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Analysis of ship noise around a dugongs' habitat

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ABSTRACT
Dugongs, *Dugong dugon*, are listed in the Red List of IUCN (The World Conservation Union) as a vulnerable species (VU). It is important that we evaluate effects of ship noises on dugongs for peaceful coexistence between humans and dugongs. There is no quantitative study that evaluated the response of the dugong to passing vessels in previous reports. In this study, we will evaluate the effects of ship noises on dugongs' behavior. We obtained the underwater sound data set using an automatic under water sound monitoring systems for dugongs (AUSOMS-D) that were deployed in the southern part of Talibong Island, Trang, Thailand. We analyzed the data recorded from 10:00 on the 28th of February to 6:35 on the 4th of March 2005. Ship noise was detected with a detection software, which allowed a frequency range of 0.3 kHz through 1.0 kHz and a spectrum level of over 82 dB. We detected 71.1 ships (average) a day through the 117 consecutive recording hours. The most frequent boat traffic was observed between 15:00 to 15:30. The next logical step of this study is to draw moving trajectories of ships and dugongs, and also to examine the reactions of dugongs against each ship.

KEYWORDS: Dugong, AUSOMS-D, ship noise, sound source direction

INTRODUCTION

The dugong, *Dugong dugon*, is an herbivorous animal like the manatee. The dugong is a large marine mammal that lives in warm, shallow waters from the tropical zone to subtropical zone. In Japan, dugongs are confirmed as alive in the sea surrounding the main island of Okinawa, which is the northern limit of their habitat. The population of the dugong in Okinawa is said to less than 50 animals (The Mammalogical Society of Japan 1997). Consequently, it is highly possible that the population of dugongs in the area around Okinawa will become extinct. The dugong is also on the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora list as an endangered species.

The dugong is one type of the four existent Sirenia and is the only member of the family Dugongidae. The dugong is the only herbivorous mammal species that is strictly marine-derived (Marsh et al., 1982; Aragones and Marsh, 2000), so the protection of dugongs is necessary for biodiversity conservation. The factors that are presently thought to cause decline of dugong population are reductions of seagrass beds, bycatches either by fishing nets or shark nets, boat strikes and illegal hunting. Fishery regulations have been set up because of concern with bycatches (Australia). Bycatches are unintended occurances in which dugongs accidentally get tangled in fixed nets and gill nets and may die from injuries. Fishing grounds often overlap the living area of dugongs. In order to mitigate the risk of the extinction of dugongs, we need information about dugongs' reactions to ship traffic. In this study, we analyzed the vocal reactions of dugongs to ship noise and examine the effect of ship traffic on dugong behavior.

MATERIALS AND METHODS

Study area

We conducted passive acoustical monitoring in the southern part of Talibong Island, Trang, Thailand. Underwater sounds were recorded in the marked area in this figure from 28th February to 4th March 2004 (Fig.1).

Fig. 1. The study site. Underwater sounds were recorded in the marked area in this figure.

Equipments

The recording was made using the automatic underwater sound monitoring systems for dugongs version 1.0, known as AUSOMS-D for short (Fig.2). The recording system was developed by System Intech Co., Ltd. around acoustical characteristics of dugong calls (Ichikawa et al. 2003).

The main features of the AUSOMS-D are stereophonic recording for over 117 hours, sampling frequency at 44.1 kHz and dynamic recording range from 74 to 120 dB with 16 bit resolution. The stereophonic recording enabled us to calculate the sound source direction by analyzing the time difference between the hydrophones.

Fig. 2. AUSOMS-D

Detection of ship traffic

By using an acoustic filter for ship detection, sounds from the ships passing through the monitored area were extracted. We then calculated the time difference, peak frequency and sound pressure level for each ship. Judging from the continuity of the time lag, we determined the start time and the end time of a ship noise. Figure 3 shows the time series change in the sound source directions. The horizontal axis is elapsed time in seconds, and the vertical axis is the sound source direction. Start-time and end time of the ship noise were determined by the continuous change of the sound source direction. After we had detected ships, we calculated the number of ships per 30 minutes.

Number of dugong calls around ship noise

To examine the vocal reaction of dugongs, we counted the number of ship traffics that were recorded near by the AUSOMS-D (n=16). The ship noise must be separated by 5 minutes to study each case as independent. Then, we counted dugong calls from 1 minute before the ship noise to 1 minute after ship noise. One-way ANOVA tests were performed to compare call rate during 1 minute before ship noise, during ship noise and 1 minute after ship noise.

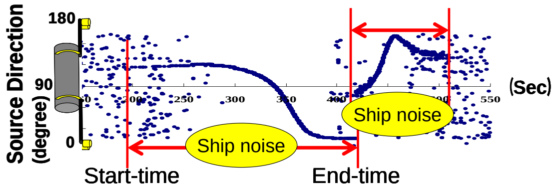

Fig. 3. The time series change in the sound source directions.

