Brief History of Management and Conservation of Nassau grouper and their Spawning Aggregations in Belize: A Collaborative Approach

Breve Historia de la Gestión y Conservación de la Cherna Criolla y sus Agregaciones de Desove en Belice : Un Enfoque de Colaboración

Brève Histoire de la Gestion et de la Conservation de Mérou Rayé et leurs agrégations de frai au Belize : Une Approche Collaborative

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ABSTRACT

The Belize Spawning Aggregation Working Group has been in existence since 2001. For the past fourteen years, this group of conservation NGOs, fisher organizations, academic institutions and the Belize Fisheries Department have collaborated and made significant progress in the protection and management of Belize's reef fish spawning aggregation sites. This includes advocating for protecting the endangered Nassau grouper (*Epinephelus striatus*) through a network of thirteen fully protected spawning sites, a four month closed season (Dec. 1st – March 31st) and implementation of minimum, 20 inches (50.8 cm), and maximum, 30 inches (76.2 cm), harvestable size limits. Of the thirteen fully protected spawning aggregations sites for Nassau grouper eight have had some level of direct population monitoring for Nassau Grouper conducted over the last 15 years. The size of spawning populations at these sites have varied with the maintenance and/or re-emergence of spawning aggregations along Belize's barrier reef (e.g. Caye Glory) lending evidence to the movement of Nassau grouper from great distances. In contrast, the existence of barriers to movement (i.e. deep water) and strong spawning site fidelity potentially make offshore (i.e. atolls) sites more vulnerable to the effects of overfishing than those on the main barrier reef. Northeast Point, Glover's Reef Atoll, is one of the last viable spawning aggregation sites for Nassau Grouper in Belize. This site has seen considerable variation in the spawning population, with highs of more than 3000 in 2001, 2005, and 2010, but a general decline over time to a low of 450 individuals in 2015. This decline coincides with evidence of illegal fishing at the spawning aggregation site even with the existence of special patrols starting in 2008. In spite of such setbacks, the efforts and successes of the Belize Spawning Aggregation Working Group highlight the need for and impact of a national coalition in promoting sustainable resource use and conservation.

KEY WORDS: Nassau grouper, spawning aggregation, marine protected areas

INTRODUCTION

The formation of spawning aggregations (SPAGs), dense gatherings of mostly mature con-specifics often at predictable times and locations, are critical behaviours in a wide variety of fish species and amongst the most spectacular strategies that fish have evolved to maximize reproductive success (Domeier and Colin 1997). Such gatherings are thought to enhance capacity of individuals to select mates, synchronise spawning and optimise survival of offspring (Thresher 1984, Colin and Clavijo 1988). Overexploitation of spawning aggregations decreases spawner abundance, alters population sex ratios, decreases mean size and associated fecundity, and may ultimately result in the disappearance of an aggregation (Russ 1991, Colin 1992, 1996, Coleman et al. 2000). However, despite the evolutionary success of spawning aggregation behaviour across a broad group of fish families, the ecological importance of spawning aggregations for species survival, and the consequences of their demise, including broader losses of income (Olsen and LaPlace 1979) and ecosystem services, it is only recently that they have been given appropriate levels of management and conservation concern (Sadovy and Domeier 2005, Sadovy De Mitcheson et al. 2008, de Mitcheson et al. 2013).

The Nassau grouper (*Epinelphelus striatus*, Bloch 1792), known to form conspicuous spawning aggregations, is often noted as one of the most widespread and abundant serranid species in the Caribbean region and is equally cited as one of the most commercially important food fish within the tropical Western Atlantic (Randall 1968, Munro 1983). Nassau Grouper have been fished commercially and recreationally, most intensively over localized spawning aggregations, by handline, longline, fish traps, spear guns and gillnets (Olsen and LaPlace 1979, Carter et al. 1994). However, declines in landings and abundance have been reported throughout its' range with some areas now being considered commercially extinct (Sadovy 1994, Sadovy and Eklund 1999). Unfortunately, *E. striatus* is now recognised as the classic example of a decline in a species due to overfishing impacts on associated spawning aggregations (Sadovy De Mitcheson et al. 2008). The Nassau grouper is currently assessed as endangered by the International Union for the Conservation of Nature (IUCN) Red List based on an estimated population decline of approximately 60% over the last three generations (27 - 30 years) (Cornish and Eklund 2003).

