at Middle Caye Glovers Reef. Incidental sightings of Tiger Grouper 'schools' moving along the outer margin of the Barrier Reef have been anecdotally reported during January and February, but the destination of these migrations have yet to be determined.

### ***Mycteroperca venenosa* (Yellow Fin Grouper)**

Yellow Fin Grouper are reported to form spawning aggregation one time per year during the full moon of February (Dormeier *et al* 1997). Salas and Ballesteros report one observation of 160 - 200 *M. venenosa* individuals at North Glovers Reef.

### ***Other Commercially Valued Grouper Species***

No information has been reported on the three remaining species of commercially valued Serranidae found in Belize. These species include *E. adscensionis*, the Rock Hind; *E. morio*, the Red Grouper; or *E. fulva*, the Coney.

### **LUTJANIDAE (snappers)**

#### ***Lutjanus analis* (Mutton Snapper)**

The Mutton Snapper reportedly aggregates to spawn at Rocky Point Ambergris Caye, Gladden Spit on the Barrier Reef, and Long Cay Glovers Reef during the full moons of April and May (Paz, personal observation). At Gladden Spit however, the species is reported by fishers and Heyman (2001) to spawn from March to June. Domeier *et al* (1997) reported that Mutton Snapper form large spawning aggregations that persist for several weeks. Other aggregations of Mutton Snapper have been reported to occur at Rocky Point, Mata (M&M's), Tres Cocos and Wacatunich (Will Alamilla, 2002, pers. com.); and English Cay (Domeier *et al* 1996).

#### ***Lutjanus jocu* (Dog snapper)**

Dog Snapper have been reported to spawn during the full moon of January, as well as the second (full moon) and third quarter moon of July. Domeier *et al* (1996) observed a spawning aggregation of Dog Snapper off English Cay in July of 1992; and Carter and Perrine (1994) observed a large school of *Lutjanus jocu* at Cay Glory during the full moon of January 1989. Heyman (2002) reports an aggregation of Dog Snapper 800 – 900 fish occurred at Gladden Spit occurred during a January aggregation site survey.

#### ***Lutjanus vivanus* (Silk Snapper)**

Little appears to be known about Silk Snapper spawning behavior. The only description found of their aggregation behavior in Belize was reported by Craig (1966), who observed unusual concentration of Silk Snapper on the grass flats south of Caye Chapel, near to Long Cay on the Barrier Reef during the month of August. This aggregation is still fished during the month of July (Derek Escobar, pers. Comm.).

#### ***Lutjanus cyanopterus* (Cubera Snapper)**

Cubera Snapper have been reported to spawn between during the second (full moon) and third quarter moon of July (Dormeier *et al* 1996) as well as between March & June, and between September and October (Heyman 2001). Domeier *et al* (1996) reports spawning aggregations of Cubera Snapper occurred at Buttonwood Caye on the Barrier Reef, and Cay Bokel Turneffe Reef.

### ***Lutjanus adopus (Schoolmaster Snapper)***

Schoolmaster Snapper have been reported to spawn between in February at Rocky Point, Ambergris Caye by Miguel Alamilla and Isaiah Mahil (personal communication), and at Half Moon Cay Lighthouse Reef during the January Full moon by Paz and Grimshaw (2001).

### ***Lutjanus synagris (Lane Snapper)***

Lane Snapper have been reported by Domeier et al (1996) and one local fisher (Carl Cabral, personal communication) to spawn between March & August.

### ***Lutjanus griseus (Grey Snapper)***

Grey Snapper have been captured in Beach Traps by local fishers in the Chetumal Bay en route to spawn outside the bay area between May & June, but the final location of the spawning event has not to date been determined.

### ***Ocyurus chrysurus (Yellowtail Snapper)***

Yellowtail Snapper have been observed to spawn at Rocky Point Ambergris Caye and Gladden Spit from February to March (Will Alamilla, personal communication; and Heyman, 2001); and have been reported to form spawning aggregations at English Caye by Carl Cabral (personal communication).

