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ABSTRACT

Belize is blessed with several reef fish spawning aggregation sites. Many of these sites have been fished, particularly for Nassau grouper, *Epinephelus striatus* since the early 1900s. According to several studies and anecdotal information from fishermen, many of the aggregations showed signs of heavy depletion. It is the goal of the Fisheries Department to promote and manage national fisheries. In response to broad concern about declines in Nassau grouper, a national spawning aggregations working committee (NSPWC) was formed to address the issue. The group includes the Fisheries Department but also includes national and international NGOs. The group has adopted a standardized monitoring protocol and signed a data sharing agreement, in order to monitor the status of spawning aggregations in Belize. After initial assessments conducted in 2000 and 2001, further analysis and broad consultation, involving a broad group of stakeholders, the Government of Belize closed 11 spawning aggregation sites within Marine Reserves in 2003 and simultaneously enacted legislation that offered further protection for Nassau grouper by creating a closed season from December through March. Monitoring has continued at several sites, every January from 2000 to 2005. Additional sites have received more comprehensive monitoring. Analysis of the status and trends for Nassau groupers in Belize, and some other species indicates that populations are exceedingly low, but that protection efforts in some areas may be helping. The analysis further indicates that there are natural intra-annual and inter-annual variations in abundance so monitoring efforts need to be long-term in order to conclusively evaluate trends. We suggest that the precautionary principle be invoked for the management of spawning aggregations in Belize and elsewhere as these fragile systems are crucially important for the maintenance of fish stocks throughout tropical regions.

KEY WORDS: Belize, spawning aggregations, Nassau grouper, marine reserve

Estatus de Agregaciones de Desove para Peces Arrecífales en Belice

Belice es privilegiado por tener muchos lugares específicos, donde los peces de arrecife desovan. En varios de estos lugares se ha pescado mero, *Epinephelus striatus* desde el principio del año 1900. De acuerdo a muchos estudios y anécdotas de pescadores, muchas de estas poblaciones están declinando rápidamente. La meta del Departamento de Pesca es promover y manejar la pesca nacional. En respuesta a una gran preocupación por la reducción del mero, se ha formado un comité nacional "National spawning aggregations working committee" (NSPWC) para buscar soluciones al este problema. El grupo incluye el Departamento de Pesca y también incluye ONGs nacionales e internacionales. El grupo ha adoptado un protocolo "standard" para monitorear las condiciones de desove en Belice y también firmaron un acuerdo para compartir datos. Después de una evaluación inicial que fue realizada in el año 2000 y 2001 y de algunos análisis y consultas con un amplio grupo de interesados, el gobierno de Belice cerró 11 lugares de desove dentro de reservas marinas en el año 2003 y simultáneamente promulgaron un decreto que ofreció protección al mero. Este consistió en crear una veda desde diciembre hasta marzo. Los monitoreos han continuado en varios lugares cada enero desde el año 2000 hasta el 2005. Sitios adicionales han tenido un monitoreo mas exhaustivo. Análisis del estado del mero y otras especies en Belice indican que las poblaciones son extremadamente bajas pero los esfuerzos de protección parecen que ha ayudado en algunas áreas. Los análisis también indican que hay variaciones intra- e inter-anuales en abundancia, así que los monitoreos deben ser a largo plazo para poder evaluar los cambios. Nosotros sugerimos que un principio de precaución sea presentado para el manejo de lugares de desove en Belice y en otros lugares ya que estos sistemas frágiles son crucialmente importantes para el mantenimiento de la reserva de pesca en todas las regiones tropicales.

PALABRAS CLAVES: Belice, agregaciones de desove, mero (*Epinephelus striatus*), reservas marinas

INTRODUCTION

For nearly 100 years, Christmas time in Belize was associated in part with the annual harvest of Nassau grouper, *Epinephelus striatus*. Every picket fence in San Pedro was leased before the end of November, in anticipation of drying salted grouper (G. Paz Personal communication). The grouper fishery at Caye Glory (locally called "Emily") drew hundreds of fishermen from around Belize during the 1960s. They cumulatively removed some two tons per day during the approximately ten days surrounding full moon in either December and/or January (Craig 1969). Eggs (roe) have always been highly prized locally and

internationally, demanding a higher price per pound than the filet. Nassau grouper, and the massive aggregations that they form, have become iconic in Belize and are important part of the history and culture of this coastal country.