METHODS

Published and unpublished data were reviewed for the historical and current status of Nassau grouper spawning aggregations in Belize. The Belize Spawning Aggregation Working Group maintains a national database that was developed by The Nature Conservancy in 2005 and was housed at the Coastal Zone Management Authority and Institute from 2006 to 2007 and the Belize Fisheries Department from 2007 to 2009. In 2010 the database migrated to the Environmental Research Institute, University of Belize for further development where it is still being housed and managed.

Eight sites (Rocky Point, Caye Glory/Emily, Maugre Caye, Dog Flea, Gladden Spit, Nicholas Caye, Sandbore and Northeast Point) that were consistently monitored from 2001 - 2015 were short listed and evaluated for this paper. Five of

the eight sites were monitored in 2000 – 2001 using a jointly developed monitoring protocol (Paz and Grimshaw 2001). Northeast Point, Glover's Reef Atoll, was monitored in December 1999 – January 2000 during which tagging and telemetry studies were also begun (Sala et al. 2001, Starr et al. 2007). Glover's Reef Atoll is located 45 km east of Dangriga Town and is the southernmost of Belize's three atolls (Figure 1a). The atoll measures 32 km long and 12 km wide with an area of 384 km^2 (Figure 1b). Northeast Point is located on the north east elbow of the atoll approximately 1 km east off the reef. The SPAG site depth ranges from 24 – 43 meters. In 2003 and 2004 the Wildlife Conservation Society monitored the Northeast Point. WCS then partnered with the Belize Fisheries Department in 2005 to monitor Northeast Point employing methods from 'Reef Fish Spawning Aggregation Monitoring Protocol for the Mesoamerican Reef and the Wider Caribbean' (Heyman et al. 2004) from 2005 – 2011. Since 2012 the BSAWG has been using the 'Revised Sections of the Spawning Aggregation Monitoring Protocol' as a supplement to the 2004 protocol. Underwater visual surveys at Northeast Point have been conducted three days after the full moon for five days during the months of January and February.

RESULTS AND DISCUSSION

In Belize, the consistent and significant exploitation of spawning aggregations, most notably for Nassau grouper (*E. striatus*), can be traced back to a multi-species site at Caye Glory (a.k.a. Emily) (Figure 2a,b, 1a), along the main barrier reef south of Belize City (Craig 1966, 1969). The availability of "sturdy sailing craft", with origins in Cuba, in the mid-1920s allowed small crews, 4 – 6 men, to transport substantial amounts of equipment (materials for shelter, holding pens, drying racks) and supplies (curing salt, water) to the remote site for extended stays around the full moon in December and January each year (Craig 1966, 1969) (Figure 2a,b). Catches of Nassau grouper remained high throughout the 1950s and 60s, being the most caught fish in British Honduras (Name of Belize Pre-Independence, 1981) with more than 300 boats converging on Caye Glory during the 1964 - 1965 season (Craig 1966, 1969). Jacques Cousteau filmed "many, many thousands" of Nassau grouper at Caye Glory in the early 1970s (Craig 1969, Paz and Truly 2007). The introduction of the spear gun in the late 1960s likely impacted local Nassau grouper populations as it did many large reef fish populations around the world (Sluka and Sullivan 1998). Early declines in Nassau grouper may be inferred as it became the second most caught fish in Belize between 1972 and 1984 across an increasing number of spawning aggregation sites throughout Belize (Carter et al. 1994, Sala et al. 2001). The recognition of local declines in Nassau grouper spurred early efforts in management including a ban on fish traps inside the areas of spawning aggregations (1982 – Belize Statutory Instrument #17), a draft national management