## **CENTROPOMIDAE: SNOOK**

### ***Centropomus undecimalis (Common Snook)***

Snook, tarpon and Crevalle jacks typically schooled and foraged near to or along river mouth bars and deeper tidal channels, and within large inland bodies of water such as Northern and Southern Lagoons, Salt Creek Lagoon, Northern River Lagoon and Shipstern Lagoon, which have year-round connections with the sea. Snook are believed to aggregate to spawn in December, January and February (Mike Huesner and Florencio Acosta, pers. com.), but no particular sites have been identified or described in Belize to date.

## **HOGFISH**

### ***Lachnolaimus maximus (Hogfish)***

No formal descriptions of Hogfish spawning locations, seasons or behavior have as yet been published in Belize. Local fishers indicate that large assemblages of Hogfish were historically known from a grassy shelf west side of Crawl Cay Turneffe Reef along during the month of September; and Heyman (2001) reports that Hogfish spawned at Gladden Spit from January to May.

## **TASK 2 PART II:**

### **SUMMARY OF GEO-SPATIAL LIFE HISTORY DATA FOR MBRS TARGET SPECIES IN BELIZE.**

Virtually all of the published records prior to the year 2000 on spawning aggregations for Belize are limited to information on the Nassau Grouper, with information on Mutton Snapper, Common Snook and Hogfish prior to 2000 being developed from fisher interviews conducted during this and prior studies. The findings of these records, along with post 2000 published records and interviews are summarized in **Table 1**, along with citations for sources of the information presented.

No information has been published or is presently in the process of being analyzed regarding the transport or dispersal of target species larvae from spawning sites in Belize; or concerning connectivity of spawning aggregations and larvae to nursery area locations and habitats for Belize.

The key ecological relationships of spawning aggregations to other resources in the larger ecosystem primarily concern the common role that Nassau Grouper, Mutton Snapper and Common Snook play as apex predators/carnivours. Interestingly, only one study has been conducted on the dietary habits of these species in Belize (Carter *et al*, 1994), and therefore it is not yet possible to identify the forage base and relationship for the rest of these species to their prey ecology. Additionally, it is important to recognize that tagging studies recently conducted by Wildlife Conservation Society have indicated that most Nassau Grouper, and quite possibly other aggregating apex predators arrive at spawning sites from nearby, resident populations, rather than from distant locations as traditional thought. This observation clearly indicates that local fishing practices outside the spawning period can directly impact spawning aggregation attendance. No records or anecdotal information was encountered concerning the Dusty Anchovy or *Majua* for Belize. Since this species was not listed in the recent compilation of *Fishes of the Continental Waters of Belize* (Greenfield and Thomerson, 1997), it may not be extant in Belize.

## **TASK 2 PART III:**

### **SOCIO-ECONOMIC, LEGAL AND MANAGEMENT INFORMATION**

Virtually no information has been developed in regard the MBRS target species save for Nassau Grouper, and this information has been summarized in **Table 2**, along with citations for sources of the information presented. . Over the 16 year period between 1984 and 2000, the catch biomass & value of Belize's Nassau Grouper fishery had fallen to < 3% of its pre-1984 level, and employing < 2 % of the fishers it employed before 1984. What is clear from the information presented is that the management efforts initiated after 1984 to regulate the take of Nassau Grouper were initiated in response to, rather than to prevent the near total collapse of the fishery; and that current efforts continue to lack a significant enforcement component to bring about management effectiveness.



