Combining Acoustic Technologies to Enhance Future Protections for Spawning Aggregations of Nassau (*Epinephelus striatus*) and Yellowfin Grouper (*Mycteroperca venenosa*)

Combinando Tecnologías Acústicas para Mejorar Protecciones Futuras para las Agregaciones de Desove del Mero Cherna (*Epinephelus striatus*) y Guajil (*Mycteroperca venenosa*)

La Combinaison de Deux Technologies Acoustiques pour Améliorer Protections Futures des Agrégations Frayères de Mérou Rayé (*Epinephelus striatus*) et Badèche De Roche (*Mycteroperca venenosa*)

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EXTENDED ABSTRACT

Nassau (*Epinephelus striatus*) and yellowfin (*Mycteroperca venenosa*) grouper form temporally and spatially predictable spawning aggregations that have historically been susceptible to overfishing (Sadovy and Domeier 2005, Sadovy de Mitcheson et al. 2012). In response to degraded spawning aggregations, seasonal and permanent fisheries closures in the U.S. Virgin Islands (USVI) have been developed to protect reproductive periods and locations. As both species produce courtship-associated sounds (CAS) at spawning aggregations (Schärer et al. 2012a, 2012b), passive acoustic and acoustic telemetry methods were combined to determine temporal patterns of reproductive activity, site usage, and fish movements in order to evaluate current protections at two marine protected areas (MPA) in the USVI: the Grammanik Bank (GB) and Hind Bank Marine Conservation District (MCD, Figure 1). Passive acoustic recorders were placed at the GB spawning site and MCD non-spawning site for both species. Additionally, five acoustic receivers were deployed: one at the GB, one at the MCD, and three at the eastern boundary of the MCD to record tag detections from the 25 Nassau grouper and 21 yellowfin grouper that were tagged in this study.

Patterns of sound production and ultrasonic acoustic tag detections revealed the formation of spawning aggregations of both species from January through May at the GB, indicating that current seasonal regulations (1 February to 30 April) do not protect spawning stocks throughout the entire reproductive season. While spawning did not likely occur within the MCD, the MPA did support elevated abundances of calling individuals during spawning periods. Sound production at the MCD ceased before the GB, indicating that both species display courtship behaviors over an expansive area prior to shifting their behaviors and likely abundances to the spawning site (GB) during the known time of spawning. Daily CAS totals yellowfin grouper exceeded those of Nassau grouper, which is supported by previous observations of higher abundances of yellowfin grouper compared to Nassau grouper (Kadison et al. 2011).

Acoustic tagging documented connectivity between the GB and MCD, highlighting the broad extent of area used, including non-protected regions, during the spawning season. Migrations of both species between the MPAs were found to occur during the spawning season, including through a 2 - 3 km distance of unprotected waters. Possible incident catch mortality outside of the protected areas suggests that the current boundaries of the MPAs do not fully protect spawning stocks given their high level of mobility prior to each spawning event at the GB. When comparing the timing of tag detections at each site for Nassau grouper to sound production a significant cross-correlation was found between time-series at the GB and a weak cross-correlation at the MCD. The coupled relationship between tag detections and a continuation of acoustic behaviors away from spawning sites during routine migrations presents a potential mechanism to lead conspecifics to the aggregation site and thereby increase reproductive fitness and spawning output.

When moving forward in the development of new and revised protections for spawning aggregations of Nassau grouper and yellowfin grouper, it is important to use multiple methodologies to gain a better understanding of the temporal and spatial requirements of spawning stocks. Herein, we found that both species used a broader expanse of area during the spawning season than was previously thought. Additionally, in the USVI both species had an extended spawning season that lasted from January to May. Given these findings we conclude that while protections in the USVI may have resulted in initial recovery of targeted spawning stocks, they currently do not fully protect either species during the spawning season. However, we did not examine the efficacy of current protections to meet management goals. Such an examination will be necessary in the future to support new developments to management plans to include the areas and times found to be important for spawning individuals in this study. Complementary studies should be conducted at other spawning aggregation locations and for additional species to achieve a better understanding of the reproductive requirements necessary for optimal spawning output and stock recovery.

KEY WORDS: Passive acoustics, ultrasonic acoustic tagging, sound production, fish movement patterns, Epinephelidae

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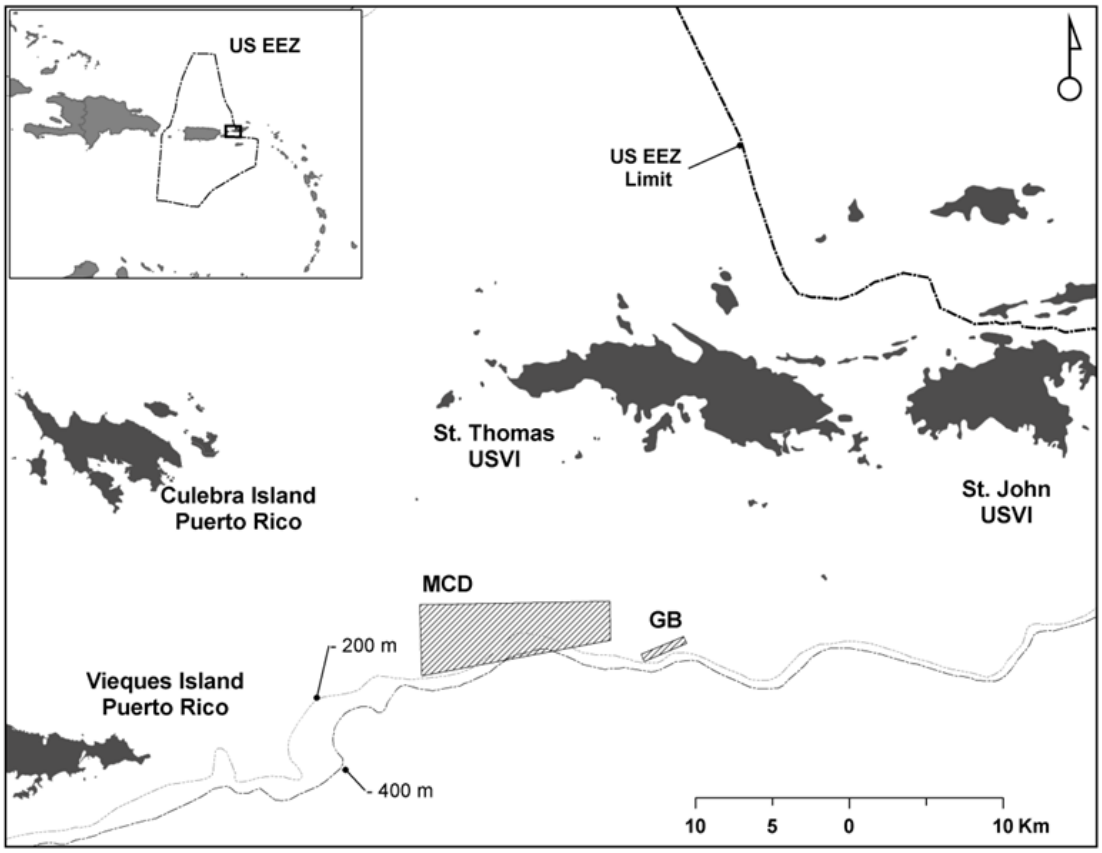

Figure 1. Map of the locations of the Hind Bank Marine Conservation District (MCD) and Grammanik Bank (GB) Marine Protected Areas.