Recent data suggest, however that the populations of these fish have declined throughout their natural range, in part by intensive fishing on aggregations (Sadovy 1994) Endangered Species (IUCN 2000). This paper attempts to analyze historical trends in landings and abundance of Nassau grouper and provide a status report of the spawning aggregations for this and other large reef-dwelling species in Belize. We include both recent fisheries-independent field-collected data and historical catch records, in an attempt to provide a historical context for present observations.

MATERIALS AND METHODS

Fisheries Dependent Historical Data Analysis

The Department of Fisheries in Belize maintains records of the commercial landings and exports of marine products. As the permitting office for commercial fishing licenses and vessels the Department also maintains data on the number and types of licenses issued each year. Some of these data have been analyzed and presented, as relevant to the status of spawning aggregations. There have been only a few published studies that illustrate landings in Belize, starting with Thompson (1944) who described the existence of several spawning aggregations in various locations in Belize. Craig (1969) detailed the exploitation of Nassau groupers at Caye Glory, and Carter *et al*. (1994) detailed the location of several grouper spawning aggregations as did Paz and Grimshaw (2001). Heyman and Requena (2002) detailed the timing and location of multi-species spawning aggregations in Belize.

Fisheries Independent Field-collected Data

Starting in 2000, members of Belize Spawning Aggregations Working committee began monitoring spawning aggregation sites, using underwater visual surveys using a jointly developed monitoring protocol (Heyman *et al*. 2004). These data were used, along with the historical information described above, to evaluate the status of spawning aggregations in Belize.

RESULTS AND DISCUSSION

Nassau Grouper

Spawning aggregations of reef fish in Belize have been heavily depleted from historical levels. Nassau grouper, the most well-studied species has been depleted to the point that localized extinction is possible. In spite of intensive efforts to conserve the species in Belize, including new legislation offering both a nearly complete closure of fishing at the species' aggregation sites (G.o.B. 2003a) and a closed season (G.o.B. 2003b), stocks have reached dangerously low levels.

Following national landings statistics, historical exports of finfish from Belize exceeded 500,000 pounds per annum between 1976 - 1992, peaking at a million pounds in 1983 (Figure 1). A rapid drop in exports started in the mid-1990s and has not rebuilt. Nassau grouper roe was sold largely in-country but was still being exported during the mid-1990s, reaching a peak of 1,000 pounds in 1996 (Figure 2). This practice was halted by 1999, but the damage had already been done.

Spawning runs for Nassau grouper were already well known by local fishermen in the 1940's (Thompson 1944) though access to markets restricted sales. By the mid 1960's, the grouper run at Caye Glory was well known throughout the region. Two tons of fish were harvested and salted, each day of the spawning moon for export to Honduras and for consumption throughout Belize. Many local fishermen remember the gold rush days of the grouper harvest and have provided historical accounts. Alfonso J. Nunez (Fox) described times when fish were so plentiful that during the heaviest part of the runs, salt and time were precious. Some fishers estimated their storage capacity poorly and many large groupers were discarded after the higher-value, easily-transportable roe was removed. We estimate a minimum of 100,000 individuals were aggregated for spawning at the site in 1965 (based on estimates provided by Craig (1969)). Abundance at the aggregation was rapidly diminished by heavy fishing pressure such that only about 15,000 fish were present by 1986 (Carter et al. 1994) and only 21 fish in 2001 (Paz and Grimshaw 2001) (Figure 3). Counts have fluctuated annually but no recent count has exceeded 5,000 individuals with most counts between 2,000 and 3,000 individuals (Figure 4). Though sufficiently large to be visually dramatic for observers, these numbers are just a small fraction of the historical abundances.

Recent fisheries-independent counts have revealed that Nassau grouper are still aggregating to spawn at several of the historical sites and may be showing some signs of recovery. Spawning has been observed at northeast Glover's Reef Atoll and at Sandbore in Lighthouse Reef Atoll (Sala et al. 2001; Heyman and Requena 2002, Belize Fisheries Department 2005. Despite near zero counts in 2002, between 1,000 and 3,000 individuals have been subsequently counted at Caye Glory with 2,500 on a single count in 2004 (Belize Fisheries Department, 2005). Recovery was also documented at Gladden Spit where counts have been repeated annually between 1998 and 2006 (Figure 5). Though numbers are still low, trends indicate increases in Nassau grouper counts at the spawning sites that were declared as marine protected areas, closed to fishing, and where the Fisheries Department and its partners have provided continuous surveillance and enforcement of the Fisheries Regulations. The fishing mortality from outside of the closed season and areas is

still significantly affecting abundance and the ability of the species to recover (Sala *et al.* 2001). The increases in abundance at two spawning sites is considered insufficient to ensure full recovery of the species, without further restrictions on the harvest of the endangered Nassau grouper. We thus recommend a full ban on the possession of this species.

