Marine Pollution Bulletin 98 (2015) 221–228

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Ambient noise and temporal patterns of boat activity in the US Virgin Islands National Park

Maxwell B. Kaplan [a,b,*], T. Aran Mooney [a]

[a] Biology Department, Woods Hole Oceanographic Institution, 266 Woods Hole Rd., MS50, Woods Hole, MA 02543, United States
[b] MIT/WHOI Joint Program, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

ARTICLE INFO

Article history:
Received 6 March 2015
Revised 23 June 2015
Accepted 27 June 2015
Available online 6 August 2015

Keywords:
Anthropogenic activity
Noise
Communication
Hearing
Vessel
Soundscape

ABSTRACT

Human activity is contributing increasing noise to marine ecosystems. Recent studies have examined the effects of boat noise on marine fishes, but there is limited understanding of the prevalence of this type of sound source. This investigation tracks vessel noise on three reefs in the US Virgin Islands National Park over four months in 2013. Ambient noise levels ranged from 106 to 129 dB_{rms} re 1 μPa (100 Hz–20 kHz). Boat noise occurred in 6–12% of samples. In the presence of boat noise, ambient noise in a low-frequency band (100–1000 Hz) increased by >7 dB above baseline levels and sound levels were significantly higher. The frequency with the most acoustic energy shifted to a significantly lower frequency when boat noise was present during the day. These results indicate the abundance of boat noise and its overlap with reef organism sound production, raising concern for the communication abilities of these animals.

1. Introduction

Anthropogenic noise is increasingly prevalent in the global ocean (reviewed in Hildebrand, 2009). Human activities such as shipping, pile driving, geophysical exploration, and sonar all introduce noise into the marine environment and this noise can propagate over a range of spatial scales (Urick, 1984). Anthropogenic noise may affect the behavior and physiology of marine organisms from invertebrates (Beets and Friedlander, 1998; Pine et al., 2012) to fishes (Popper and Hastings, 2009) and marine mammals (Di Iorio and Clark, 2010). However, noise levels and their effects are largely unknown (Slabbekoorn et al., 2010).

Much of the documented increase in ocean noise levels has been attributed to commercial shipping activities (Andrew et al., 2002; Chapman and Price, 2011; McDonald et al., 2006) and has primarily been quantified for open-ocean environments. However, small boats can act as transient, high-amplitude noise sources (e.g. Erbe, 2002). These vessels are often operated in near-shore, coastal waters within a range of ecosystems (e.g. Codarin et al., 2009). At present, the extent to and timescales over which small vessel traffic increases ambient noise levels are unknown for most habitats.

As ocean noise increases, so does concern for its impacts on the behavior and physiology of marine animals. Effects have been documented from both transient and continuous anthropogenic noise, with research largely focusing on high-amplitude sources such as air guns (e.g. Fewtrell and McCauley, 2012; McCauley et al., 2003; Popper et al., 2005). However, there is growing evidence that small boat noise can impact fishes. Exposure to boat noise from a range of vessels disrupted schooling behavior in captive bluefin tuna, which the authors argued could affect feeding if a similar response occurred in wild tuna (Sara et al., 2007). Playbacks of vessel noise in the lab raised hearing thresholds for three species of Mediterranean fish, particularly in the frequency range where acoustic communication takes place (Codarin et al., 2009). There is some evidence that boat noise may disrupt orientation behavior in captive larval fish (Holles et al., 2013); however, the extent to which this may occur in the wild is unknown.

Vessel sounds may also help quantify how often boats enter areas of interest. While commercial ship activity can be tracked via Automatic Identification System (AIS) software (Hatch et al., 2008), this technology is typically not used aboard smaller boats. However, small boat presence can be tracked through vessel engine noise (Lammers et al., 2008). Listening for this noise may offer resource managers a way to track the occurrence of at least some boats. Such a tool may be particularly valuable in marine protected areas or locations that are not easily accessed or monitored visually.

In light of these data limitations on small boat noise prevalence and characteristics in coastal waters, and the potential utility of boat noise as means of tracking small vessel activity, the purpose

* Corresponding author.
E-mail address: mkaplan@whoi.edu (M.B. Kaplan).

