Reef Fish Spawning Research in the Florida Keys: Science and Management for the Past 10 Years

Investigación en las Agregaciones Reproductivas de Peces de Arrecife en los Cayos de Florida: Ciencia y Gestión Durante los Últimos 10 Años

Recherche sur les Agrégations de Poissons de Récif dans les Keys de Floride: Science et Gestion Depuis 10 Ans

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EXTENDED ABSTRACT

Many commercially and recreationally important reef fish species form spawning aggregations that are predictable in both space and time, making them vulnerable to over-exploitation (Sadovy de Mitcheson et al. 2008). The Florida Keys contains several reef fish species known to aggregate to spawn. In 2000, Lindeman and colleagues documented known aggregations sites throughout the Florida Keys based on landings and commercial fisherman interviews. To better understand the status of these aggregations, the Florida Fish and Wildlife Research Institute has been partnering with several agencies over the past decade to improve documentation of these sites and provide the best possible science to management for their conservation.

Riley's Hump

In 2008, the Florida Fish and Wildlife Conservation Commission (FWC) focused their spawning aggregation research on a site known as Riley's Hump in the Dry Tortugas region of Florida. This site had been previously reported as having mutton snapper (*Lutjanus analis*) aggregate in the tens of thousands but had been heavily exploited, and in 2004, a school of only 300 mutton snapper was reported by divers (Burton et al. 2005). Two ecological reserves were implemented in the Dry Tortugas region in 2001, the Tortugas North and South Ecological Reserves. The Tortugas South Ecological Reserve provided year-long spatial protection to Riley's Hump. Six years later, the Research Natural Area, a newly established no-take marine reserve, was added to part of Dry Tortugas National Park and increased the network of no-take marine reserves in the Dry Tortugas region (Figure 1).

Through federal, state, non-governmental organization, and academic institution collaborations, numerous research approaches were used to monitor fish resources in the Dry Tortugas region. Feeley and colleagues used acoustic telemetry to track mutton sapper migratory movements and aggregation timing (Feeley et al. 2018). Reef visual census data were analyzed to report the changes in legal sized mutton snapper over time (Figure 2). In addition to mutton snapper, passive acoustic hydrophones demonstrated seasonal peaks in grouper sound production, suggesting that they too were using Riley's as a spawning site (Locascio and Burton 2016, Sanchez et al. 2017). Additional technologies such as remotely operated vehicles, diver surveys, and stereo cameras revealed large aggregations of cubera snapper *(Lutjanus cyanopterus)* (Figure 3). Echosounder surveys conducted from National Oceanic and Atmospheric Administration (NOAA) research vessels measured the biomass of these aggregations.

All of this information was presented to the FWC Commissioners during their February 2018 meeting. These data, coupled with additional information about the Dry Tortugas region, informed their decision to allow the network of no-take marine reserves in the Dry Tortugas region to remain in place for the following 20 years (Florida Fish and Wildlife Conservation Commission communication).

Spawning Aggregation Work in Other Parts of the Florida Keys

From 2010 – 2014, FWC partnered with NOAA to conduct more extensive spawning aggregation research throughout the rest of the Florida Keys. Aerial, echosounder, and diver surveys around known spawning aggregation times

of targeted snapper and grouper species were focused on those sites previously described by Lindeman and his contemporaries. One particular area showed the most promise as a year-round, multi-species aggregation site that could be similar to Riley's Hump. This was an area offshore of Western Dry Rocks southeast of Key West, Florida. Divers reported elevated densities of permit *(Trachinotus falcatus)*, mutton snapper, gray snapper *(Lutjanus griseus)*, mahogany snapper (*Lutjanus mahogoni*), yellow goatfish, (*Mulloidichthys martinicus*), and Atlantic spadefish (*Chaetodipterus faber*). However, this site was heavily utilized by boaters and fishers and it was difficult to conduct diving operations or echosounder surveys in this area. Therefore, acoustic telemetry was applied to collect information regarding the use patterns of this aggregation site.

