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Boat noise in an estuarine soundscape – A potential risk on the acoustic communication and reproduction of soniferous fish in the May River, South Carolina

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ABSTRACT

The impact of boat related noise on marine life is a subject of concern, particularly for fish species that utilize acoustic communication for spawning purposes. The goal of this study was to quantify and examine the risk of boat noise on fish acoustic communication by performing acoustic monitoring of the May River, South Carolina (USA) from February to November 2013 using DSG-Ocean recorders. The number of boats detected increased from the source to the mouth with the highest detections near the Intracoastal Waterway (ICW). Boat noise frequency ranges overlapped with courtship sounds of silver perch (*Bairdiella chrysoura*), black drum (*Pogonias cromis*), oyster toadfish (*Opsanus tau*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus*). In the May River estuary, red drum may experience the greatest risk of auditory masking because of late afternoon choruses (21% time overlap with boat noise) and only one spawning location near the noisy ICW.

1. Introduction

According to NOAA's State of the Coast Report (2013), 123.3 million people, or 39% of the US nation's population, lived in counties directly on the coastline in 2010. This number is expected to increase to 48% of the population by 2020. The population density of these coastal shoreline counties is over six times greater than inland counties (NOAA's State of the Coast, 2013). Of the individuals that live on the coast, and including those that live within driving distance, 75 million use boats with over 16,800,000 recreational boats registered in the U.S. (Lydecker and Podlich, 1999). Sound travels much greater distances at higher amplitude levels, as well as faster, in water when compared to air, and the impact of boat related noise on marine life is a subject of concern (Slabbekoorn et al., 2010). With the human population of the world expected to increase by 2.3 billion between 2011 and 2050, anthropogenic noise in the marine environment is also likely to increase (Radford et al., 2014). Recreational and commercial vessel noise accounts for > 90% of the acoustic energy that humans emit into the sea and investigating how this noise impacts marine life is essential to mitigation and management (Celi et al., 2016).

In response to anthropogenic noise, marine animals have exhibited hearing threshold shifts (e.g., Halvorsen et al., 2012b; Finneran, 2015), direct physical damage to auditory structures (e.g., Casper et al., 2013; McCauley et al., 2003), interference with communication (i.e., masking of biological acoustic signals) (e.g., Slabbekoorn et al., 2010; Vasconcelos et al., 2007), reduced predator avoidance (e.g., Bruintjes and Radford, 2013; Peng et al., 2015), and increased stress levels (e.g., Nichols et al., 2015; Neo et al., 2015). In damselfish (*Chromis chromis*), brown meagre (*Sciaena umbra*), and red-mouthed goby (*Gobius cruentatus*), boat noise reduced auditory sensitivity; decreased time spent by adults in nests and caring for young; and increased time spent by fish in shelters (Codarin et al., 2009). In Lusitanian toadfish (*Halobatrachus didactylus*), boat noise affected acoustic communication and decreased hearing sensitivity immediately after exposure to the boat noise stimulant (Vasconcelos et al., 2007). Boat noise also reduced digging, defense capabilities, and increased aggression in the daffodil cichlid (*Neolamprologus pulcher*) and increased metabolism and induced motility in European seabass (*Dicentrarchus labrax*) and gilt-headed bream (*Sparus aurata*) (Bruintjes and Radford, 2013; Buscaino et al., 2010). Most of these studies were evaluated in captivity, limiting interpretations regarding the impacts and risks to wild populations. Therefore, there is a need for more in-depth, in situ studies on the risks of anthropogenic sound on fish.

