Comparative Geomorphic Analysis of Nassau grouper Spawning Aggregation Sites in Belize and the Cayman Islands

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ABSTRACT

Nassau grouper (*Epinephelus striatus*) use the same few spawning aggregati sites each year. The goal of this paper is to map the location of existing and historical Nassau grouper spawning aggregation sites in Belize and the Cayman Islands in relation to reef geomorphology. Observations and data suggest that Nassau grouper spawning aggregations are located near shelf edges and reef promontories so we measured these distances in all cases. A promontory is defined as a distinct turning point, or bend, in the shelf break. The locations of 10 sites in Belize were collected directly in the field while the locations of 5 sites in the Cayman Islands were provided by the Cayman Islands Department of Environment. The geomorphologic reef inventory from the Millennium Reef Mapping Project was used to identify the shelf edge contour in Belize. Bathymetric data in Cayman Islands were collected with an echosounder in order to identify the shelf edges. While Dog Flea Caye in Belize is not distinctive but small mound shape horizontally, the reef structure surrounding all of the other spawning aggregation sites jut into deep water in a convex shape. All spawning aggregation sites in Belize and the Cayman Islands were located within 120 m from the shelf edges and 550 m of turning points in the shelf break. We conclude that though not all spawning aggregations occurred at the exact point of a reef tip, they are located near shelf edges and reef promontories.

KEY WORDS: Spawning aggregation, reef geomorphology, Nassau grouper

Análisis Geomorfológico Comparativo de Sitios de Desove para Mero Criollo en Belice y las Islas Caimán

El mero Criollo (*Epinephelus striatus*) usa los mismos sitios de desove cada año. El objetivo de este estudio fue el de mapear las localidades históricas y existentes de desove del mero Criollo en relación con la geomorfología del arrecife en Belice y las Islas Caimán. Observaciones y data sugieren que las agregaciones de desove para mero Criollo están localizadas cerca de los bordes de plataforma y de los premonitorios de arrecife así que esas distancias fueron medidas para todos los casos. Un promontorio es definido como un punto de curvatura distinto en la ruptura de la plataforma. Las posiciones de 10 sitios fueron coleccionadas directamente en el campo mientras 5 sitios fueron proporcionados por el Departamento de Ambiente de las Islas Caimán. El inventario geomorfológico de arrecife del Proyecto Milenario de Mapeo de Arrecife fue usado para identificar el contorno de borde de la plataforma en Belice. Los datos batimétricos de las Islas Caimán fueron coleccionados con un ecosonda a fin de identificar los bordes de la plataforma. Mientras el cayo "Dog Flea" es pequeño y con forma de un pequeño montículo horizontal; en general, los sitios de desove están ubicados en aguas profundas y son de superficie convexa. Todos los sitios de agregación de desove en Belice y las Islas Caimán fueron localizados dentro de los 120 m de los bordes de plataforma y 550 m de puntos de flexión del arrecife. Nuestra conclusión fue que aunque no todas las agregaciones de desove ocurrieran en la punta del arrecife exactamente, todos ellos estuvieron localizados cerca de los bordes de plataforma y de promontorios arrecifales.

PALABRAS CLAVES: Agregaciones de desove, geomorfología de arrecife, Mero criollo

INTRODUCTION

A critically endangered reef fish species, Nassau grouper (*Epinephelus striatus*) migrate long distances to the specific places once or twice per year in sequential months. The primary reason for the Nassau grouper's decline has been attributed to intense harvesting of its highly site specific spawning aggregations.

Overfishing may not be limited to Nassau grouper. The National Spawning Aggregations Working Committee in Belize has compiled four years of data that suggest that over 20 different species aggregate and spawn at Gladden spit, Halfmoon Caye, and South Point Lighthouse in Belize. More importantly, they first noted that each of the 13 known spawning aggregation sites share similar geomorphologic characteristics. Tucker *et al.* (1993) described historical Nassau grouper aggregation sites in the Cayman Islands: twelve mile bank, southwest and east end of Grand Cayman, east end of Little Cayman, and the east end of Cayman Brac. Whaylen *et al.* (2004) described a re-discovered aggregation site on the west end of Little Cayman Island. The west end Little Cayman site can be considered currently the only known healthy Nassau grouper aggregation in the Cayman Islands; and a multi-species aggregation site.