Bonefish and Tarpon Trust (BTT) partnered with FWC to examine permit connectivity between the habitats of the nearshore flats and offshore reef environment using acoustic telemetry. FWC also partnered with the integrated Tracking of Aquatic Animals in the Gulf of Mexico (iTAG) and the Ocean Tracing Network (OTN) to increase the number of underwater acoustic receivers in the Florida Keys. Through partnerships with BTT, iTAG and OTN, the

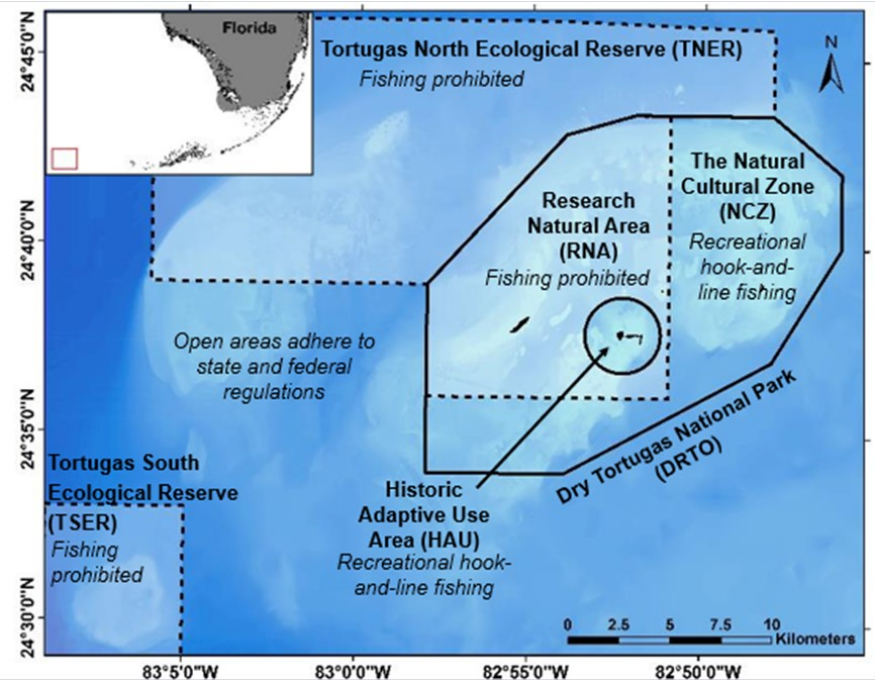

Figure 1. Location of the Dry Tortugas with different management zones highlighted. Tortugas North and South Ecological Reserves were established as no-take marine reserves in 2001. The Research Natural Area became a no-take marine reserve in 2007. Riley's Hump is within the Tortugas South Ecological Reserve.

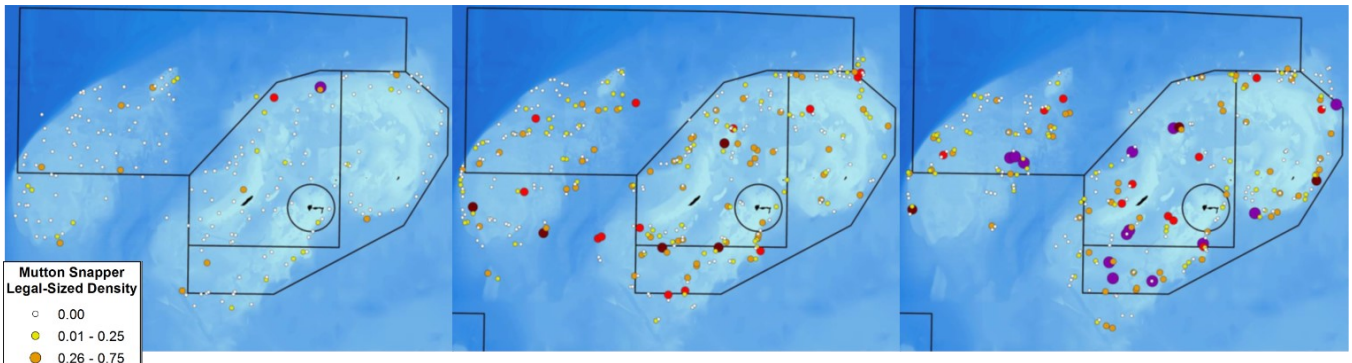

Figure 2. Increase in density over time of legal sized mutton snapper observed during the Reef Visual Census surveys. Each circle represents the location of a diver survey. The size and color of the circle increases as the density increases. The numbers in the lower portion of the panel indicate the years of the surveys.

number of underwater acoustic receivers in the Florida Keys increased from 46 in 2014 to over 200 by 2018.

The partnership between BTT, iTAG, and FWC resulted in documenting permit movement patterns that were formerly unknown (Brownscombe et al. 2020). Previous management regulations had a harvest prohibition on permit in Monroe County, Florida, for the months of May and June to protect them during their spawn. However, data from acoustic telemetry revealed that they arrived at spawning sites an entire month earlier. This information was presented to FWC Commissioners, and the harvest prohibition was extended to include the month of April (Brownscombe et al. 2019).