There is evidence that short-term exposure to noise pollution is

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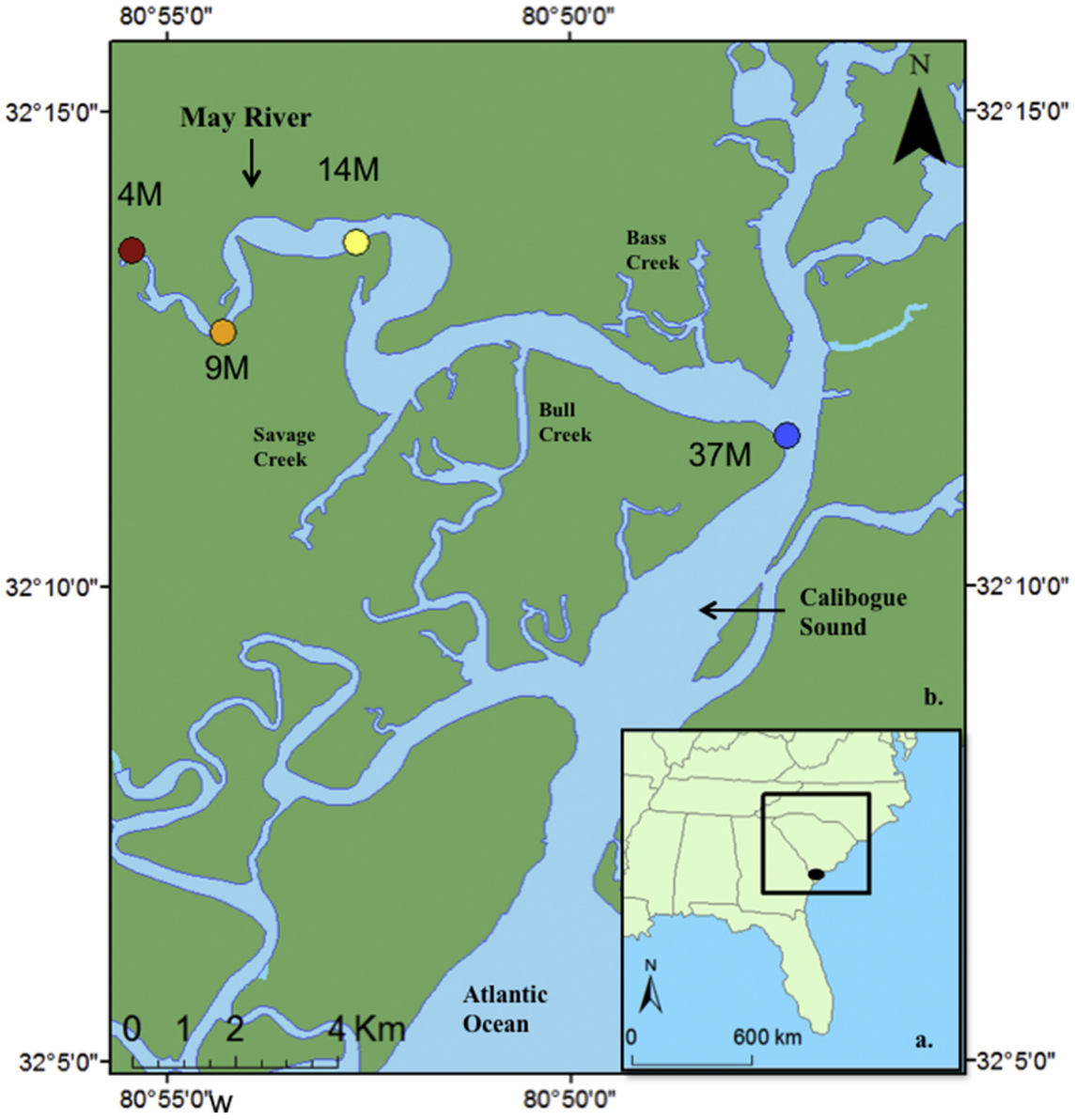

Fig. 1. (a) The location of the May River in reference to the southeast United States is shown by the black circle. (b) The colored circles indicate locations of the DSG-Ocean acoustic recorders at four stations in the May River, South Carolina. These locations were chosen based on previous work that identified these areas as "hot spots" for fish sound production (Montie et al., 2015).

more harmful to fish than long-term exposure (Celi et al., 2016). Boat noise, especially in a recreational context, commonly occurs in intermittent bursts as boats move across a given location (Nichols et al., 2015). Greater exposure to intermittent boat noise during spawning seasons could cause interference and masking of important acoustic signals necessary for successful spawning. In many sciaenid species, males use sound as part of their courtship behavior (e.g., Luczkovich et al., 1999; Sprague, 2000; Lowerre-Barbieri et al., 2009; Luczkovich et al., 2008; Walters et al., 2009; Montie et al., 2015; Montie et al., 2016; Montie et al., 2017). From previous studies, it is thought that males broadcast calls and females are attracted to the sound, and therefore the spawning aggregation (Connaughton and Taylor, 1996). Larger aggregations of males and more calling increases chorus loudness, which can propagate outward over longer distances from the source and attract females from further locations. In addition, drumming in sciaenids may contain information regarding male fitness (Connaughton and Taylor, 1996). If too much boat noise occurs within the frequency range of the acoustic signal, then it is possible that females may not hear male courtship calls and the aggregation could be smaller and less productive. In a study of Lusitanian toadfish in shallow water estuaries exposed to ferryboat traffic, the addition of the ferryboats decreased hearing thresholds from 23 dB to 12 dB. The authors predicted that the ability of females to detect the boatwhistle call of nesting males decreased to about 2 m (Vasconcelos et al., 2007). With the number of commercial and recreational boats increasing, there could be a reduction in successful reproductive events if female fish are unable to locate male chorusing aggregations.

The May River, located near Hilton Head Island, South Carolina, is a large, productive subtidal river estuary with high biodiversity. The river is an important spawning habitat for fish species such as silver perch (*Bairdiella chrysoura*), black drum (*Pogonias cromis*), oyster toadfish (*Opsanus tau*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus*) (Montie et al., 2015; Monczak et al., 2017). All five of these species rely heavily on sound for their spawning events (Locascio and Mann, 2008; Locascio and Mann, 2011; Maruska and Mensinger, 2009; Roumillat and Brouwer, 2004; Parmentier et al., 2014; Montie et al., 2016; Montie et al., 2017). The human population surrounding the May River has grown by 14% between 2000 and 2005