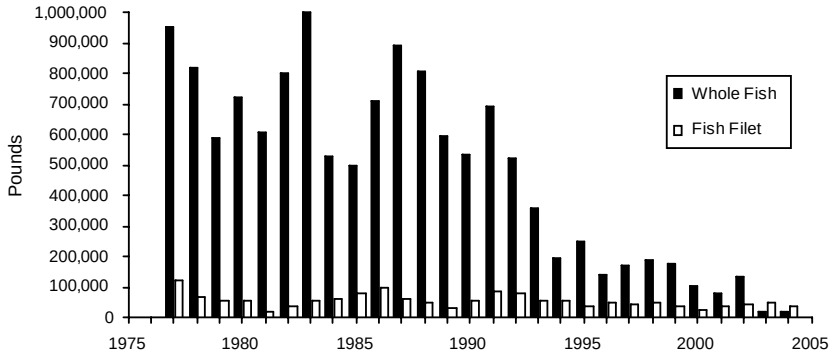

Figure 1. Export of finfish from Belize from 1975 to 2005. The majority of that reported is grouper and snapper. Data are from the exports of National and Northern Cooperatives and summarized by the Belize Fisheries Department.

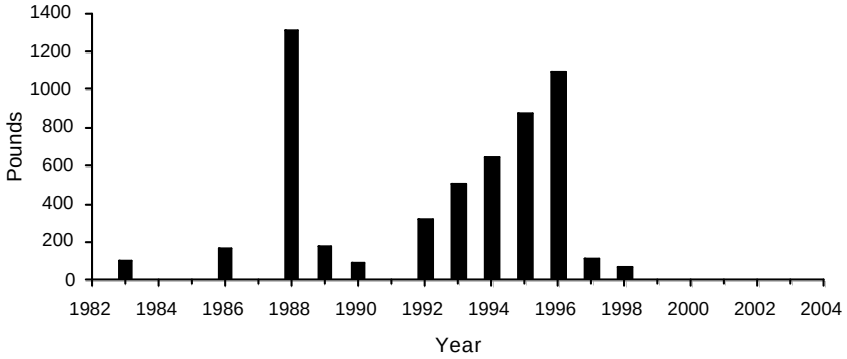

Figure 2. The export of Nassau grouper roe, 1983 - 2003. Data are compiled from the exports of National and Northern Cooperatives, summarized by the Belize Fisheries Department. No roe were exported after 1998.

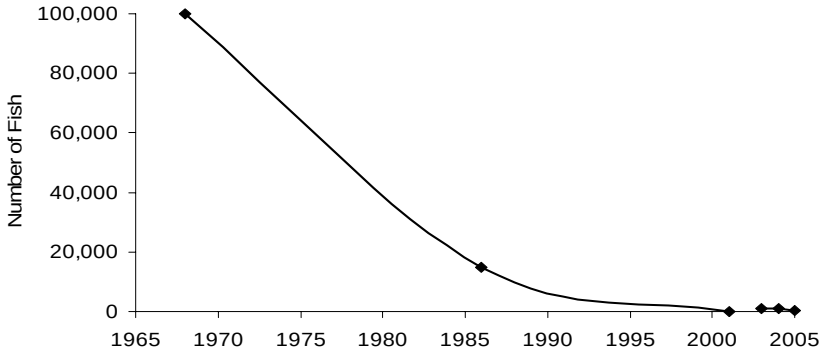

Figure 3. Historical decline of Nassau grouper at the Caye Glory spawning aggregation site. Data for 1965 are estimated from Craig (1969); data from 1986 estimated by Carter et al. (1994); remaining data are from the underwater visual surveys kindly provided by the Belize Spawning Aggregations Working Committee.

