Behavioral Responses of Diamondback Terrapins (*Malaclemys terrapin terrapin*) to Recreational Boat Sounds

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1 Introduction

Anthropogenic sound caused by recreational boat traffic is a major concern for many marine animals because it may alter their behavior, mask sounds necessary for survival, and cause hearing loss. These alterations could potentially lower the chance of survival for individuals and lead to population declines. In this study, the diamondback terrapin (*Malaclemys terrapin terrapin*) in Barnegat Bay, NJ, is used as a model organism to understand how boat engine sound influences behavior. Previously, we used the auditory brain stem response (ABR) technique to determine that terrapins can hear a limited range of low-frequency tones less than 1,000 Hz. Most anthropogenic activities such as recreational boating also produce sound with low-frequency components (Richardson and Würsig 1997).

During the summer months, Barnegat Bay has one of the highest densities of recreational boating in the world (BBNEEP 2002). Terrapins are likely exposed to high levels of anthropogenic sound in Barnegat Bay. Diamondback terrapins are listed as a species of special concern in New Jersey (Hart and Lee 2006); population declines have been caused by anthropogenic impacts such as habitat destruction, roadkill, bycatch in crab traps, commercial harvesting, and increased recreational boating. Of over 3,000 terrapins that have been captured as part of a population study in Barnegat Bay, 14% have scars caused by boat propellers. Thus our research goal was to determine whether terrapins behaviorally respond to playback recordings of approaching recreational boats.

2 Methods

An underwater recording was made with a C54XRS hydrophone and a Sound DSA ST191 digital-recording computer of an approaching Lowe Boat (14 ft, 9.9 hp, 22.9 km/h). The experimental site consisted of a 60-m section of a mosquito ditch. Mosquito ditches are dug to drain marsh surface waters (especially intermittent pools that are used by mosquitoes as breeding habitat) to decrease the mosquito population. Each terrapin was exposed to a 1-min playback recording of boat engine sound using

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an underwater speaker (Lubell LL9816) that was suspended in the water at the center of the experimental site during high tide.

Terrapins were exposed to playback recordings of boat sounds in situ. An individual terrapin was placed in the mosquito ditch at one end and allowed to swim 60 m. The playback recording was started when the terrapin was 10 m from the speaker. Six experimental trials were run for each terrapin: three sound trials and three control trials in which no sound was played. Flags were placed at 10-m increments along the side of the mosquito ditch to divide the ditch into 6 sections. The amount of time that the terrapin spent swimming in each section was monitored as an estimate of its speed before, during, and after sound exposure. A DST milli-L temperature and depth data logger was secured with epoxy on each terrapin's carapace to measure its depth every second during the trials. The depth data logger allowed us to determine if the terrapin was attempting to escape the sound by sticking its head out of the water, burying in the substrate, or climbing out of the ditch.

3 Results

There was high interindividual variation of behavioral responses to the playback recordings of boat sound. Some terrapins spent more time near the surface during sound exposure, whereas others spent more time buried in the substrate at the bottom of the mosquito ditch. The swimming rate of the terrapins before, during, and after sound exposure also varied considerably among the individuals. Some terrapins increased swimming speed in response to the sound; however, other terrapins' swimming speed slowed or remained constant.

4 Discussion

Boat injuries are prevalent in terrapins captured in Barnegat Bay, NJ, and may be detrimental to long-term population viability. Kemp's ridley sea turtles (*Lepidochelys kempii*) alter behavior in response to anthropogenic sound by increasing the mean submergence time (Samuel 2004). By increasing the mean submergence time, *L. kempii* minimize the risk of boat strike. Although terrapins are sensitive to boat sound frequencies, many of the individuals in this study did not alter behavior during and after exposure to the playback recordings. The failure of many terrapins to behaviorally respond to anthropogenic sounds may be detrimental to survival in areas with intense boating. Partial or complete closure of some estuarine areas to boating may be necessary to decrease injury and mortality rates of terrapins and possibly other wildlife.

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