The Courtship Associated Sounds of Nassau Grouper, *Epinephelus striatus* (Pisces: Epinephelidae) During Spawning Aggregations

Sonidos Asociados al Cortejo del Mero Cherna, *Epinephelus striatus* (Pisces: Epinephelidae) durante Agregaciones Reproductivas

Courtship Associés sons de Mérou Rayé, *Epinephelus striatus* (Pisces: Epinephelidae) au cours de Frayères

MICHELLE SCHÄRER-UMPIERRE*, TIMOTHY ROWELL, MICHAEL NEMETH, and RICHARD APPELDOORN
Department of Marine Science, University of Puerto Rico, P.O. Box 9000
*Mayagüez, Puerto Rico 00681. *michelle.scharer@upr.edu.*

ABSTRACT

Nassau grouper, *Epinephelus striatus,* were studied at three spawning aggregation sites to document the species acoustic behaviors. At least two types of sounds are produced by Nassau grouper; one related to alarm or distress and the other associated with courtship. Autonomous video and audio recordings collected at Glover's Reef, Belize and Bajo de Sico, Puerto Rico allowed us to determine a relation between the tonal sound and courtship behavior, hence defined as a courtship-associated sound (CAS). With this information the temporal dynamics of Nassau grouper were quantified with audio-only, long-term recordings at two sites (Grammanik, USVI and Bajo de Sico, PR) in 2011 for the former and 2012 for the latter. The residence time and peak sound production days and months at both sites were similar; however, important discrepancies suggest that each site and year may be unique in spawning aggregation dynamics. The association between sound and reproductive behaviors provides an important clue that allows the assessment and monitoring of multiple spawning aggregations sites simultaneously over a greater time span. Information on the temporal patterns of CAS during spawning aggregations applies directly to the protection of the most critical phases of reproduction for this endangered species via seasonal or site specific management efforts.

KEY WORDS: Nassau grouper, spawning aggregation, sound, courtship, reproductive behavior

INTRODUCTION

The Nassau grouper, *Epinephelus striatus*, was one of the most commercially important coral reef species supporting fisheries in the Caribbean. Today it is considered as Endangered in the Western Atlantic by the IUCN due to steep declines in population size (Cornish and Eklund 2003, Sadovy et al. 2012). One of the main factors for this decline has been the collapse of their spawning aggregations due to intense fishing pressure (Sadovy 1995, Sadovy and Domeier 2005, Aguilar-Perera 2006). In order to protect the few remaining spawning aggregations they must be located and monitored in a continuous manner to determine population trends. Sounds produced during reproductive behaviors have served to locate and measure reproductive activity of other species such as Goliath grouper, *Epinephelus itajara* (Mann et al. 2009); the red grouper, *Epinephelus morio* (Nelson et al. 2011); red hind, *Epinephelus guttatus* (Mann et al. 2010); and yellowfin grouper, *Mycteroperca venenosa* (Schärer et al. 2012a). In order to apply this type of information to help recover spawning aggregations of Nassau grouper, the sound production during courtship must be well understood. During this study Nassau grouper were studied at three spawning aggregation sites to document the temporal patterns of sounds produced during reproductive behaviors at spawning aggregations. With this information the temporal dynamics of Nassau grouper were quantified with audio-only, long-term recordings at two sites (Grammanik, USVI and Bajo de Sico, PR).

METHODS

Passive acoustic data were recorded along with video at two spawning sites; Glover's Reef (GR), Belize and Bajo de Sico (BDS), Puerto Rico (see Schärer et al. 2012b) and long-term audio only datasets were collected at two spawning aggregation sites; BDS, Puerto Rico, and the Grammanik Bank (GB), USVI in the Caribbean (Figure 1). These recordings were made during the expected spawning season for Nassau grouper during 2011 in Grammanik Bank and during 2012 at Bajo de Sico. The Nassau grouper sounds associated with courtship (described in Schärer et al. 2012b) were quantified in long-term, audio only recordings made with DSG-Ocean (Loggerhead Instruments Inc., Sarasota, FL), digital underwater sound recorders. Recordings of 20 seconds were made every 5 minutes in .dsg files, which later were converted to .wav files that are audible and can be inspected visually with spectrograms generated with Adobe Audition software. These were then used along with the characterization statistics to identify and isolate sounds from the long-term passive acoustic data.