There are numerous observations of several transient reef fish aggregations occurring at reef promontories (projections of the reef seaward from the general reef contour) or on the outer reef edges (Johannes 1978, Carter 1989, Colin 1992, Sadovy *et al.* 1994, Koenig *et al.* 2000, Sala *et al*. 2003, Whaylen *et al.* 2004). However, there is only a limited understanding of geomorphology of these spawning aggregation sites; no comparative study among the sites exists. For marine protected areas (MPAs) to be useful in conservation, it is necessary to incorporate appropriate habitats. It is significantly important for ecosystem-based management to include multi-species spawning aggregation sites in MPA networks.

The objective of this paper is to increase the geospatial

understanding of the existing and historically known Nassau grouper spawning aggregation sites in Belize and the Cayman Islands with respect to their distances from shelf boundaries and inflection points of reef promontories and with respect to their horizontal shapes of reef structures.

METHODS

The locations of ten Nassau grouper spawning aggregation sites in Belize were collected directly in the field with GPS, while the locations of five sites in the Cayman Islands were provided by the Cayman Islands Department of Environment (Table 1).

Table 1. The study sites in Belize and Cayman Islands. Convex/concave attributes were examined shape of shelf edge extending the coast within 2 km buffer circle of spawning aggregation site.

Country	Location	Sites name	Shape
Belize	Turneffe Reef Atoll	Dog Flea Caye	convex
		Cay Bokel (Elbow)	convex
	Lighthouse Reef Atoll	Sandbore	convex
		Halfmoon	convex
	Glovers Reef Atoll	North Glovers	convex
		Middle Caye	convex
	Barrier Reef	Rocky Point	convex
		Emily	convex
		Gladden spit	convex
		Rise and Fall bank	-
Cayman Islands	Grand Cayman	GC SW points	convex
		GC East End	convex
	Little Cayman	LC West End	convex
		LC East End	convex
	Cayman Brac	CB East End	convex

Bathymetric data for two spawning aggregation sites in Belize and five sites in the Cayman Islands were recorded using a Lowrance LCX-17M echo-sounder with a 200/50 kHz transducer. All measurements were tracked using GPS with Wide Area Augmentation System (WAAS) capability, and these point data interpolated to produce a smooth surface of the bottom (Heyman *et al.* 2007). Then, 10 m-incremented depth contours were created.

The Institute for Marine Remote Sensing (IMaRS) at the University of South Florida provides an inventory of coral reefs for the Millennium Reef Mapping project. The Institute used a consistent dataset of multispectral Landsat 7/ETM+ images acquired between 1999 and 2002 (Gasch 2000). Distinct coral reef areas were then digitized and classified. The dataset of the IMaRS products for this study is the geomorphology map of the Mesoamerican barrier reefs that cover all spawning aggregation sites in Belize. The output classification data was given in an ESRI ArcGIS® shapefile format. For the analysis of non-bathymetric data available sites in Belize, the outer boundaries were used to determine the shelf edges of approximately 20 - 40 m depth, depending on water clarity throughout the remotely-sensed imagery. A satellite-based shelf-edge line does not lie on exactly the same depth contour lines at the Gladden spit in Belize, but show the real shelf edges well. Thus, the outer boundaries of the Millennium Reef Mapping project were assumed to show shelf edges in other areas.

In order to compare the reef shape among spawning aggregation sites, 2 km buffer circles of each spawning aggregation site were created. Within the circle, the reef shapes facing seaward were evaluated, and then distances from the spawning aggregation sites to the inflection points of reefs (tip of reef promontory) were measured. The distances between the spawning aggregation sites and the closest shelf edges were also measured.