TABLE 1

## SUMMARY AGGREGATION SITE CHARACTERISTICS FOR MBRS TARGET SPECIES

Site Number	Pre-1980 Qty Individuals Observed	Post-2000 Qty Individuals Observed	Habitat	Season	Timing	Duration	Size Ranges	Age	Sex Ratios	Currents	Other Species Present	Other species Abundance	
<b>NASSAU GROUPEL (<i>Epinephelus striatus</i>)</b>													
Cay Glory, Barrier Reef	Countless Numbers/Unquantified [1944]		Sand Bottom; depth of 10-15 fathoms	Late December or early January	full moon	4 days	N/A	N/A	N/A	N/A	N/A	N/A	The Fisheries of British Honduras, 1944
Cay Glory, Barrier Reef	Astonishing Numbers/Unquantified [1964/65]		Rocky Bottom, 10 Km <sup>2</sup> in area, depth of 15-20 fathom	Late December to mid January	full moon	4-5 weeks	N/A	N/A	N/A	strong southerly current	N/A	N/A	Craig, 1966
Cay Glory, Barrier Reef	15,000 [1988]		Spur & Groove; area of 150-200 M <sup>2</sup> ; depth of 80-100 ft.	Late December to mid January	full moon	3 weeks	N/A	N/A	2F:1M	northerly 1-2 knots	N/A	N/A	Carter, 1988
Cay Glory, Barrier Reef	10,000 [1989]		Spur & Groove; area of 150-200 M <sup>2</sup> ; depth of 80-100 ft.	Late December to mid January	full moon spawning on 6th day after the full moon	3 weeks	5-20 lbs		3F:1M		Black Groupers, Dog Snappers	Thousands of Dog Snappers	Carter, 1989
Cay Glory, Barrier Reef		3 [1999]	Spur & Groove; area of 150-200 M <sup>2</sup> ; depth of 80-100 ft.	January full moon	3 days before and 3 days after the full moon	7 Days	N/A	N/A	N/A	N/A	Black Groupers, Tiger Groupers	N/A	Wade, 1999
Cay Glory, Barrier Reef		21 [2001]	Spur & Groove; area of 150-200 M <sup>2</sup> ; depth of 80-100 ft.	January full moon	after the full moon	3 days	N/A	N/A	N/A	N/A	Black Groupers, Dog Snappers, Jolthead Porgy, Yellow Fin Grouper, Trunkfish	60 Black Groupers, 600 Dog Snappers, 215 Jolthead Porgy, 2 Yellowfin Grouper, 80 Trunkfish	Paz and Grimshaw, 2001
North End, Glovers Reef	15,000 [1970's]	4,600 [2002] 2,700 [2001] 3,000 [2000]	Spur & Groove; 25 - 40m depth;	January full moon	5 days after the full moon	6 days	N/A	N/A	N/A	N/A	Black Groupers, Tiger Groupers, Yellowfin Groupers	300 Tiger Groupers, 160 Yellow Fin Groupers, 60 Black Groupers	Sala, 2000, 2001, 1002
Sandbore, Lighthouse Reef		4000 [2001]	Low relief Spur & Groove; depth 20-27m	January full moon	peak 5 days after the full moon	1 week					Black Groupers, Tiger Groupers	40 Black Groupers, 5 Tiger Groupers	Paz and Grimshaw, 2001
Gladden Spit, Barrier Reef		107 [2001] 350 [2002]	Sand bottom with low profile mound	January full moon	peak 5 days after the full moon	1 week					Black Groupers, Yellow Fin Groupers, Dog Snappers, White Margate, Trunkfish, Jolthead Porgy	40 Black Groupers, 9 Yellowfin Groupers, 1,500 Dog Snappers, 30 Margate	Paz and Grimshaw, 2001; Heyman and Requena, 2002
Cay Bokel, Turneffe Reef		13 [2001]	high relief spur and groove	January full moon		1 week					Black Groupers, Tiger Groupers, Dog Snappers, Mutton Snappers, Horse-Eye Jacks	23 Black Groupers, 5 Tiger Groupers, 300 Dog Snappers, 500 Mutton Snappers	Paz and Grimshaw, 2001
Dog Flea, Turneffe Reef		100 [2001]	Low relief Spur & Groove; depth 25-40m	January full moon		1 week					Black Groupers, Tiger groupers	5 Black Groupers, 2 Tiger Groupers	Paz and Grimshaw, 2001
Nicholas Caye, Barrier Reef		70 [2002]		January full moon							Black Groupers, Red Hind, Trigger groupers		Heyman and Requena, 2002

Continued....