In order to determine temporal patterns in sound production, the Nassau grouper sounds in each 20 s (.wav) file were quantified. The CAS were detected by visually utilizing spectrograms generated in Ishmael 2.0 software with a 1024 FFT Hann window and verified audibly. The number of CAS per 20 s was averaged per hourly interval over the February to May 2011 spawning period for Grammanik Bank and February to March 2012 for Bajo de Sico. Non-parametric multiple comparison Kruskal-Wallis ANOVA and medians tests were performed in order to differentiate the peak temporal units of sound production.

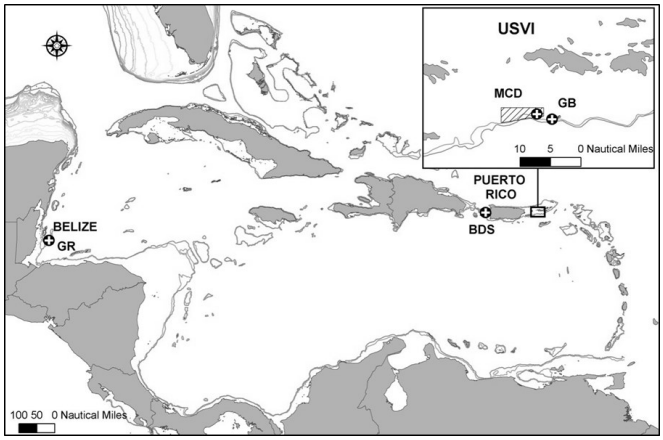

Figure 1. Map of study sites where passive acoustic recordings were collected (Glover's Reef - GR, Bajo de Sico - BDS, Grammanik Bank - GB, United States Virgin Islands - USVI).

RESULTS AND DISCUSSION

Based on the autonomous video and audio recordings at Belize and Puerto Rico the sounds produced by Nassau Grouper are consistent and recognizable to species (Schärer et al. 2012b). Two types of sounds are produced by this species: an alarm sound (http://www.fishbase.org/physiology/FishSoundsSummary.php?autoctr=254) and a tonal sound (http://www.fishbase.org/physiology/FishSoundsSummary.php?autoctr=247). The alarm sound of Nassau grouper had been documented previously by Moulton (1958) and the sound production mechanism is associated with muscles behind the operculum that set the swim bladder into vibration (Hazlett and Winn 1962). Based on the analysis of the videos, tonal sounds were more abundant when bi-color fish were actively swimming above the water column, which is an indication of imminent spawning (Archer et al. 2012) and associated with courtship behaviors previously described by Colin (1992). Hence, we defined the tonal sound as a courtship-associated sound (CAS) associated with behaviors leading to spawning.

The residence time of Nassau grouper as determined by the increase, peak and decrease in sound production over continuous days occurred the week after the full moon for both sites (Figure 2). During the 8-day residence at the Grammanik Bank the highest number of CAS was detected 8 days after the full moon (DAFM) followed by a continuous decline until 12 DAFM. This is in accordance with the observations of Kadison et al. (2010) regarding the arrival, residence time and departure from this aggregation site. At Bajo de Sico the onset of residence time was not captured in February during the main aggregation due to equipment malfunction. However, during March of 2012, CAS increased from 7 to 14 DAFM, with a peak 11 DAFM. In the Cayman Islands, peak spawning occurs 24-48 h after reaching maximum numbers in abundance (Whaylen et al. 2006), therefore if the number of CAS is positively related to abundance we can expect that spawning occurred 8 and 12 DAFM at Grammanik Bank and Bajo de Sico respectively. Subsequent high (> 1,000 CAS/day) peaks in sound production were detected at the Grammanik Bank after the full moons of March and April, with a reduced peak in May. These peaks in Nassau grouper CAS could be due to a small number of fish aggregating after March that may be associated with other species, such as yellowfin grouper (*M. venenosa*), which spawn in subsequent months and are also present at this site (Nemeth et al. 2006). The reported