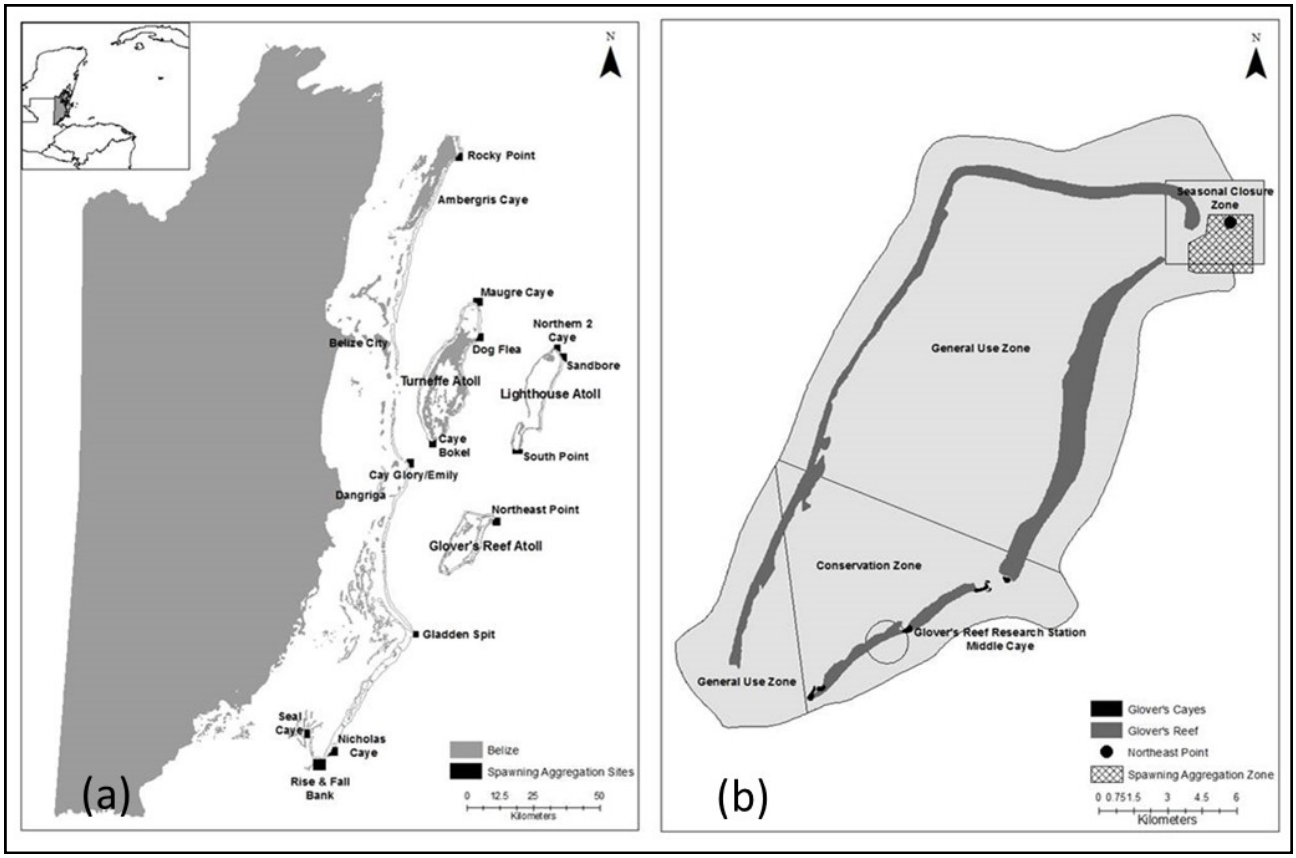

Figure 2. (a) Fully protected spawning aggregation sites across Belize, (b) Glover's Reef and the fully protected spawning aggregation site and associated seasonal closure area (SCZ) at NE Point.

plan specifically for Nassau Grouper (Carter and Marrow 1991) and the establishment of several marine reserves including Glover's Reef Atoll and an associated closed season (Dec. 1st – Mar 1st) for Nassau grouper at that site. Unfortunately these early efforts of management were either not implemented or enforced.

By the late twentieth century acute declines in Nassau grouper landings motivated extensive surveys across Belize revealing that only two of nine traditional spawning sites (Figure 1a) had aggregations of Nassau groupers numbering in the thousands (NE Point, Glover's Reef and Sandbore Caye, Lighthouse Reef) with the remaining sites having very low numbers or no fish at all (Paz and Grimshaw 2001). The additional realization that fisheries impacts on Nassau grouper spawning aggregations were likely affecting other co-occurring species of groupers and other reef fish resulted in a national workshop being held in Belize City to present survey results, discuss management options, and call for the urgent protection of Nassau grouper spawning aggregation sites, however, no follow up action was taken other than establishing a Working Group (Anonymous 2001, Gibson et al. 2007). This period also marked the implementation of the first scientific studies of the Nassau grouper spawning aggregation at Glover's reef (Figure 1) including detailed population assessments, estimates of catch, modelling of future declines and telemetry studies (Sala et al. 2001, Starr et al. 2007). By 2002 the Spawning Aggregation Working Group, which had been revitalized through the efforts of the Wildlife Conservation Society (WCS), had introduced protective legislation for Nassau grouper: the year-round protection of eleven spawning aggregation sites (Figure 1a) and a four month (Dec. 1st – March 31st), nation-wide closed season. As of 2003 the Working Group added several objectives to govern its activities including:

i) Monitor and patrol aggregation sites with stakeholders,
ii) Analyse data and provide a database,
iii) Provide recommendations for the conservation, protection and sustainable use of the sites, and
iv) Prioritize future research and management objectives (Gibson et al. 2007).