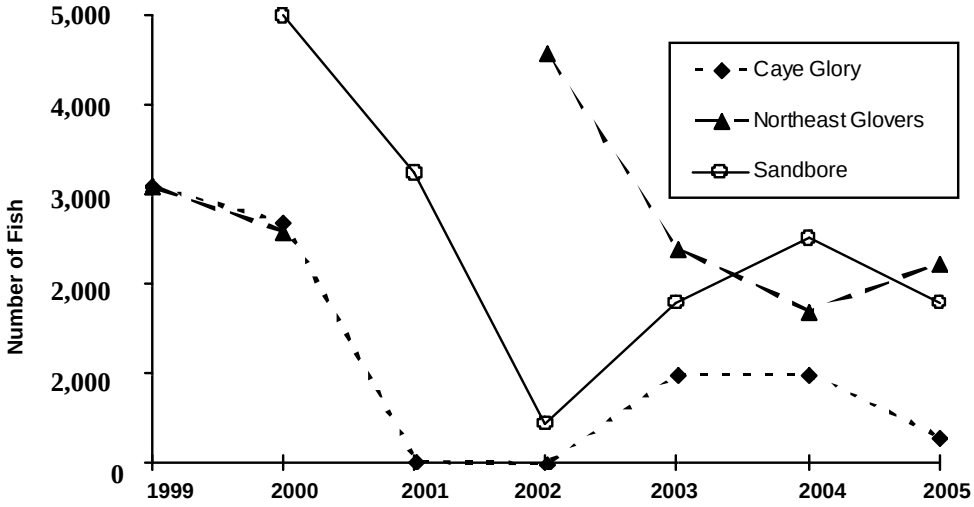

Figure 4. Nassau grouper abundance from 1999 - 2005 at the three healthiest spawning aggregation sites in Belize from underwater visual surveys. Data kindly provided from the National Spawning Aggregations Working Committee.

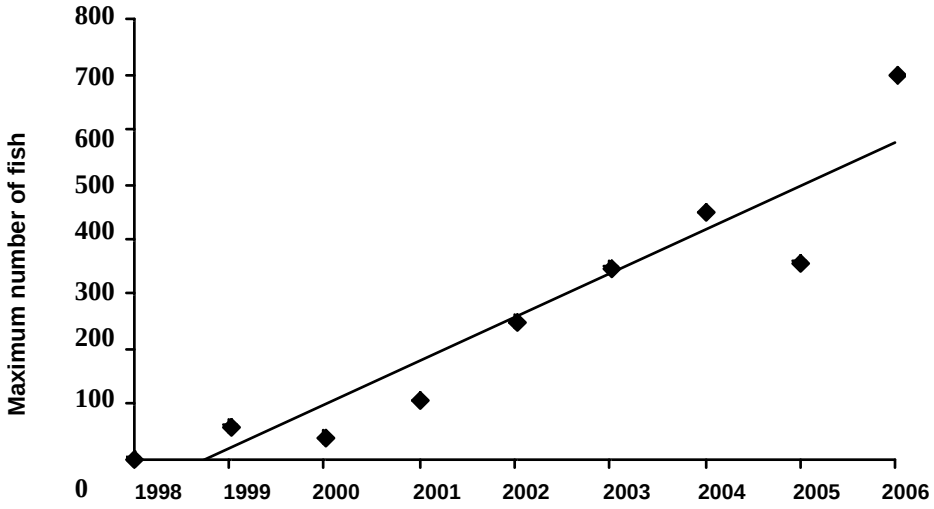

Figure 5. Nassau grouper abundance at Gladden Spit, 1998 – 2006. Nassau grouper abundance has risen steadily (R^2 = 0.88). Data provided by Friends of Nature.

Multi-species Spawning Aggregations

In addition to the Nassau grouper, as documented above, many of the known spawning aggregation sites harbor multi-species spawning aggregations (Thompson 1944, Sala *et al*. 2001, Auil-Marshallek 1993, Paz and Grimshaw 2001, Heyman and Requena 2002, Heyman 2004, Belize Fisheries Department 2005). Though the existence of these sites has been well known by fishermen for many years, detailed quantitative monitoring of the diversity and abundance of various species at these sites has only recently begun and there status has not been well documented.

Gladden spit is probably the best documented multi-species aggregations harboring over 20 different transient spawning aggregation species including groupers, snappers, jacks and others (Heyman and Requena 2002, Heyman *et al*. 2001, 2005). Though the site has been almost entirely closed to fishing, the monitored mutton snapper fishery continues at the site. Reports from the fishery-dependent monitoring efforts are not easily

analyzed due to inconsistencies in monitoring timing and efforts. A close look at those data is warranted. The most closely monitored species, Cubera snapper, has increased in abundance between 1998 and 2006 (Figure 6). This increase was particularly evident after the night fishing closure began to be enforced in 2002.