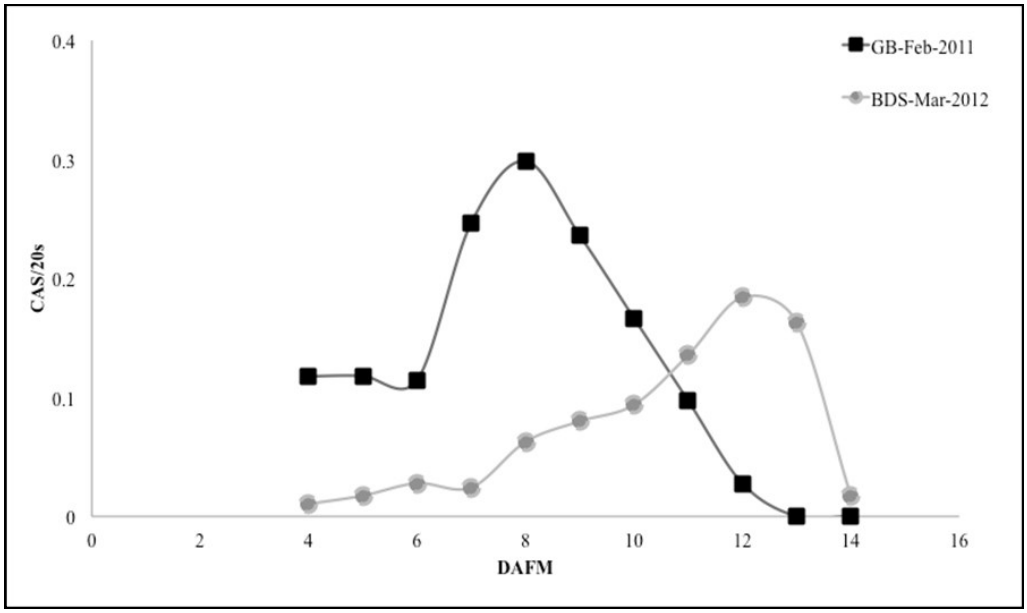

Figure 2. Courtship-associated sound (CAS/20s) production of Nassau Grouper during February of 2011 at Grammanik Bank (GB) and March 2012 at Bajo de Sico (BDS) on days after full moon (DAFM).

time of Nassau grouper spawning has traditionally been from November to February, therefore the presence of CAS during March and extending until May suggests that the temporal variability of this species reproductive behavior warrants more research.

A diel pattern was observed on the peak days of sound production at both sites. The greatest proportion of sounds on the days of highest CAS production was from 19:00 to 20:00 h period, which is after sunset and corresponds to the documented time of spawning (Colin 1992, Whaylen et al. 2006). It is possible that spawning occurs into the evening. On the other hand it may be that courtship displays in which sound is produced are continuing past the timing of spawning.

The association between sound and reproductive behaviors provides researchers with an important clue that allows for the assessment and monitoring of multiple spawning aggregations sites simultaneously over a greater time span. Information on the temporal patterns of CAS during spawning aggregations applies directly to the protection of the most critical phases of reproduction for this endangered species via seasonal or site specific management efforts

LITERATURE CITED

Aguilar-Perera, A. 2006. Disappearance of a Nassau grouper spawning aggregation off the southern Mexican Caribbean coast. *Marine Ecology Progress Series* **327**:289-296.

Colin, P.L. 1992. Reproduction of Nassau grouper, *Epinephelus striatus* (Pisces: Labroidei) and its relationship to environmental conditions. *Environmental Biology of Fishes* **34**:357-377.