The Spawning Aggregation Working Group continued to support the regular monitoring of network sites by assisting in the development of a regional monitoring protocol (Heyman et al. 2004) as well as field training in the implementation of the protocol (2005, hosted by WCS, Glover's Reef Research Station) and the implementation of an online database system (2007, presently hosted by the Environmental Research Institute, University of Belize). In 2008, WCS partnering with the Belize Fisheries Department, began special armed patrols at NE Point, Glover's Reef to enforce the SPAG closure. Additional legislation for the protection of Nassau Grouper was implemented in 2009 through the use of minimum, 20

Figure 2. Nassau grouper fisheries and monitoring activities in Belize. (a) Belizean "Smack" boats used to transport supplies and conduct fishing at the Caye Glory spawning aggregation (Craig, 1969), (b) Nassau grouper pens and shelters (background) at Caye Glory (Paz & Truly 2007), (c) Nassau grouper spawning aggregation at NE Point, Glover's Atoll (A.Tewfik/WCS, Feb., 2015), (d) Hooked (illegal fishing) Nassau grouper with monitoring diver at NE Point, Glover's Atoll spawning aggregation (A.Tewfik/WCS, Jan., 2015)

inches (50.8 cm), and maximum, 30 inches (76.2 cm), harvestable size, a requirement to land Nassau grouper whole and that all other fish fillets were to be landed with a skin patch (2"x1" inches) for species identification. These regulations coincided with a nation-wide ban on herbivorous fish species (acanthurids, scarids). In 2012, two additional spawning sites, Maugre Caye and Northern 2 Cayes, were added to constitute the 13 fully protected sites for Nassau grouper that exist today (Figure 1a).

Of the thirteen fully protected spawning aggregations sites in Belize (Figure 1a) eight have had some level of direct population monitoring for Nassau Grouper conducted over the last 15 years (Figure 3). These include the previously described site at Caye Glory (a.k.a Emily) as well as Rocky Point (Ambergris Caye) on the Northern Barrier Reef. The Caye Glory SPAG has gone through significant variation with a recent high of several thousand Nassau Grouper while Rocky Point appears to be extinct. The Southern Barrier Reef sites of Gladden Spit and Nicholas Caye have had consistent monitoring but consistently low numbers reported since 2001 with both having less than 100 individuals in 2015. The two sites at Turneffe Atoll, Maugre and Dog Flea Cayes, have been monitored rather infrequently but indicate a possible extinction at Dog Flea as late as 2013 but slight increases at Maugre between 2013 and 2015. Sites at Sandbore, Lighthouse Atoll and Northeast Point, Glover's Atoll have been continuously monitored since 2001 (Figure 3). The Sandbore aggregation appears to be recovering to levels first noted in 2001, approximately 4000 individuals, while Northeast Point indicates considerable variation, highs of more than 3000 in 2001, 2005, 2010, but a general decline over the time series to a low of 450 individuals in 2015 (Figure 2b, 3). This coincides with evidence of illegal fishing (anchors, hooked fish – Figure 2d) on the spawning aggregation site despite the existence of special patrols starting in 2008. However, it should be noted that the aggregation has avoided predictions of extinction as modelled in an early study based on a baseline of 15000 fish (1975):

> *"...although the aggregation will not be eliminated until 2013, the fishery will be abandoned in 2009, when the number of Nassau groupers at the spawning aggregation declines to less than 48."*
> (Sala et al. 2001).