RESULTS

Detection of ship traffic

In total, 345 ships were detected during the 117-hour recording. Figure 4 shows the number of ships per 30 minutes. The number of ships between 6:00 – 18:00 accounted for 75.94% of all. Traffic peak occurred twice a day, in the morning and in the afternoon.

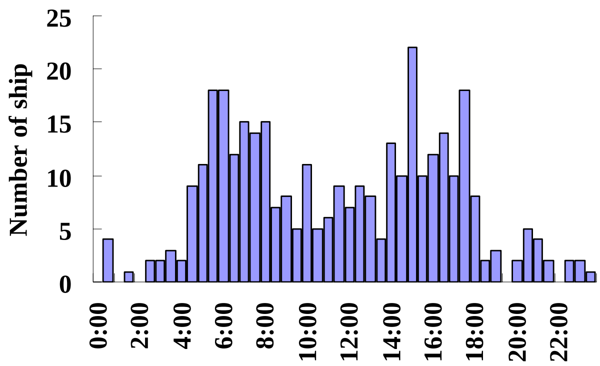

Fig. 4. Number of ships per 30 minutes

Number of dugong calls around ship noise

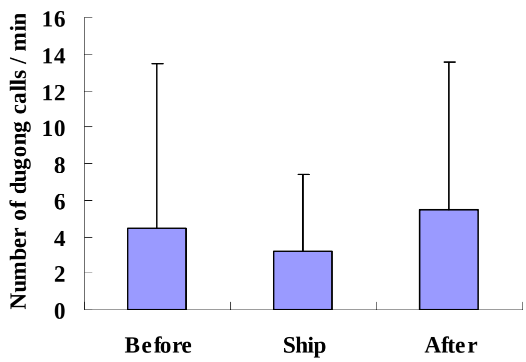

Fig. 5. The number of dugong calls per 1 minute before ship noise heard, during ship noise and after ship noise.

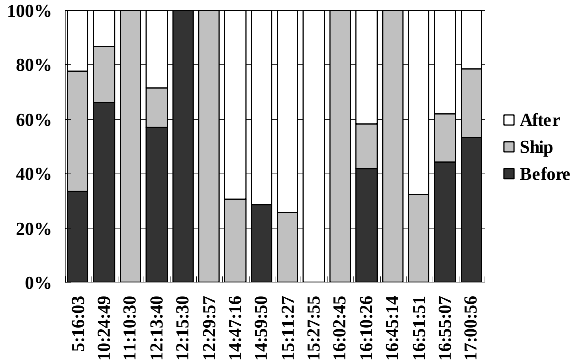

Fig. 6. The ratio of dugong calls per 1 minute before ship noise coming, during ship noise and after ship noise.

Dugongs' vocal reactions were examined with 16 ship traffics. Total number of dugong calls was 260 around the 16 ships. The number of dugong calls per 1 minute before ship noise coming, during ship noise and after ship noise were 4.5±9.0, 3.2±4.3, 5.5±8.0, respectively (average±SD, Fig. 5). One-way ANOVA was used to test whether the presence of ship noise affected the call rate. While there was an increasing trend in call rate in the presence of a ship, it was not significant ($F_{2,,54}$ = 0.382, P = 0.684). Thus, call rate does not vary significantly relative to ship approaches. The proportion of dugong calls vocalized before, during and after each ship noise was showed in Fig. 6.

DISCUSSION

We found out that we could count the number of ships and find the start time and the finish time of ship noise by the graph of sound source direction. This suggested that we can monitor ships by an unmanned system. We cannot say the number of ships was accurate, because we did not compare the number to the actual number of cases. To examine the accuracy of the ship detection, we need the observation during recording. We conducted observations of ships during recordings in October 2005, so we will analyze both data sets. If we can draw pathways of ships and swimming locus of dugong, we think the relationships between ships and dugongs will become clear.

We could not find a clear relationship between the ship noise and the vocalization frequency of the dugong. However when we look at the time of each ship, similar reactions were observed in a relatively short period. Around 10:00 AM to 12:15, the dugong vocalized more often before the ship, but around 14:47 to 15:27, the dugongs were more likely to vocalize after the ship. This might have happened because the positional relationships between the ship, AUSOMS-D and the dugong were different.

The dugong reaction should have been recorded differently according to the positional relationships of the ship, ASUOMS-D and the dugong. If the dugong was closer to the ship than the ASUOMS-D, the vocal reaction of the dugong would be recorded earlier than the ship noise. If the AUSOMS-D was closer to the ship than the dugong, the ship noise would be recorded first and then the dugong's vocal reaction. So, the next logical step for analyzing the reaction of the dugongs to the ship traffic is to locate the positions of the ship and the dugongs.

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