http://dx.doi.org/10.1016/j.marpolbul.2015.06.047
0025-326X/

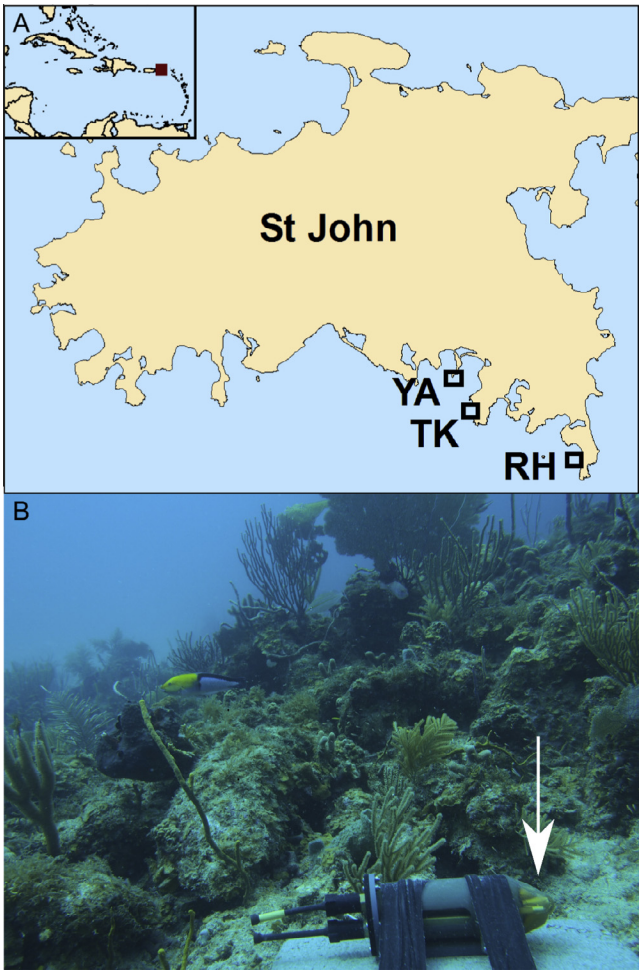

Fig. 1. Deployment map (A) showing locations of three reefs located within the U.S. Virgin Islands National Park on which acoustic recording devices were deployed (TK – Tektite, YA – Yawzi, RH – Ram Head) in 2013. Example of an acoustic recorder mooring (B) showing a DMON (arrow points to hydrophones).

Table 1
Boat noise occurrences and proportion of recording time with boat noise by reef.

Reef	Number of boat noise occurrences	Total minutes recorded	Proportion of minutes with boat noise	Proportion of days free of boat noise
Tektite	115	939	0.12	0.24
Yawzi	72	1267	0.06	0.48
Ram Head	83	1257	0.07	0.50

of this investigation was to characterize the diel, weekly and summer trends in boat noise at three coral reefs located off the island of St. John in the U.S. Virgin Islands National Park. St. John contains a popular marine park, seeing ca. 500,000 visitors per year, many of whom use boats to access local reefs. The island is nearly 60% National Park, with the Park containing ca. 5650 acres of submerged coral reefs, mangrove, and seagrass habitats. It is also a system under stress, seeing declines in coral cover in recent years (Edmunds, 2013). The quantification of potential stressors such as boat noise is needed to gauge the extent of human activity in this ecosystem. The results present a means to potentially track boat occurrence and noise levels in areas of interest.

2. Methods

Three reefs located in the US Virgin Islands National Park were instrumented with acoustic recording devices for ca. four months, starting in April 2013 (Fig. 1). Reefs were chosen based on long-term survey data (Edmunds, 2013) and a rapid, preliminary visual survey of 10 reefs in the area. Two of these – Tektite and Yawzi Point – have been studied for 25 years (see Edmunds, 2013 for review). The third reef – Ram Head – was selected as a comparison site. Mooring balls were located near each of these reefs, some of which were for daytime use only while others could be used for overnight mooring. Tektite ranged from ~9–18 m depth and consisted of a large sloping reef face, Yawzi ranged from ~5–10 m depth and was composed of a large mound that sloped down to sand, and Ram Head ranged from ~8–13 m and was

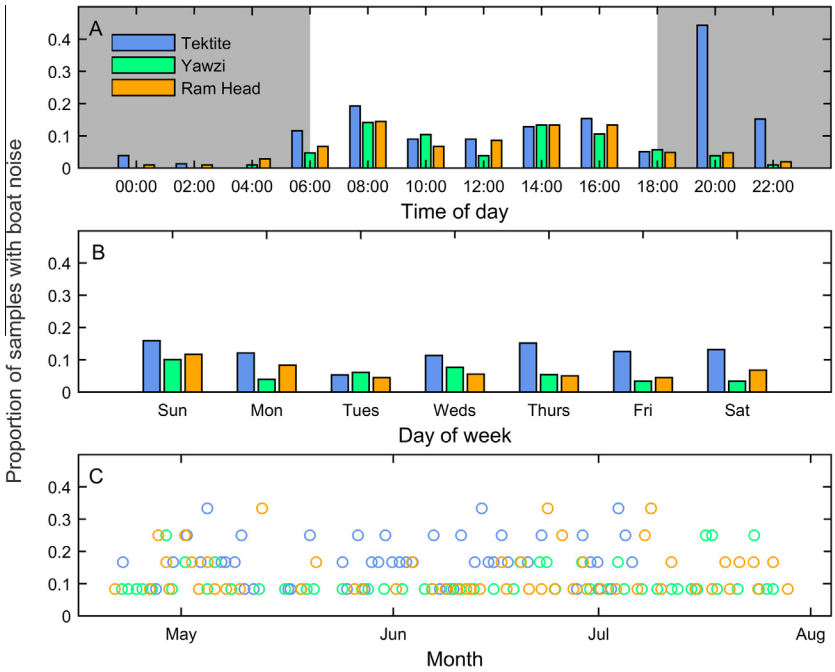

Fig. 2. Summary of the presence of boat noise at three reefs in the US Virgin Islands from April to August 2013 (A) by time of day (gray is 20:00–04:00), (B) by day of week, and (C) summed by day over the entire deployment period.