Passive Acoustics Record Grouper Spawning Activity at Multi-species Aggregations

Acústicas Pasivas Graban Actividad de Desove de Meros en Agregaciones de Múltiples Especies

Acoustiques Passives à Évaluer L'activité de Frai de Mérous à des Agrégations D'espèces Multiples

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ABSTRACT

Many large groupers (Epinephelidae) form multiple species aggregations at specific times and predictable locations. Documenting the timing of site usage and spawning is essential for understanding the annual dynamics of spawning aggregations and developing protections. Spawning and courtship associated vocalizations of red hind (*Epinephelus guttatus*), yellowfin grouper (*Mycteroperca venenosa*), and Nassau grouper, (*Epinephelus striatus*) have been identified as important spawning behaviors and can be used as indicators of density, habitat use, and spawning. From January to May, 2011, passive acoustic recorders collected acoustic data at two protected grouper spawning aggregations off St. Thomas, USVI: the Grammanik Bank (GB) and the Red Hind Bank, Marine Conservation District (MCD). *E. guttatus*, *M. venenosa*, and *E. striatus* vocalizations were quantified audibly and visually from spectrograms and summed for each day at each site. The resulting time-series revealed that the GB hosted spawning aggregations of *M. venenosa* and *E. striatus* during the months of January-May with lunar periodicity and low abundances of *E. guttatus* in January-February. *E. striatus* aggregated in later months than previously observed at other Caribbean locations. The MCD primarily supported spawning aggregations of *E. guttatus* in January and February, but recordings of all species' vocalizations were present during all months, indicating that *M. venenosa* and *E. striatus* use the MCD during the spawning season. Passive acoustic techniques provided species specific information on when spawning peaked and at which locations spawning occurred at a higher resolution than previously attainable with traditional methods.

KEY WORDS: *Epinephelus guttatus*, *Epinephelus striatus*, *Mycteroperca venenosa*, sound production, St. Thomas, marine protected areas

INTRODUCTION

Many commercially important large groupers (Epinephelidae) in the tropical western Atlantic Ocean are known to form transient spawning aggregations (Domeier and Colin 1997), and are particularly susceptible to overfishing because of their behavior of forming large aggregations at known sites and times for spawning (Sadovy and Domeier 2005). Overfishing aggregations can result in a decrease in stock size, mean length, and recruitment, diminished density and biomass, female biased sex ratios, or complete disappearance of the aggregation (Aguilar-Perera 2006, Aguilar-Perera and Aguilar-Dávila 1996, Beets and Friedlander 1992, Coleman et al. 1996, Sadovy 1994, Sadovy and Figuerola 1992). Recent decreases in grouper stocks in the Caribbean have been well documented and warrant increases in monitoring and regulation strategies (Beets and Friedlander 1992, Sadovy 1994, Sadovy and Domeier 2005, Sadovy and Figuerola 1992).

In response to declines in grouper stocks in the US Caribbean, a series of seasonal closed areas have been designated. Seasonal and subsequently full closure of grouper spawning areas off St. Thomas has resulted in a large increase in the spawning stock (Nemeth 2005, Nemeth and Quant 2005). Monitoring the outcomes of protections and fishing throughout the US Caribbean is important for supporting current and new management strategies and understanding shifts in fish abundance and spawning behavior. As many large groupers are known to produce species specific vocalizations as part of spawning and courtship behaviors, including *Epinephelus guttatus* (Mann et al. 2010, Rowell et al. 2012), *Epinephelus striatus* (Schärer et al., In press), *Mycteroperca venenosa* (Schärer et al. 2012), *Epinephelus itajara* (Mann et al. 2009), *Epinephelus morio* (Nelson et al. 2011), and *Mycteroperca bonaci* (M.T.S., Unpublished data), passive acoustics is a promising tool to study the timing of grouper spawning and habitat use at multiple sites for multiple species simultaneously. Sound production has also been shown by Rowell et al. (2012) to be an indicator of *Epinephelus guttatus* density at spawning sites, and such a methodology may be expanded to other species, providing measurements of relative abundance from species specific vocalization frequencies and in-situ noise levels recorded passive acoustically. Changes in sound levels may be used as indices of relative abundance, providing insightful information for managers.

The goal of this project was to develop a passive acoustic monitoring methodology for multi-species aggregations at two grouper spawning aggregation sites in the waters of St. Thomas, U.S. Virgin Islands. Insight into temporal patterns and relative abundance of *Epinephelus guttatus, Epinephelus striatus*, and *Mycteroperca venenosa* were to be examined.