Lessons Learned for Monitoring and Management

There have been inter- and intra-annual differences in maximum abundance of Cubera snapper at Gladden Spit (Heyman *et al*. 2005; Figure 6). These differences may be an artifact of the counting techniques as well as natural variations in the size and timing of the aggregations. Since the school of Cubera is found in waters of 30-80m, the entire school of fish is not always observed and counts may be underestimated. More likely, there are biological reasons for the observed variations in counts. The monthly buildup of fish within an aggregation can vary in relation to the lunar calendar (Heyman *et al*. 2005). The actual location of the aggregation may also vary during the day both vertically and horizontally such that depending on water clarity and the number of dives conducted, the aggregation might not be encountered at all. Monitoring efforts need to be wary of these issues and thus be sure that the peak abundance each day, month and year of monitoring is captured in the sampling effort. Real trends in abundance at the aggregations can only be evaluated after long periods of monitoring where the effects of natural variations and possible counting errors are reduced through statistical analysis.

The effectiveness of management actions are difficult to assess in the short term. This is particularly true for the management of transient spawning aggregations and the species that utilize this strategy. These mobile species may require additional site, seasonal, gear restrictions, and species-specific, and regionally agreed upon restrictions in order to maintain populations. In some cases, such as for Nassau grouper, the populations have reached dangerously low levels and legislation has not been sufficient to avoid continued decline. At some sites, like Gladden Spit, were protection and management have been intensive, populations of Nassau grouper and Cubera snapper have rebounded, indicating that management interventions can have a positive effect.

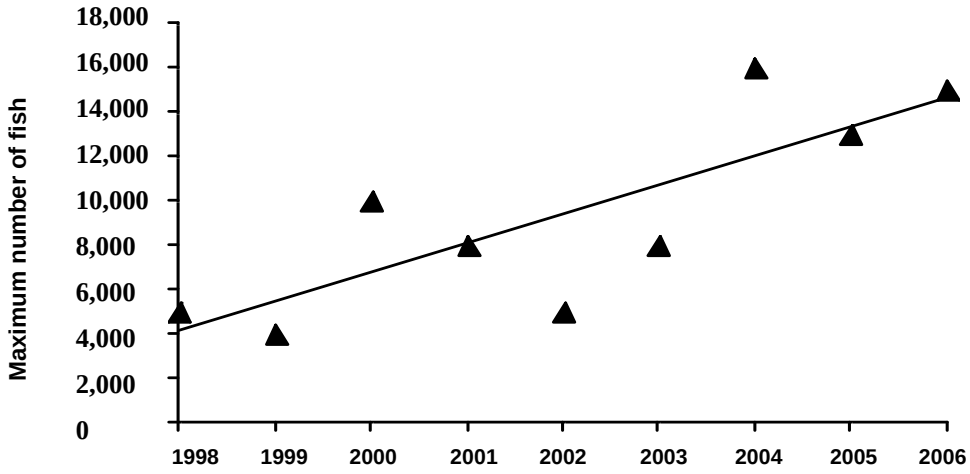

Figure 6. Cubera snapper abundance at Gladden Spit based on maximum number observed using underwater visual surveys. There has been an increase ($R^2 = 0.65$) in Cubera snapper from 1998 – 2006, particularly since 2002 when enforcement within the Gladden Spit Silk Cayes Marine Reserve became regular. Data are provided by Friends of Nature.

Recommendations for Management and Research

The long-term data sets for Nassau grouper in Belize clearly indicate a massive decline from historical levers. Small increases in abundance noted at some sites should be evaluated in historical terms. There remains only a fragmented relict population of Nassau grouper in Belize. We recommend a full ban on the possession of Nassau grouper. Invoking the precautionary principle, we further recommend continued and indefinite closure of the multi-species spawning aggregation sites in Belize.

In order to evaluate the effectiveness of the closures over time, we recommend continued and increased monitoring efforts for multi-species aggregations. Since transient multi-species spawning aggregations have been found at several reef promontories in Belize, we suggest that the deep areas around reef promontories be evaluated for the possible presence of additional spawning species and that the migratory routes to and from these spawning areas be more fully documented. Finally, we recommend that research be conducted to evaluate the effects of ecotourism

on spawning aggregations. Dive tourism may serve as an economic alternative to fishing aggregations. This strategy can only be viable, however, if it can be shown that the reproductive activity of spawning fish is not negatively affected.

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