Acoustic tag returns and associated telemetry studies confirm that Nassau grouper have strong fidelity to the spawning site at the Northeast Point, do not leave Glover's Atoll and are unlikely to swim over surrounding deep water (Starr et al. 2007). Large-scale movements of Nassau grouper, as great as 250 km, have only been reported from large barrier reef systems, including Belize, where fish can maintain close contact with continuous habitats or chains of

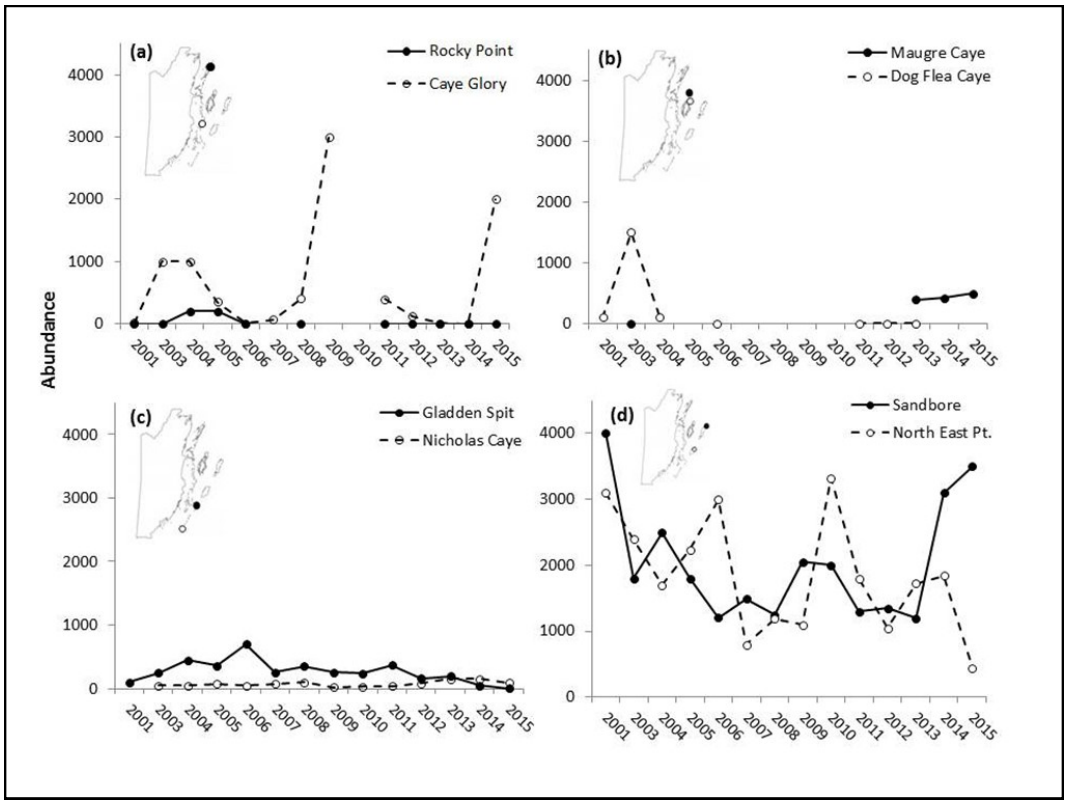

Figure 3. Monitoring data (2001 – 2015, excluding 2002) of eight fully protected Nassau grouper spawning aggregation sites across Belize divided into geographic sub-areas: (a) Northern barrier reef; (b) Turneffe Atoll (c) Southern barrier reef and (d) Outer Atolls (Lighthouse and Glover's). Data source: Belize Spawning Aggregation Database

islands connected by shallow water (Carter et al. 1994, Bolden 2000). The maintenance and/or re-emergence of spawning aggregations along Belize's main barrier reef (e.g. Caye Glory) lend evidence to the movement of Nassau grouper from great distances. Therefore, the existence of barriers to movement (i.e. deep water) and strong spawning site fidelity may make offshore (i.e. Atoll) sites more vulnerable to the effects of overfishing than those on the barrier reef. In addition, recent research in Belize indicates that current regimes at spawning sites concentrate eggs and keep larvae closer to nearby reefs, maintaining relatively similar recruitment patterns year after year (Karnauskas et al. 2011). Offshore sites may therefore take many years to replenish, if at all, after being exterminated, given the limited potential for external recruitment. It is therefore critical that the SPAG focused activities, especially at the remotest sites, and overall successes protecting Nassau grouper in Belize continue. Key accomplishments of the Belize Spawning Aggregation Working Group for the endangered Nassau grouper include 13 fully protected SPAGs, seasonal closures nation-wide, harvestable slot size, and increased public awareness. Perhaps more importantly, these efforts and successes highlight the need for and impact of a national coalition of resource users, managers, scientists, and conservation entities in promoting sustainable resource use and conservation especially where national financial resources may be limited.

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