TABLE 1

SUMMARY AGGREGATION SITE CHARACTERISTICS FOR MBR'S TARGET SPECIES

(Continued)

Site Number	Pre-1970 Qty Individuals Observed	Post-2000 Qty Individuals Observed	Habitat	Season	Timing	Duration	Size Ranges	Age	Sex Ratios	Currents	Other Species Present	Other species Abundance	
<b>MUTTON SNAPPER (<i>Lutjanus analis</i>)</b>													
Gladden Spit, Barrier Reef	N/A	500 [2002]	N/A	March, April, May, June	full moon	1 week	N/A	N/A	N/A	N/A	N/A	N/A	Heyman and Requena, 2002
Long Cay, Glovers Reef	N/A	N/A	N/A	April	full moon	1 week	N/A	N/A	N/A	N/A	N/A	N/A	Will Alamilla (pers. comm.)
Cay Bokel, Turneffe Reef	N/A	1000 [2000]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Cubera snappers, Dog snappers, Black groupers, Tiger Groupers	N/A	Carl Cabral (pers. comm.)
<b>COMMON SNOOK ( <i>Centropomus undecimalis</i> )</b>													
Shipstern Lagoon	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
Spanish Point	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	full moon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
Northern River Lagoon	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
Salt Creek Lagoon	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
Northern Lagoon	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
Southern Lagoon	N/A	N/A	Estuaries, river mouths, creeks and coastal areas	Dec-Feb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Craig, 1966; Mike Huesner, per. Comm.
<b>HOGFISH ( <i>Lachnolaimus maximus</i> )</b>													
Gladden Spit	N/A	N/A	N/A	Jan - May	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Heyman, 2001
Crawl Cay, Turneffe	500	N/A	Sand Bottom	September	full moon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Tino Gonzales (pers. comm.)
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**TABLE 2**