Cornish, A. and A.M. Eklund. 2003 *Epinephelus striatus*. In: *2011 IUCN Red List of Threatened Species. Version 2011.2.* www.iucnredlist.org. Accessed April 7, 2012.

Hazlett, B., and H.E. Winn. 1962. Sound producing mechanism of the Nassau grouper, *Epinephelus striatus*. *Copeia* **2**:447-449.

Kadison, E., R.S. Nemeth, J. Blondeau, T. Smith, and J. Calnan. 2010. Nassau Grouper (*Epinephelus striatus*) in St . Thomas, US Virgin Islands, with evidence for a spawning aggregation site recovery. *Proceedings of the Gulf and Caribbean Fisheries Institute* **62:**273-279.

Mann, D., J. Locascio, M.T. Schärer, M.I. Nemeth, and R. Appeldoorn. 2010. Sound production by red hind (*Epinephelus guttatus*) on spatially segregated spawning aggregation sites is not synchronized. *Aquatic Biology* **10**:149-154.

Mann, D.A., J.V. Locascio, F.C. Coleman, and C.C. Koenig. 2009. Goliath grouper (*Epinephelus itajara*) sound production and movement patterns on aggregation sites. *Endangered Species Research* **7**:229-236.

Moulton, J.M. 1958. The acoustical behavior of some fishes in the Bimini area. *Biological Bulletin* **114**:357-374.

Nelson, M.D., C.C. Koenig, F.C. Coleman, and D.A. Mann. 2011. Sound production of red grouper *Epinephelus morio* on the West Florida Shelf. *Aquatic Biology* **12**:97-108.

Nemeth, R.S., S. Kadison, S. Herzlieb, J. Blondeau, and W.A. Whiteman. 2006. Status of a Yellowfin (*Mycteroperca venenosa*) grouper spawning aggregation in the US Virgin Islands with notes on other species. *Proceedings of the Gulf and Caribbean Fisheries Institute* **57**:543-558.

Sadovy Y. 1995. The case of the disappearing grouper: *Epinephelus striatus* the Nassau grouper in the Caribbean and Western Atlantic. *Proceedings of the Gulf and Caribbean Fisheries Institute* **45:**5-22.

Sadovy, Y. and M. Domeier. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. *Coral Reefs* **24**:254-262.

Sadovy de Mitcheson, Y., M. Craig, A. Bertoncini, K. Carpenter, W. Cheung, J. Choat, A. Cornish, S. Fennessy, B. Ferreira, P. Heemstra, M. Liu, R. Myers, D. Pollard, K. Rhodes, L. Rocha, B. Russell, M. Samoilys, and J. Sanciangco. 2012. Fishing groupers towards extinction: a global assessment of threats and extinction risks in a billion dollar fishery. *Fish and Fisheries* **448**:93-104.

Schärer, M.T., M.I. Nemeth, D.A. Mann, J.V. Locascio, R.S. Appeldoorn, and T.J. Rowell. 2012a. Sound production and reproductive behavior of Yellowfin grouper, *Mycteroperca venenosa* (Serranidae) at a spawning aggregation. *Copeia* **1**:135-144.

Schärer, M.T., T.J. Rowell, M.I. Nemeth, and R.S. Appeldoorn. 2012b. Sound production associated with reproductive behavior of Nassau grouper *Epinephelus striatus* at spawning aggregations. *Endangered Species Research* **2012**:29-38.

Whaylen, L., P. Bush, B. Johnson, K.E. Luke, C. McCoy, S. Heppell, B. Semmens, and M. Boardman. 2006. Aggregation dynamics and lessons learned from five years of monitoring at a Nassau grouper (*Epinephelus striatus*) spawning aggregation in Little Cayman, Cayman Islands. *Proceedings of the Gulf and Caribbean Fisheries Institute* **59**:413-421.