Florida Fish and Wildlife Conservation Commission also acoustically tagged several species of grouper in the Western Dry Rocks region to determine if they used this site during their spawning season. The tagged grouper were more likely to be present at the Western Dry Rocks site during spawning season (Keller et al. In Press). This telemetry data, coupled with the previous aerial, diver, and echosounder surveys was provided to the Florida Keys National Marine Sanctuary (FKNMS) and their advisory board as they continue to work through the process of revising the management plan of the Florida Keys National Marine Sanctuary.

The Continuation of Reef Fish Aggregation Research in the Florida Keys

In addition to acoustic telemetry, other technologies are being explored to better document spawning aggregations in the Florida Keys. Partnering with Florida Atlantic University, Harbor Branch Oceanographic Institute, we are experimentally deploying wave gliders at Riley's Hump to determine the efficacy of using this technology in the Florida Keys to study reef fish spawning aggregations (Chérubin et al. 2020). Florida Fish and Wildlife Conservation Commission has also partnered with the FKNMS to deploy a series of passive acoustic hydrophones to listen to courtship calls produced by grouper. Additionally, efforts are being made to deploy tethered echosounder buoys to monitor biomass at known spawning aggregation sites to determine their seasonal patterns and changes over time. Despite having knowledge of multiple aggregation sites throughout the Florida Keys, Riley's Hump is currently the only multi-species spawning aggregation site that receives the protection of a year-round spatial closure (Feeley et al. 2018). As the Florida Keys reefs become increasingly stressed due to fishing pressure, coral disease (Precht et al. 2016), water quality, and the pressures of climate change, being able to protect these spawning aggregations is now even more critical to ensure that we have these marine resources in the future.

KEYWORDS: Spawning aggregations, telemetry, management, technology

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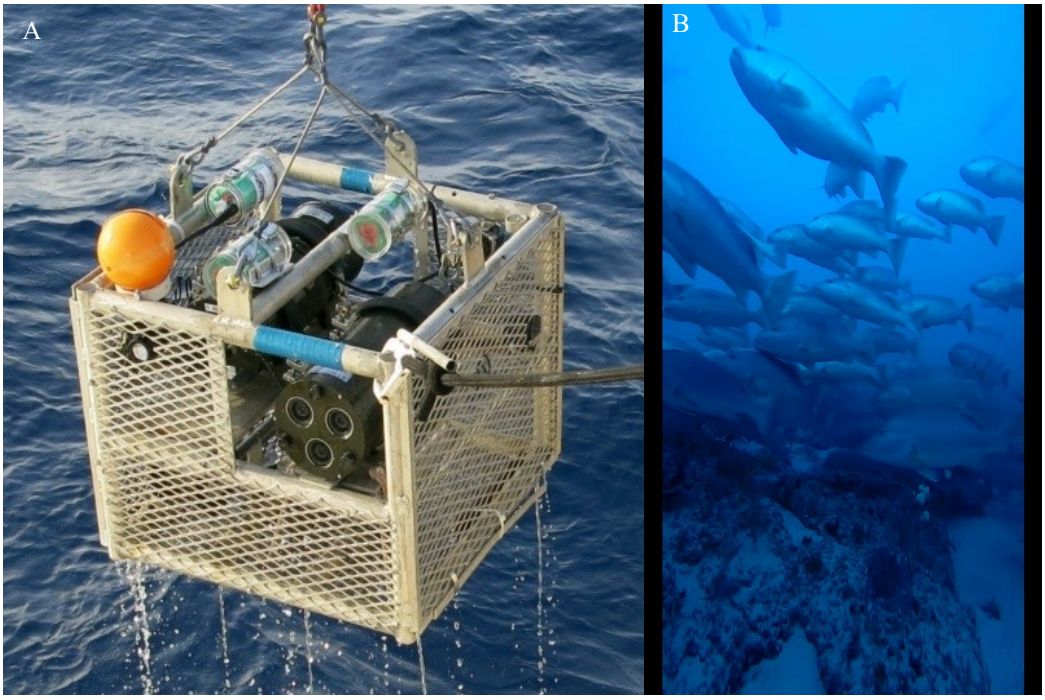

Figure 3.A. The stereo camera deployed to record aggregation activity at Riley's Hump. **B**. Screenshot from the video of the cubera snapper aggregation recorded by the stereo camera.

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