**SOCIOECONOMIC, LEGAL AND MANAGEMENT INFORMATION NASSAU GROUPEL IN BELIZE**

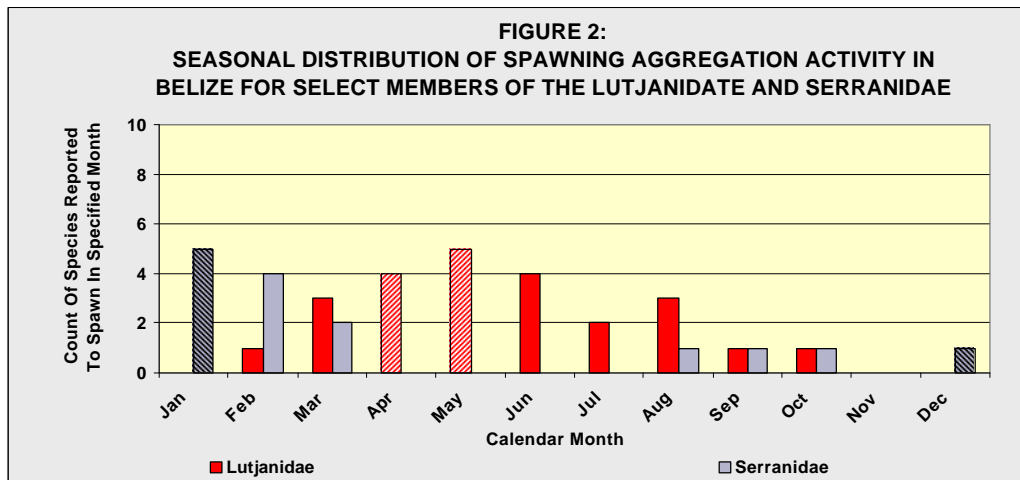
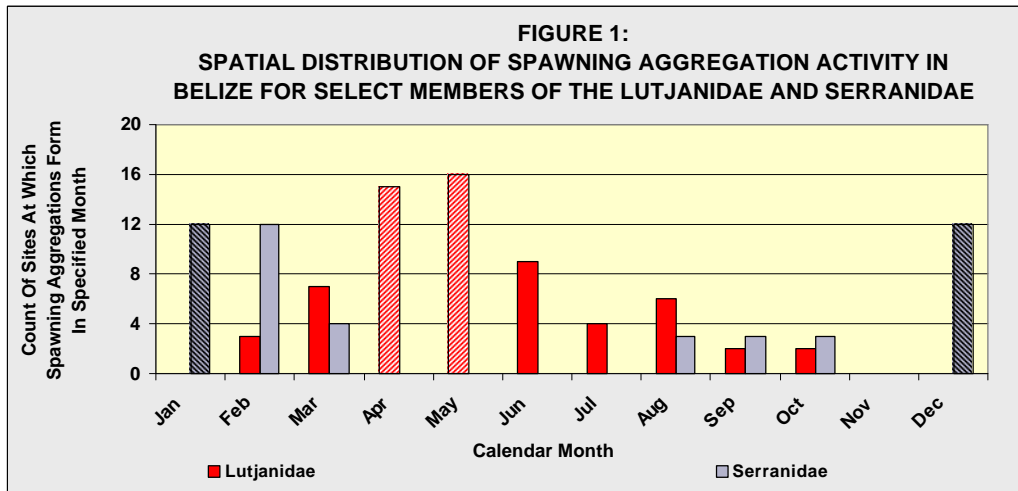
<b>CATEGORY</b>	<b>1950's - 1970's</b>	<b>1980's - 1990's</b>	<b>2000 - Present</b>
<b>SEASON</b>	December, January	December, January	December, January
<b>TIMING</b>	After the full moon	After the full moon	Full moon
<b>FISHERS/FISHER EFFORT</b>	1940's: All available fisherman; 1964-65: ~ 900 Fishermen	1965 - 1984: 240 Fishermen; 1996 - 15 Fishermen; 1999 - 24 Fishermen	2001: 38 Fishermen; 2002: 12 Fishermen;
<b>VESSEL USE</b>	1940's: All available boats; 1964-65: ~ 300 Boats	1984-85 - 40 boats; 1996 - 5 boats; 1999 - 6 boats	2001 - 16 boats; 2002 - 5 boats
<b>GEAR/METHODS</b>	Hand line	Hand line & Fish Traps	Hand line & Fish Traps
<b>SEASONAL CATCH</b>	1964-65: 200,000 lbs; 1978: 130,000 lbs	1984: 200,000 lbs; 1988: 27,000 lbs; 1996: 2,000 lbs; 1999: < 2,000 lbs (219 Groupers)	2001: 6,292 lbs
<b>EFFORT DATA</b>	National CPUE: > 75 Fish/Man-Day (3 fishermen land 100 - 150 dozen fish/week)	N/A	National CPUE Estimate: 3.9 Fish/Man-Day
<b>ECONOMIC IMPORTANCE</b>	Substantial	1984 Catch Is Worth ~ BZ\$ 546,650	2001 Catch Is Worth ~ BZ\$ 16,000
<b>REGULATIONS</b>	None	Fish traps at spawning banks were prohibited; Glovers reef bank was closed from December to March but not enforced; Declaration of a series of Marine Protected Areas	Fish traps at spawning banks were prohibited; Glovers reef bank was closed from December to March but not enforced
<b>MANAGEMENT</b>	None	None	Proposed Seasonal Closure for all Nassau Grouper Aggregation Sites except for Northern Two Cay and Mauger Cay
<b>EFFECTIVENESS</b>	None	Regulations not enforced; Seasonal closure site at Glovers Reef no enforced; Most MPA have no management presence	Fish traps still being used at Sandbore Spawning site; Glovers Reef was closed for 2001-2002 spawning season, Fisheries Department & Ministry of Natural Resources sign Co-management agreement with NGOs; There is more presence and enforcement in the MPAs
<b>PROPOSED REGS</b>	Expand fishing efforts to new and undiscovered sites to relief fishing effort on Cay Glory Spawning Site	Establish Permanent Marine Fishery Reserve (MFR): Close the Glover Reef Bank; and apply traditional fishery management such as Size Limits(12inches), Permanent Limited Entry (one-time, non-transferable permits to fish at Cay Glory, Northern Two Cay and Mauger Cay); Maintaining Existing Fisheries Regulations such as No Fishing with SCUBA, net mesh size, No traps outside the reef, bans on explosives, poisons, spear guns etc.,	Total Closure of all Nassau Grouper Spawning Aggregation Sites; Seasonal closure of most of the Nassau Groupers Spawning Sites.
<b>ALTERNATIVE USE</b>	None	Fisheries research and tourism training	Tourism; Research
<b>EFFECTS</b>	Other fishing banks were discovered but were also exploited to the point where they have failed commercially or show evidence of collapse	Successful in having a Seasonal Closure at Glovers and Bacalar Chico but not 100% enforced.	Success pending enactment of new legislation of the protection of Nassau Grouper in Belize; Tourism has increased in these areas (e.g. Gladden Spit) and Research and monitoring are ongoing.

