Influence of Turbidity on the Incidence of Sound Production in Atlantic Croaker (*Micropogonias undulatus*) in Pamlico Sound, North Carolina

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1 Introduction

Increased sound production by fishes, which is used for communication during mating, in territorial defense, and possibly in echolocation, has been associated with decreased light and increased temperature and salinity (Luczkovich et al. 2008; Mok and Gilmore 1983). There has not been an attempt to associate changes in sound production with other environmental factors such as turbidity. Sediment deposition and resuspension commonly occur in estuaries due to changes in current velocity and direction, water runoff, and wave height. These factors can lead to shearing on the bed surface and thus an overall increase in water column turbidity (Whitehouse et al. 2000). It has been hypothesized that increased water column turbidity will lead to increased sound production in fishes because visual cues will be impaired. The goal of this research is to associate the incidence of sound production by *Micropogonias undulatus* (Atlantic croaker) to variations in estuarine temperature, salinity, dissolved oxygen, and particularly turbidity.

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2 Materials and Methods

Water quality and sound production by *M. undulatus* were monitored at one site (PCS) in Pamlico River, NC, from March through December 2008. A long-term acoustic recording system (LARS), which recorded 10-s wave files every 10–15 min at frequencies < 10 kHz, was used to monitor fish calls. Environmental conditions were logged one to three times per hour with a Hydrolab DS5X (to monitor temperature, salinity, and dissolved oxygen) and an optical backscatter sensor (D&A OBS-3, 8-Hz sampling rate; to monitor turbidity). All LARS files were analyzed with extensible bioacoustics tools (http://www.XBAT.org) developed for MATLAB (version 7.0.1). A spectrogram detector with a minimum correlation rate of 54%, using known *M. undulatus* sounds, identified sound recordings of this species throughout the recording period. Any sounds with a correlation below 60% were analyzed by hand. Sounds that were not made by *M. undulatus* were removed from further analyses. *Micropogonias undulatus* sounds were analyzed using the number of croaks per hour and normalized by the number of recorded seconds in a given sampling hour. Sounds were averaged over a day to obtain the mean number of sounds per recorded hour per day. Correlations with water quality parameters were produced.

3 Results

At PCS, *M. undulatus* sound production was greatest in October and was highly correlated to water quality. Sound production was positively correlated to temperature (0.72; $P < 0.001$) and turbidity (0.61; $P < 0.001$), whereas salinity was negatively correlated with *M. undulatus* sound production (−0.65; $P < 0.001$) (Fig. 1). Dissolved oxygen levels did not significantly influence sound production (0.30; $P = 0.114$) at PCS.

4 Discussion

Sound production by *M. undulatus* is related to a variation in water quality parameters. Luczkovich et al. (2008) found that salinity, temperature, depth, and location in the estuary are contributing factors for four other sciaenid sound-producing fishes; however, sound production intensity, as measured by a qualitative index, was dependent on species and time of year. Luczkovich et al. (2008) did not look at *M. undulatus* sound production nor did they assess turbidity levels. In this study, we found that the most influential factors in *M. undulatus* sound production were temperature, turbidity, and salinity. Temperature and turbidity were positively correlated with sound production, whereas salinity was negatively correlated with *M. undulatus* sound production. The relationship with temperature and sound production was expected because other sciaenids have been shown to become reproductively active as the temperature increases and dissolved oxygen remains above a threshold (Luczkovich et al. 2008). However, the increased sound production in high turbidity has never been documented and suggests that sound cues may become more useful to Atlantic croaker when light levels are diminished by sediment resuspension events (e.g., storms and waves). Alternatively, Atlantic croaker activity levels may increase for other reasons and cause resuspension of sediments due to their feeding activities. Because temperature and salinity changes, low dissolved oxygen (hypoxia), and high-turbidity events may occur only for short periods of time during the passage of weather systems and stratification of the water column, a continuous recording system of fish sounds and environmental parameters was required in this study. Hurricanes cause massive sediment resuspension (Goni et al. 2007), yet the passage of hurricanes has not been found to