METHODS

Digital Spectrogram Long-Term Acoustic Recorders (Loggerhead Instruments Inc.; DSG) were deployed at two protected spawning aggregation sites off St. Thomas: the Grammanik Bank (GB) and Red Hind Bank Marine Conservation District (MCD). The GB is closed to non-migratory species fishing from 1 February until 30 April, while the MCD is

protected from fishing year round. The GB is a known site of *E. striatus* and *M. venenosa* aggregations, while the MCD is the location of a well studied *E. guttatus* aggregation. The two managed areas are separated by approximately 1 nautical mile of unprotected habitat. The DSGs recorded ambient noise from 20 January until 31 May, 2011 at an interval of 20 seconds every 5 minutes at each site. Upon retrieval, acoustic files were converted to .wav files and examined manually. Vocalizations of *E. guttatus, E. striatus*, and *M. venenosa* were identified visually and audibly from spectrograms generated in Ishmael 2.0 (CIMRS Bioacoustics Lab). Vocalizations were summed day^{-1} for each species and multiplied by 15 to account for the 20 seconds every 5 minutes sampling, yielding an estimate of total vocalizations/day/species at each site. Time-series of total vocalizations/day were generated for each species in MATLAB (The Mathworks) to determine the timing and amplitude of peak vocalizations during each month in relation to the full moon.

RESULTS

Vocalizations of *E. guttatus, E. striatus*, and *M. venenosa* were recorded at both the GB and MCD during the study period. At the GB, *E. guttatus* total vocalizations/ day peaked within one day of the full moons in January and February, but were both low in amplitude. Vocalizations of *E. striatus* and *M. venenosa* peaked following the full moons in January through May, with *M. venenosa* peak vocalization totals amounting to on average threefold the peak vocalization totals of *E. striatus* in all months with the exception of January, when totals were similar.

Sound production at the MCD was overwhelming dominated by *E. guttatus* vocalizations during the months of January and February, with January levels tenfold the levels of February. Temporal patterns of peak *E. guttatus* sound production were identical to patterns at the GB. The MCD DSG recorded *E. striatus* vocalizations in all months; however, peaks following the full moons could not be distinguished. *M. venenosa* sound production peaked in all months studied. On average, *E. striatus* and *M. venenosa* vocalization totals at the MCD were less than the totals recorded at the GB by a power of ten.

DISCUSSION

Temporal patterns in sound production revealed that the MCD was the primary location of a large *E. guttatus* spawning aggregation, while the GB supported notable aggregations of *E. striatus* and *M. venenosa*. The levels of *E. guttatus* sound production at the GB followed the same pattern in peak sound production in relation to the full moon in the months of January in February as the MCD, but were more indicative of small abundances and not necessarily a productive aggregation. Vocalization totals of *E. striatus* and *M. venenosa* at the GB indicated that abundances and possibly inferred spawning of both species peaked after the full moons in January through May, with *M. venenosa* abundances greater than *E. striatus.* *M. venenosa* and *E. striatus* sound production during the month of May warrants an examination of the current management strategy at the GB and in the US Caribbean: the cessation of protections on 30 April. Additionally, the presence of *E. striatus* and *M. venenosa* vocalizations at both the GB and MCD needs further examination. While the GB is understood to be the primary location for spawning aggregations of both species, acoustic data indicates that the MCD is also utilized by both species during the spawning season and may serve as a migratory corridor or foraging habitat. Consequentially, the unprotected area between the GB and MCD is also likely to serve an important role for both species and should be considered in future studies and management strategies.

The occurrence of acoustic evidence of aggregation formation for *E. striatus* during the months of January to May contradicts other studies that have found *E. striatus* to aggregate during the months of November through February in the North Atlantic and Caribbean (Colin 1992, Cushion et al. 2008), but is corroborated by other studies conducted at the GB (Nemeth et al. 2006) and in Puerto Rico (T.J.R. and M.T.S., Unpublished data) that have found *E. striatus* aggregating into later months. Passive acoustic results indicate *E. striatus* have a broader aggregation period at the GB, which could be a result of a recovering population. Future long-term acoustic studies can monitor the continuance or reversal of this occurrence at GB and examine similar temporal variability among other locations.

The results of this study lay a foundation for the expansion of passive acoustic techniques into studying and managing multi-species aggregations worldwide. Additionally, due to the acoustic behavior of many groupers, it is likely that species specific vocalizations can be indentified for species whose vocalizations are currently unknown and can be incorporated into monitoring surveys to identify habitat use, relative abundance, and timing of spawning of soniferous fishes at multi-species aggregation sites.

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