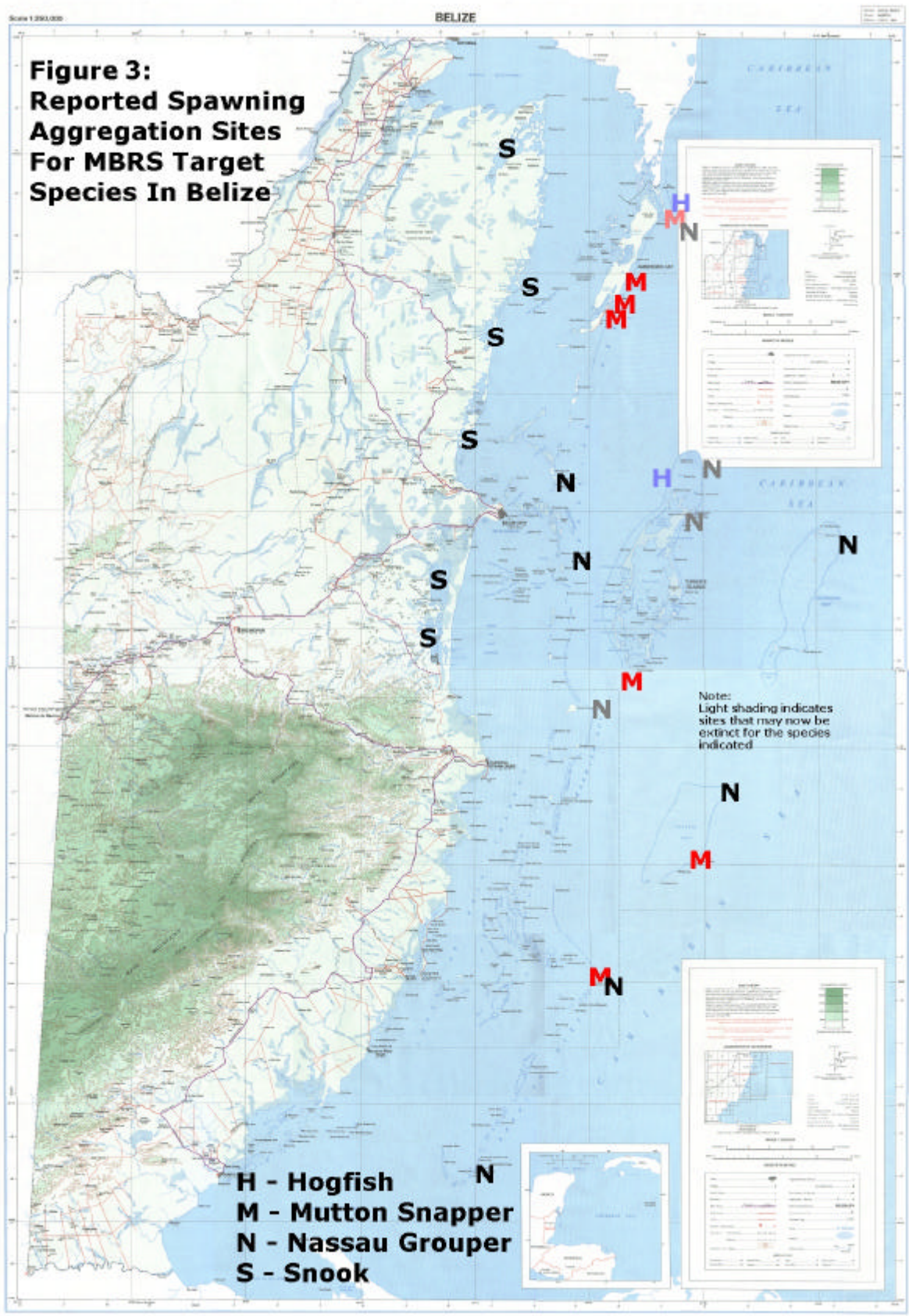
**TASK 3:**

**SPAWNING AGGREGATION SITE MAP PRESENTATION**

The information presented in Task 2 of this report was collated for the purpose of developing insights about the distribution of temporal-spatial characteristics of reported/verified aggregation sites for the MBRS target species. The temporal distribution of aggregations and site occupancy for all species reviewed in Task 2 are summarized in Figures 1 & 2, and the spatial distribution of 30 reported/verified aggregations sites for the MBRS target species is presented in Figure 3.

In general, the spawning aggregations of the Serranidae (Groupers) and Lutjanidae (Snappers) appear to be fairly well segregated in time, with most Groupers spawning during either the first or last quarters of the year, and most Snappers spawning during the second and/or third quarters of the year. In Figures 1 & 2 the seasonal occurrence of Mutton Snapper is shown by red/white hatching, and the seasonal occurrence of Nassau Grouper is shown by blue/black hatching. Snook and Hogfish appear to be segregated spatially from Groupers and Snappers, but no published reports were encountered detailing the specific locations or dates of their respective spawning aggregations.





## TASK 4:

### CONCLUSIONS AND RECOMMENDATIONS

#### *Monitoring Design*

Perhaps the single most important finding of the preceding review of literature and anecdotal information on spawning aggregation sites in Belize is the observation that Grouper and Snapper aggregations appear to be temporally segregated in Belize (Cf. Figures 1 & 2). This finding suggests that a skewed sampling design for monitoring may be better suited to (1) establishing the efficacy of Nassau Grouper and Mutton Snapper aggregations as indicator species of aggregation status in general, as well as (2) acquiring a more robust sampling return for the majority of aggregating species about which very little is known.

