Charting a Course for Nassau Grouper Recovery in the Caribbean: What We've Learned and What We Still Need to Know

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ABSTRACT

Nassau grouper (*Epinephelus striatus*) were historically one of the most important shallow water fisheries in the Caribbean, yet now are rarely taken. Although normally solitary, during the winter full moon Nassau grouper attend aggregations at spawning site to reproduce. Now, however, there are only a handful of known Nassau grouper aggregations with more than 1,000 fish left in the Caribbean. Why has the species declined so precipitously, and what can be done to reverse the trend? I will discuss recent and on-going research into the behavior and ecology of Nassau grouper, and highlight the conservation implications of this work. I will also discuss critical research needs in the ongoing effort to identify prudent conservation measures for this species.

KEY WORDS: Nassau grouper, aggregation, recovery, endangered, *Epinephelus striatus*

Planear un Curso para la Recuperación del Grouper de Nassau en el Caribe: Qué Hemos Aprendido y Lo Que Todavía Necesitamos Saber

El grouper de Nassau (*Epinephelus striatus*) era históricamente una de las industrias pesqueras bajas más importantes del agua del Caribe, con todo ahora se toma raramente. Aunque normalmente es solitario, durante el grouper de Nassau de la Luna Llena del invierno atienda a las agregaciones en la freza del sitio para reproducirse. Ahora, sin embargo, hay solamente un puñado de agregaciones sabidas del grouper de Nassau con más de 1.000 pescados a la izquierda en el Caribe. ¿Por qué la especie ha declinado tan empinado, y qué puede ser hecho para invertir la tendencia? Discutiré la investigación reciente y en curso en el comportamiento y la ecología del grouper de Nassau, y destaco las implicaciones de la conservación de este trabajo. También discutiré necesidades críticas de la investigación en el esfuerzo en curso de identificar las medidas prudentes de la conservación para esta especie.

PALABRAS CLAVES: Epinephelus striatus, agregación, recuperación

WHAT WE KNOW ABOUT NASSAU GROUPER

Nassau grouper are long lived; on average they mature at seven years of age, and have a lifespan of 16 years of age. Some individuals have lived to be over 30 years of age (Sadovy and Eklund 1999). Because the species grows slowly, is long lived, and has a long reproductive window to capitalize on sporadic recruitment, it can be classified as a periodic strategist (Winemiller and Rose 1992). This life-history strategy is favored in environments that have large-scale cyclic or spatial variation. Periodic strategists present a management challenge, as they tend to present 'boom and bust' recruitment, and are typically not dependent on recruitment equilibrium. Setting management goals based on catch rates may, therefore, prove ineffective at managing the species over the long-term.

Nassau grouper are particularly susceptible to overfishing, owing to the fact that they reproduce in mass spawning aggregations (Smith 1972, Sala *et al.* 2001). Recent evidence suggests that fish may migrate hundreds of kilometers to attend aggregations (Bolden 2000), and that most reproductive aged fishes go to spawning sites each year. In places where spawning sites are discovered, heavy harvest typically results in a rapid reduction or total collapse of spawning stocks (Sala *et al.* 2001).

There is little evidence that Nassau grouper stocks recover once they are fished-out. For instance, despite well over a decade of complete no-take protections on the species in Bermuda and in the Florida Keys, Florida, the species has made no appreciable recovery in either location. We propose the following hypotheses for the lack of resilience in Nassau grouper:

HABITAT CAPACITY HAS DECLINED DUE TO DEGRADATION

While Nassau grouper are typically thought of as strictly a reef associated species, they transition through a series of ontogenetic shifts, from planktonic larvae, to near-shore sea-grass and algae habitat, to predominantly reef habitat (eg. fore reef and reef crest). Even within reef habitat, there appears to be ontogenetic sorting, such that the larger individuals tend to occupy the deeper, more rugose reef areas. Each of these general habitats has undergone and continues to undergo change.

Open-ocean larval habitat is being influenced by the ongoing increase in ocean sea-surface temperatures. These

changes in temperature may influence habitat quality directly through physiological stress, or indirectly through impacts to prey and predator densities (Anderson 1988).

Seagrasses are in decline globally (Lotze et al. 2006); the decline of turtle grass in the Caribbean may reduce the amount of suitable habitat for newly settled Nassau grouper, and may influence the abundance of prey items for new recruits.

Coral reef biogenic structure is in decline, owing in large part to the dramatic decline in Acroporid corals. Furthermore, the ongoing decease in ocean acidity is likely to have a dramatic influence on the accretion rate of coral species in the future (Hoegh-Guldberg *et al.* 2007). It is possible that the ongoing and projected decline in biogeneic structure on Caribbean coral reefs will have a dramatic impact on the availability and quality of reef habitat for mature Nassau grouper.

DEPENSATION

Depensation, also known as the Allee effect (Allee 1931), occurs when a population is incapable of replacing itself when the abundance or density of individuals drops below a critical threshold. The different mechanisms hypothesized to cause depensation in Nassau grouper can be loosely classified as either ecological (e.g. high predation at low population levels) or behavioral (e.g. lack of behavioral cues leading to spawning).

Because of the size (Smith 1972) and apparent behavioral complexity (Whaylen et al. 2004) of Nassau grouper spawning aggregations, behavioral depensation appears to be the mostly widely accepted mechanism for the lack of population recovery (Bolden 2000, Sadovy 2001). For instance, it may be that the "ecological knowledge" of spawning site locations is lost to grouper populations when heavy harvest on aggregation sites removes the old individuals with such knowledge (Bolden 2000). Alternatively, it may be that the grouper are migrating to spawning site locations, but due to low densities, individuals are choosing to leave and explore alternative shelf edges and reef promontories in expectation of finding higher densities elsewhere. Thus, fish spend the spawning season in search of spawning sites, and never spawning. Finally, it may be that fish are able to find the spawning site, and stay at the spawning site during spawning season, but due to perceived poor mate choice and low densities, fish forgo spawning (Semmens *et al.* 2006).

RECRUITMENT LIMITATION

i) Recent research has demonstrated that recruitment is often local for short-lived, continuous spawners. However, local recruitment has not yet been convincingly demonstrated for long-lived reef fishes such as grouper and snapper (Mora and Sale 2002). In fact, given that periodic strategists are expected to have punctuated recruitment events, it seems likely that the reproductive strategy of Nassau grouper is aimed at high-risk, high-reward long distance larval-dispersal. If so, the variability of Nassau grouper recruitment (intermittent strong recruitment pulses; Grover *et al.* 1998) may be the mechanism causing the apparent failure of populations to recover. Indeed, local recovery may be nearly exclusively dependent on 'upstream' spawning populations. We note here that genetic work on Nassau grouper indicates not much differentiation in populations, suggesting recruitment may integrate across upstream spawning stocks.

FUTURE RESEARCH DIRECTIONS

In order to address these hypotheses, the following research thrusts much be pursued:

i) Habitat capacity – work to link Nassau grouper abundance/distributions with key habitat characteristics,
ii) Depensation – investigate spawning behaviors in places where spawning aggregations have been fished to exhaustion, and
iii) Recruitment variability – conduct genetic and otolith analyses to gain a better handle on relatedness of spawning stocks and the periodicity of recruitment pulses.

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