Three-dimensional analysis of reef fish spawning aggregation sites in Belize and the Cayman Islands

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Fish spawning aggregation (FSA)

- A group of conspecific fish gathered for the purpose of spawning with fish densities or numbers significantly higher than those found in the area of aggregation during non-reproductive periods (Domeier & Colin 1997).

- Resident Spawning Aggregations
- Transient Spawning Aggregations
Transient spawning aggregations

- Relatively large body size
- Migrate relatively long distance
- 3x abundance
- Specific time of year
  - One/two weeks of a year (2-3 consecutive months, depend on species)
  - Lunar cycle
- Same places
- (maybe) only the known reproductive chance for the species
- Highly predictable
FSAs (Video)

QuickTime™ and a decompressor are needed to see this picture.
<table>
<thead>
<tr>
<th>Family and genus and species</th>
<th>Records</th>
<th>Countries</th>
</tr>
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<tbody>
<tr>
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</table>

Sadovy et al. 2008
Many sites are gone.

Belize and the Cayman Islands still have active spawning aggregation sites.

Based on distribution of grouper & snapper, South America could have spawning aggregation sites.

Sadovy *et al.* 2008
Vulnerable to fishing

- Improved technology
- Limited understanding of their ecological importance
- Increased number of fishermen
- Inappropriate management practices

- Endangered species
- Many sites are gone.
**Example**

Nassau Grouper at Caye Glory  
Belize

![Graph showing the decline of Nassau Grouper numbers from 1965 to 2005. The graph indicates a significant decline over time, with a peak in 1969 according to Craig (1969).](image)

Heyman *et al.*
Why these places?

Any specific characteristics?
- Specific place – there is something intrinsically advantageous about the site.

- Focus on the reef structure.

- The well-studied FSA species, *Epinephelus striatus* (Nassau grouper) are known to share their sites with other grouper, snapper and jacks.
Possible reef structure

- Four reef structures encompass almost all possible reef structures (Claydon 2004):
  - (1) Channels and passages
  - (2) Walls
  - (3) Reef slopes
  - (4) Promontories/shelf-edges

- But all of the terminology is subjective and dependent on scale (Claydon 2004).
  - There are no fine-scale topography data
    - No quantitative comparison among FSA sites.
To Understand geomorphology of historically known sites

Belize & Cayman Islands
- Known FSA sites
- Geospatial analysis
- Describe FSA sites quantitatively. (Similarities/difference)

Los Roques, Venezuela
- Reef promontory theory
- Previously no FSA info.
- Potential FSA sites
Methodology
1. Identify sites

1. Rocky Point
2. Dog Flea Caye
3. Soldier
4. Calabash
5. Cay Bokel
6. Emily
7. Sandbore
8. Half moon Caye
9. Glovers – Northeast
10. Middle Caye
11. Gladden Spit
12. Nicholas Caye
13. Rise and Fall Bank
Airmar M260 Transducer
200 kHz: 6 ° cone angle
50 kHz: 12 ° cone angle
**Shape**

1km buffer circle from spawning aggregation sites
Methodology (Cont’)

- Spawning aggregation sites
- 1km buffer circle from spawning aggregation sites (red line)
- Shelf edge line (more than 20 degree slope) (green line)
- Vertical profiles across the spawning aggregation sites
- Distances from shelf edges and from inflection points.
- Shapes
## Depth and Distances

<table>
<thead>
<tr>
<th>Location</th>
<th>Reef types</th>
<th>Shape</th>
<th>Orientation</th>
<th>FSA</th>
<th>shelfedge</th>
<th>Distance to (m)</th>
<th>inf. pts</th>
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Vertical Profiles

Less than 5 degree slopes

FSAs at least 20 m depth

At least 50 m depth differences

Shelf edges (more than 20 degree slopes)
The Cayman Islands

Kobara and Heyman 2008
Belize and Cayman Islands

- All spawning aggregation sites were located
  - convex-shaped seaward extending reefs
    - Reef Promontories
  - At least 20 m depth
  - Steep drop-off
  - Proximity to deep water
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Predicting potential FSA sites

- The six widely scattered grouper aggregation sites in Belize are all reef promontories (Carter et al. 1994).

- Nearly all reef promontories are visible in Aerial photo/Landsat imagery (Carter et al. 1994, Heyman and Requena 2002).

- Based on two-dimensional shape information and satellite imagery for Los Roques, Venezuela, we predicted the occurrence of spawning aggregation sites at reef promontories within the archipelago.
The Venezuelan government declared the area a national park in 1972.

*Cervigón (1993) described aggregation of Mutton snapper (*Lutjanus analis*) and Nassau grouper fishing*

Large groups of schoolmaster snapper (*Lutjanus apodus*) displaying possible reproductive behaviors near Cayo Sal in September 2005
30 interviews with experienced local fishermen and divers described Groupers (*Epinephelus* spp. and *Mycteroperca* spp.) as uncommon (except *E. guttatus*).

Interviews identified probable spawning aggregations of *Lutjanus analis* at Cayo Sal in May.
Cayo Sal

Visual Survey was conducted by Universidad Simon Bolivar
Feb – Aug 2007
Increases in density of *Lutjanus apodus* (Schoolmaster), *L. analis* (Mutton snapper), *L. griseus* (Gray snapper), and *Caranx latus* (Horse-eye jack) were observed in certain months although spawning events were not observed (Boomhower *et al.* in review).
Geomorphological features of Los Roques were different from those of Belize and Cayman.

- Visual survey sites in Los Roques generally occurred on **shallower** shelf edges (7m, Cayo Sal) than sites in Belize and the Cayman Islands.
- The site was generally **not steep wall and proximal to deep waters**.
- These differences may have influenced the non-occurrence of spawning aggregations for large groupers and snappers at these sites.
Spawning aggregation sites (Belize, Cayman) are reef promontories, deeper than 20 m depth, more than 20 degree slopes of shelf edge and adjacent to deep water.

Nassau grouper
Movement in depth
Tagged fish w/ depth sensors
Starr et al. 2007

Fig. 4. *Epinephelus striatus*. Depth profiles of tagged Nassau groupers at Glover's Reef. The line represents average depth, and shading depicts range of minimum to maximum recorded depths. Each letter on the x-axis represents the first day of the month. Dashed lines at the top indicate the times when groupers were aggregating at the spawning site.
Thank you