The skewed sampling design envisioned here should entail fewer months and more sites in order to better allocate resources in relation to spawning aggregation activity in Belize. In particular, we recommend that monitoring visits should focus on sites where aggregations have been documented between the months of February to June, and between the months of August to September (7 months) at no less than 10 sites, for a total monitoring effort of 70 site-months; as opposed to the initially planned allocation of for twelve months for a fewer number of sites. We further recommend that the months of November, December, January and July be omitted from the sampling effort, along with further monitoring at North Glovers and Gladden spit, because these months and sites have been thoroughly addressed by the recent studies of Paz and Grimshaw (2001), Salas and Ballesteros (2000-2002); Heyman (2002), respectively.

To these ends, we recommend the monitoring design shown in **Table 3** for Belize, with the provision that if sufficient resources are available, Rendezvous Cay (CZM), and the Elbow at Glovers Reef (TNC/WCS) should also be monitored. The recommended design would serve to capture aggregation information on 5 species of Grouper believed to aggregate in Belize (i.e. Black, Tiger, Yellow Fin, Red Hind, and Goliath), which can be compared to the recently collected data on Nassau Grouper, and this design would further serve to capture information about all 6 species of Snapper believed to aggregate in Belize (i.e. Cubera, Mutton, Dog, Schoolmaster, Yellow Tail and Silk).

We further recommend that either by capture, sacrifice and study of sample individuals from aggregation assemblages, or by sampling of fisher catches taken at aggregation sites, species specific analyses of stomach contents are conducted to determine respective forage base of the subject species during all monitoring exercises. This information can provide insights as to the primary forage base and hence, ecological linkages of MBRS target species as well as other apex predators aggregating during the monitoring exercise.

