

# **Fish Spawning Aggregation Monitoring and Management in the Modern Era: Insights from the Cayman Islands**

## **Vigilancia y Gestión de la Agregación de los Peces en la Era Moderna: Perspectivas de las Cayman Islands**

## **Suivi et Gestion de L'agrégation de la Multiplication des Poissons à L'ère Moderne: Aperçu des Cayman Islands**

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### **PLENARY ADDRESS**

Nassau Grouper (*Epinephelus striatus*) have been a prized target of fishermen in the Cayman Islands for over 100 years. While for much of that time period, take of the species at fish spawning sites (FSAs) during the winter months was subsistence in nature, technological advances and commercialization in the latter part of the last century led to overexploitation. By the late 1980s, concern within the fishing community regarding diminishing catch led the Cayman Islands Department of Environment to begin active research into the status of the species in the region. Subsequent landings data illustrated a rapid decline in catch at aggregation sites, and by the 1990s the Department ceased collecting landings data due to a complete collapse in catch at all known spawning sites.

The Grouper Moon Project is a conservation science partnership between Reef Environmental Education Foundation (REEF) and the Cayman Islands Department of Environment (DoE) with scientists from Scripps Institution of Oceanography (UC San Diego) and Oregon State University. The collaboration began investigating the spatial ecology and life history of Nassau Grouper in the Cayman Islands in 2001, the same year a large (~7000 fish) fish spawning aggregation (FSA) of the species was re-discovered at the western tip of Little Cayman. The intent of the program is three-fold:

- i) To generate the science necessary for the Cayman Islands to establish effective and adaptive management of Nassau Grouper aimed at maintaining both its ecological role on Cayman reefs and a healthy fishery,
- ii) To generate novel scientific findings that support management of the species throughout the Caribbean basin, and
- iii) To communicate the findings of the project to the Cayman government, public, and the citizens of the wider Caribbean.

This latter goal is critical, as it encapsulates efforts to provide lessons learned and good-practices for other governments that seek to institute their own FSA conservation initiatives. The Grouper Moon Project targets monitoring and research at key points along the Nassau Grouper life cycle. Below we describe our research aspects in terms of the main natural history stages of the species. Subsequently, we briefly discuss our efforts to communicate our research and monitoring products to the public and policy makers.

### **Near-shore Habitat Use & Spawning Behavior in Reproductive Aged Individuals**

In the early part of the Grouper Moon Project (2001 - 2003), research focused on documenting the impact of fishing at the West-end Little Cayman spawning site (WELC) through diver-based observations at the spawning site. In addition to estimating the number of aggregating Nassau Grouper, divers also monitored spawning behaviors in other species at the site, and recorded detailed life-history information related to spawn timing and the associated color phases of spawning individuals. In 2003, the Cayman Islands Marine Conservation Board established no-take marine protected areas (specific to Nassau Grouper) at all known spawning sites around the Cayman Islands, including the WELC.

In 2005, we began an acoustic tagging program around Little Cayman in order to monitor the movements of spawners year-round. This work was expanded to include Cayman Brac in 2006, and Grand Cayman in 2008. Unfortunately, the exceptionally low number of spawners on Grand Cayman resulted in our failure to capture and tag adults in any large number. Beginning in 2008, we began conducting annual visual mark recapture studies of aggregating Nassau Grouper on the WELC site in order to better estimate the abundance of spawners. This work was supplemented in 2014 by an active acoustics survey of the aggregation sites on all 3 islands; this active acoustic work is not on-going.

Because several species of grouper using the aggregation sites vocalize as part of reproduction, we established permanent passive acoustic monitoring stations at most of the documented aggregation sites around the islands, and at one off-aggregation site (control). These hydrophones record vocalizations year-round, with the intent of providing a more comprehensive record of spawning behaviors. In addition, for the last two years (2016 and 2017), we established a temporary multi-hydrophone passive acoustic array at the WELC site, with the intent of spatially mapping the calling behaviors of multiple

grouper species at the aggregation site (2 - 5 m accuracy).

#### **Early Life History (Eggs and Larvae)**

Since 2008, we have collected eggs of Nassau Grouper on nights of spawning. Each year we preserve samples from a plankton net towed through the spawn cloud by divers on multiple nights (integrated tows). Additionally, since 2014, we have collected eggs from individual spawn bursts (presumably individual females). We preserve half of these samples with ethanol (for future genetic work) and half with formalin (for estimates of fertilization rates). During the last two years, we have collaborated with scientists at the Central Caribbean Research Institute (CCMI) to document fertilization rates, development, and survival to starvation. We are also investigating the influence of different temperature regimes on each of these factors.