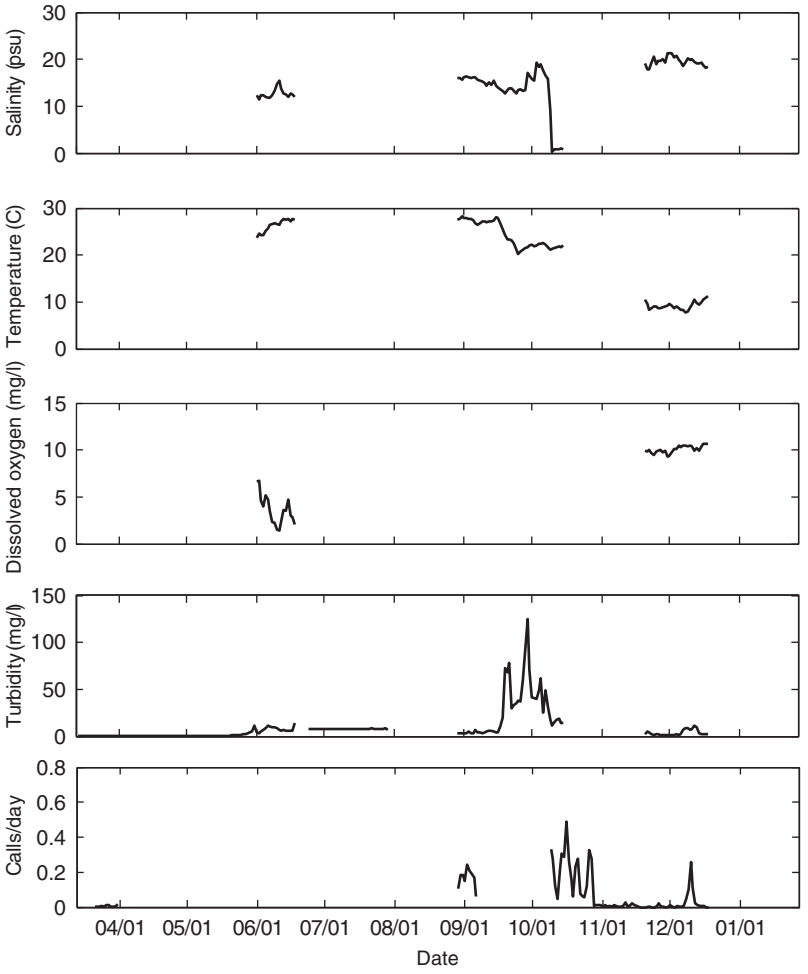

Fig. 1 Salinity (practical salinity units [psu]), temperature, dissolved oxygen, turbidity, and sound production by the Atlantic croaker (mean number of calls per recorded hour per day) for the PCS site in Pamlico River, NC, from March through December 2008. Breaks indicate periods of instrumentation failure

influence the sound production of spawning sand sea trout (Locascio and Mann 2005). This suggests that not all scaienids react similarly to changes in their environment. It is evident that *M. undulatus* sound production is tied to turbid events within the estuary.

References

Goni M, Alleau Y, Corbett R, Walsh JP, Mallinson D, Allison MA, Gordon E, Petsch S, Dellapenna TM (2007) The effects of hurricanes Katrina and Rita on the seabed of the Louisiana shelf. Sediment Rec 5:4–9.

Locascio JV, Mann DA (2005) Effects of Hurricane Charley on fish chorusing. Biol Lett 1:362–365.

Luczkovich JJ, Pullinger RC, Johnson SE, Sprague MW (2008) Identifying the critical spawning habitats of sciaenids using passive acoustics. Trans Am Fish Soc 137:576–605.

Mok HK, Gilmore RG (1983) Analysis of sound production in estuarine aggregations of *Pogonias cromis, Bairdiella chrysoura*, and *Cynoscion nebulosus* (Sciaenidae). Bull Inst Zool Acad Sin (Taipei) 22:157–186.

Whitehouse RJS, Soulsby R, Roberts W, Mitchener HJ (2000) Dynamics of estuarine muds. Thomas Telford Publishing, London.