RESULTS

Cayman Islands

All spawning aggregation sites in the Cayman Islands were located within 50 m from the shelf edges (30 or 40 m depth contour lines) and deep water (> 200 m) (Figure 1). The spawning aggregation site at the west end of Little Cayman was located on the 30 m depth shelf edge line as Whaylen *et al.* (2004) described. The distances from the spawning aggregation sites to the inflection point of the reefs vary for each island. The spawning aggregation site at the east end of Cayman Brac reef lies on the tip of reef promontory. On the other hand, the spawning aggregation sites in Grand Cayman reef were located at least 400 m from the bend of reef structure. However, within the 2 km buffer around all aggregation sites, all reefs extend seaward towards adjacent deep water in convex shape.

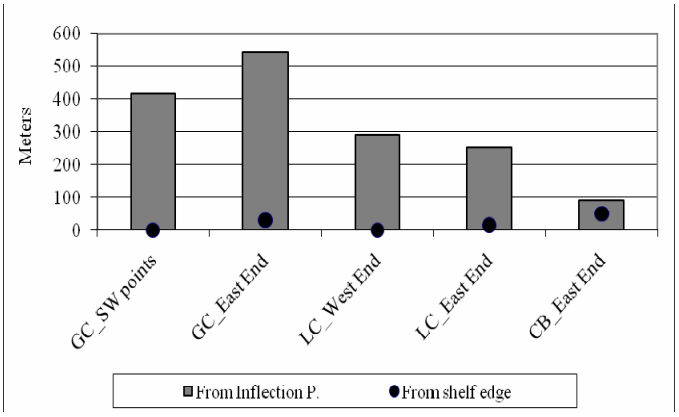

Figure 1. The distance (meters) from shelf edges (dot) or the inflection point of shelf edge line (bar) to the spawning aggregation site in the Cayman Islands.

Belize

Rocky Point at Ambergris Caye was located on the edge of ocean exposed fringing reef and on the inflection point of the reef. However, based on the remotely-sensed classification data, there are undetermined shelf marginal structures extending seaward from the fringing reef that complicate this analysis, offsetting the spawning aggregation site by 360 m. Without considering Rocky Point, all spawning aggregation sites were located within 120 m of the satellite-based shelf edge lines (Figure 2). The average distance to the shelf edge line is 82 m (n = 9).

The distances to the inflection points were relatively shorter than those of the Cayman Islands. Excluding Rocky Point, the average distance from the Nassau grouper spawning site to the inflection point of the reef is 195 m. Within the 2 km buffer circle around all of the spawning aggregation sites in Belize (except Rise and Fall Bank) were convex. The spawning aggregation site at Rise and Fall Bank lies on the edge of a small drowned reef with multiple inflection points (Figure 3c). The Dog Flea Caye site is a less distinctive convex inflection than others, exhibiting a small mound shape horizontally (Figure 3d). The reef surrounding all of the other spawning aggregation sites jut into deep water.

The average distance to the shelf edges in the Cayman Islands was less than that of Belize, but the average distance to the inflection point was greater.

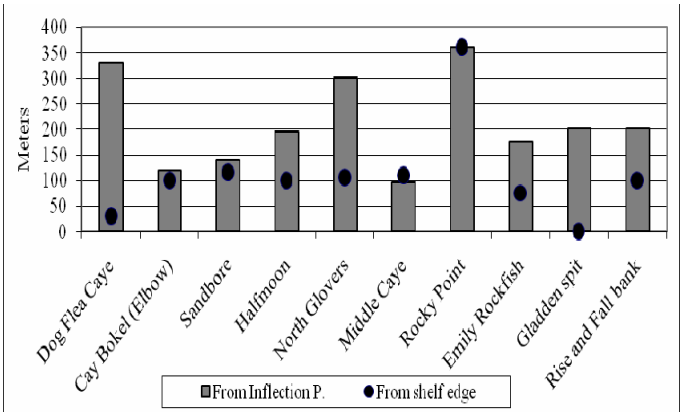

Figure 2. The distance (meters) from shelf edges (dot) or the inflection point of shelf edge line (bar) to the spawning aggregation site in Belize.