Since 2008 we have used satellite drifters to track the bodies of water Nassau Grouper are spawning in over multiple nights. On days leading up to spawning, these drifters are released on consecutive nights and recovered 10-20 hours later. On nights of peak spawning, the drifters are released and subsequently monitored for a period of 45 days. Beginning in 2016, we supplemented this drifter work with a towed underwater microscope capable of imaging individual plankton/eggs in high volumes of water, and towed plankton net sampling. Both sampling regimes are carried out in the vicinity of the drifters for periods of 6 - 36 hours post-spawning, with the aim of documenting the distribution of eggs and larvae, and the associated planktonic prey and predator fields experienced during the early life-history stages of Nassau Grouper.

#### **Settlement and Recruitment**

Since 2008 we have conducted annual snorkel surveys of young-of-the-year Nassau Grouper around Little Cayman just prior to spawning season. In both 2008 and 2009, we fished larval light traps on both Little Cayman and Grand Cayman approximately 30 - 45 days post spawning (during the presumed settlement window). However, because this effort captured only one settling Nassau Grouper in one year, we ceased surveying in subsequent years. With the exception of 2012, no young-of-the-year Nassau Grouper were found in snorkeling surveys. During the large recruitment event of 2012, ~10 juveniles were captured, tagged, and fin clipped for subsequent genetic work.

#### **Communication and Outreach**

The products of the research and monitoring outlined above are intended to serve the management agencies and citizens of the Cayman Islands specifically, and the Caribbean in general. In order to meet this goal, we developed and have carried out a K-12 education curriculum with “live-from-the-field” elements since 2011. Schools from across the Caribbean and US participate in this program, with support provided through a teacher-training workshop held on Grand Cayman. In addition to the K-12 education program, Grouper Moon scientists have presented research and monitoring programs to Cayman

ministers, and regularly give public talks on all three Cayman Islands. Our team also worked with the award-winning nature documentary program out of WBPT in Miami, *Changing Seas*, to produce an episode that has been widely distributed online and in person. These efforts are all aimed at supporting the effective management of marine resources through public engagement and science communication.

#### **Policy Outcomes**

In August 2016, thirteen years after the initial FSA protections were passed under a sunset clause, the Cayman government passed comprehensive and permanent Nassau Grouper legislation based on the scientific findings of the Grouper Moon Project. The new law created a closed season for Nassau Grouper from December through April. When take is permitted (May – November), only fish between 16" - 24" can be kept and no more than 5 Nassau Grouper per fishing vessel per day can be kept. The law also prohibits the take of Nassau Grouper by spear gun. The government is currently working on additional protections through the proposed Marine Park Law.

#### **Next Steps**

Findings from this long-term monitoring program indicate a dramatic recovery in the population following over a decade of spawning site protections -- Nassau Grouper numbers at the WELC site have grown from ~1,200 fish to ~7,000 fish. We believe this population forms the largest remaining Nassau Grouper aggregation in the Caribbean. Given the small size and narrow shelf of Little Cayman, it is possible that the population is closing in on carrying capacity. However, continued growth in the population may ultimately result in a “splitting” of the aggregation, such that 2 separate aggregations form simultaneously at both ends of the island. The reconstitution of defunct aggregations following population recovery would be an important conservation success. As such, we will continue to acoustically monitor aggregating behavior on Little Cayman, and have recently revitalized our acoustic tagging program. These efforts are largely aimed at documenting the changing aggregation dynamics in the recovering population.

Understanding the barriers to population recovery on Cayman Brac and Grand Cayman remains a top priority. The majority of fishing effort in the Caymans is focused on these more populous islands; in addition, the fishing communities on these islands are more skeptical of recent fisheries management actions. It is therefore critical that we evaluate the success of management actions in terms of Nassau Grouper recovery on these islands. To do this, we will continue:

- i) Monitoring abundance through video transects at aggregation sites on the islands,
- ii) Opportunistically acoustically and visually tag Nassau Grouper to better understand aggregating behavior,
- iii) Continue monitoring aggregation sites via

- acoustic recordings, and
- iv) Opportunistically conduct surveys of the size frequency of aggregating fishes.

Taken together, these observations will allow us to monitor changes in the number and size distribution of aggregating fish. These pieces of information are fundamental components of fisheries assessment, and will allow us to support an evaluation of FSA management throughout the Cayman Islands and wider Caribbean.

KEYWORDS: Nassau Grouper, *Epinephelus striatus*, spawning aggregations, recruitment, monitoring