**TABLE 3**  
**RECOMMENDED MONITORING DESIGN FOR SPAWNING AGGREGATION SITES IN BELIZE**

Site	Site No	Species Anticipated To Be Encountered During Monitoring							Potential Monitoring Agency <sup>1</sup>
		Feb	Mar	Apr	May	Jun	Aug	Sep	
Rocky Point Ambergris Caye	1	Black Grouper, Yellow Tail Snapper	Black Grouper, Yellow Tail Snapper	Mutton Snapper	Mutton Snapper, Schoolmaster Snapper	Schoolmaster Snapper	?	?	BCMR, GREI
Sandbore, Ambergris Caye	2	Black Grouper	Black Grouper	Mutton Snapper, Dog Snapper	Mutton Snapper, Dog Snapper	Dog Snapper	?	?	HCMR, GREI
Cay Glory, Barrier Reef	3	Red Hind, Yellow Fin Grouper, Black Grouper	Yellow Fin Grouper, Black Grouper	?	?	?	Goliath Grouper	Goliath Grouper	CZM
Nicholas Caye, Barrier Reef	4	?	?	?	?	?	?	?	TIDE/TNC
Mauger Cay, Turneffe Reef	5	Yellow Fin Snapper	Yellow Fin Snapper	?	?	?	?	?	UB, GREI
Cay Bokel, Turneffe Reef	6	Tiger Grouper, Black Grouper	Black Grouper, Cuberra Snapper	Mutton Snapper, Cuberra Snapper, Dog Snapper	Mutton Snapper, Cuberra Snapper, Dog Snapper	Cuberra Snapper, Dog Snapper	?	?	UB, GREI
Sandbore, Lighthouse Reef	7	Tiger Grouper, Yellow Fin Grouper, Black Grouper	Yellow Fin Grouper, Black Grouper	?	?	?	?	?	AS
El Nick, Lighthouse Reef	8	Black Grouper	Black Grouper	?	?	?	?	?	AS
Long Caye, Glovers Reef	9	Tiger Grouper (?), Black Grouper (?)	Black Grouper (?)	Mutton Snapper	Mutton Snapper	?	?	?	WCS/TNC
SW Site, Glovers Reef	10	Black Grouper	Black Grouper	?	?	?	Silk Snapper	?	WCS/TNC

## ***Management and Conservation***

The recent Nassau Grouper Research and Advocacy program conducted by Green Reef addressed many of the social impacts and obstacles to spawning site management and conservation likely to be encountered in Belize and elsewhere. Of particular concern in this regard is the procession of research and advocacy where Green learned that subsequent to research, considerable attention to the benefit/cost aspects of spawning aggregation conservation need to be addressed before regulatory frameworks and management arrangements in the form of marine protected areas can be embraced by stakeholders and effectively implemented with reasonable assurance of compliance. Green Reef found that it is particularly important that local stakeholders are adequately convinced of the science behind proposed regulatory measures, and that fishers in particular are shown tangible sources of replacement income from alternative livelihood initiatives before they are willing to relinquish their traditionally unregulated fishing practices.

Further in this regard, recent public consultations with both stakeholders and fishery scientists resulted in the understanding that no single conservation measure alone, in the form of regulatory action or marine protected area establishment, are likely to successfully achieve conservation success. Rather, both types of measures are needed to assure that over-advantageous or strategic fishing practices do not unduly harm resident populations outside of their spawning aggregation sites, and to insure that the spawning act itself is strategically protected as a complementary action to regulatory actions. Consequently it is important to appreciate that the appropriate *procession* for a management and conservation initiative should entail:

1. ***A Thorough Research Initiative***, detailing the population domain and status of the target specie(s) in question;
2. ***A Comprehensive Benefit/Cost Analysis***, which clearly identifies the foregone opportunity cost to fishers that will result from proposed regulatory and conservation measures;
3. ***Development Of Appropriate Arrangements*** for alternative stakeholder (fisher) livelihood that can tangibly replace forgone fishers revenue; and ultimately
4. ***Implementation*** of the necessary regulatory and conservation measures.



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