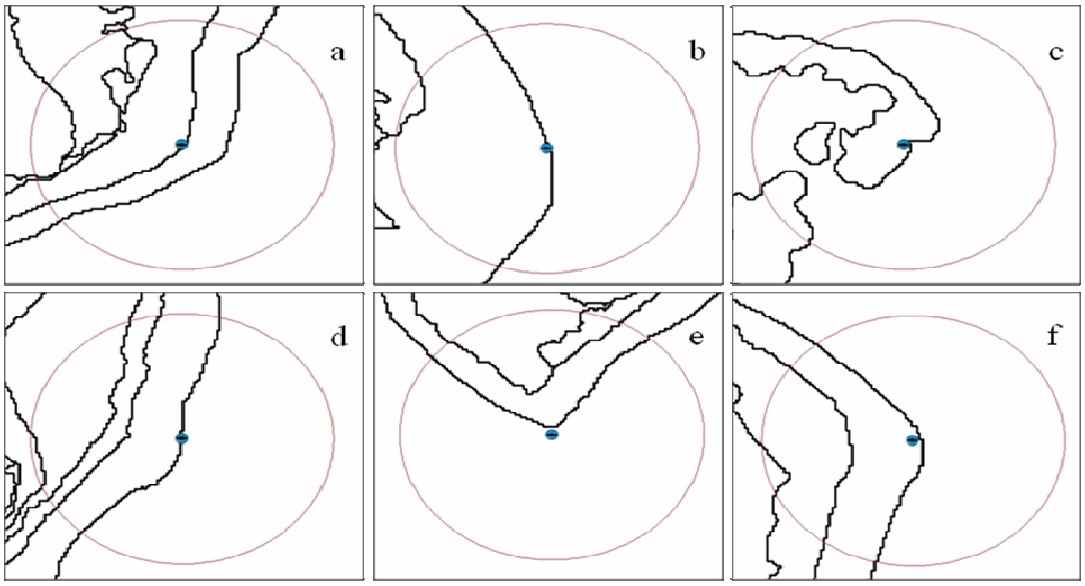

Figure 3. The historically known spawning aggregation sites in Belize with 2 km-buffer circles at the scale of 1:35,000. (a) Rocky Point, (b) Gladden spit, (c) Rise and Fall Bank, (d) Dog Flea Caye, (e) Cay Bokel and (f) Emily.

DISCUSSION

For the Cayman Islands and Belize, shelf edges are important reef structure for Nassau grouper spawning aggregation sites. All spawning aggregation sites were located within 120 m of shelf edges. One exception is the Rocky Point site in Belize, that appears (from remotely-sensed data) to have an extended shelf area seaward of the aggregation site (Figure 3a). Field-collected bathymetric data will help to resolve the geomorphology and structures more clearly. Aguilar-Perera (1996) described a Nassau grouper spawning aggregation site in Mexico were the inside of reefs that attached mainland. It is the only difference observed from the current data. Otherwise, all the other (13 of 14) spawning aggregation sites lie within 120 m of shelf edges.

With one exception, all 14 Nassau grouper spawning aggregation sites in Belize and the Cayman Islands were located near inflection points of convex-shaped seaward extending reefs. Though the Rise and Fall Bank does not show a clear convex set like other areas, the aggregation site is located on the edges of the banks. Dog Flea Caye in Belize exhibits a small horizontal mound shape protruding from the otherwise convex bending reef (Figure 3d). It appears that Nassau grouper spawning aggregations in Belize and the Cayman Islands occur preferentially near seaward-protruding reef convex reefs.

Though not all spawning aggregations occurred at the exact bending point of the reefs, they were located within 360 m of reef promontories in Belize and within 550 m in the Cayman Islands. While Gladden Spit is commonly considered an aggregation site at a reef promontory, the site is 200 m from the inflection point. These distances are exaggerated in part by the fact that spawning aggregation sites are recorded as points (centroids), rather than by the larger polygons in which they actually occur. Considering that Nassau grouper commonly migrate hundreds of kilometers for aggregation spawning, the distance between the spawning aggregation sites and the shelf edges, and reef promontories seems trivial. The Nassau grouper spawning aggregation sites evaluated here occur at reef promontories and are all included within marine protected areas in Belize and the Cayman Islands. We offer quantitative biological/geomorphological patterns that may be worthy of evaluation in other locations that are designing networks of marine reserves.

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