Preliminary study of acoustic identification of odontocetes in the Istanbul Strait, Turkey

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ABSTRACT

In the Istanbul Strait, three odontocetes species are observed; the harbor porpoise which belongs to Phocoenidae and the common dolphin and the bottlenose dolphin which belong to Delphinidae. Previous visual observation conducted in the middle of this Strait showed, Phocoenidae appeared frequently in March and April, whereas Delphinidae appeared throughout the year. However, visual observation can only occur during daytime. On the other hand, acoustic observation can be used all day long, but is not suitable to identify and distinguish different species. In this study, we examined whether a two band acoustic comparison of biosonar sounds can identify family or species of odontocetes. We compared the sound intensity ratio of two frequency bands at 70 kHz and 130 kHz. Narrow-band sounds, with dominant frequency around 130 kHz, correspond to a large ratio of two band intensities, possibly originating from Phocoenidae. In contrast, broad-band sounds provide similar intensities at both frequencies, which possibly originating from Delphinidae. The results show Phocoenidae appeared frequently in March and April, whereas Delphinidae appeared during all months. These findings are consistent with previous visual observations and suggest that two band acoustic monitoring of small odontocetes could be useful for the identification of harbor porpoises from Delphinidae species in a long term study.

KEYWORDS: **Passive acoustic monitoring, harbor porpoise, Phocoenidae, Delphinidae**

INTRODUCTION

Visual detection has been commonly used to observe odontocetes. However, a number of limitations can be noted. Observers can detect only a part of the animal when it surfaces. The animals are visible only during daytime and at a low sea state without fog. In addition, the variability of attention spans among observers could provide additional biases (Li et al., 2009).

The passive acoustic observation method is becoming increasingly common as the alternative to visual observation. Its detection performance did not change on account of weather or light conditions and was not affected by the observation efforts of humans. Small odontocetes such as dolphins and porpoises frequently vocalize sounds used for navigation, orientation and prey capture (Au 1993; Akamatsu et al., 2005a). This is the key reason that they are suitable for passive acoustic observation, which recently has been used more widely (reviewed by Mellinger et al., 2007).

Passive acoustic monitoring systems using hydrophone arrays have been widely applied for the density estimation and behavior observation of odontocetes (e.g., Hastie et al., 2006; Verfuß et al., 2007; Kimura et al., 2010) Recently, passive acoustic monitoring was also used for species identification (Roch et al., 2007; Osward et al., 2007; Soldevilla et al., 2008). However, large-scale and expensive array systems make wider application difficult. Additionally, a complex algorism for the identification prevents the comparison of data between different observation systems (Todd et al., 2009).

It is known that animals from the Delphinidae family use broadband sounds to recognize their surroundings. The biosonar sound has energy over a broad frequency ranging from 20 kHz to 200 kHz (Au 1993). The power spectrum level shows a relatively flat shape from 50 kHz to 130 kHz. On the other hand, the Phocoenidae family uses narrow-band high-frequency sounds with the peak energy reached at approximately 130 kHz (Madsen et al., 2005). These differences are effective to assist in identifying families of small odontocetes.

In the Istanbul Strait, there are three odontocetes species, the harbor porpoise (*Phocoena phocoena*) the common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Tursiops truncatus*). Harbor porpoises belong to Phocoenidae and the other two species belong to Delphinidae. In this study, we examine whether it would be possible to identify family or species using only a two band ratio of 130 kHz and 70 kHz. It is so easy that even a simple logging system can achieve this and it does not require complicated analysis.

MATERIALS AND METHODS

Acoustic equipment

We used a stationary stereo acoustic data-logger, A-tag (ML200-AS2, Marine Micro Technology, Saitama, Japan) for passive acoustic monitoring. It consisted of two ultrasonic hydrophones (-200 dB/V sensitivity), approximately 650 mm apart. A passive band-pass filter of 55-235 kHz, which includes the peak-to-peak frequency of the harbor porpoise, (129-145 kHz, Villadsgaard et al., 2007) was used in the analogue preprocessing of the A-tag's circuit. A-tag is an event data logger that records sound pressure as well as the time difference in sound arrival between two hydrophones. The resolution of time difference in sound arrival is 271 ns. Each hydrophone has a different maximum sensitivity of frequency. One hydrophone reaches maximum sensitivity at 130 kHz, and the other at 70 kHz. Received sound pressure from the two hydrophones and the sound time arrival difference were recorded every 0.5 ms. Note that the acoustic event recorder A-tag did not store waveform. The details of A-tag were described in Akamatsu et al., 2005b.

Study site

A-tag has been deployed in the middle of the Istanbul Strait from July 2009 to the present (Fig. 1). The A-tag was fixed onto a steel pipe beside the water break (Fig. 2). The maximum detection distance which could detect both the harbor porpoise and Delphinidae was approximately 730 m, assuming spherical sound propagation and peak-to-peak source level of the harbor porpoise is 205 dB referred to 1 µPa (Villadsgaard et al., 2007). The absorption coefficient was 0.02 dB/m calculated using the formula of Francois and Garrison (1982).

Data analysis

We used effectively recorded acoustic data from March, April, August, and September of 2010 for this study.

The two band ratio is defined as the ratio of received sound pressure of two hydrophones (130 kHz/70 kHz). Two band ratio was calculated click by click and averaged value was calculated in a click train. If the intervals of clicks were longer than 200 ms, we defined this as the boundary of two click trains since inter-click intervals longer than 200ms were scarcely observed.

Numbers of click trains in each month were sorted according to the two band ratio value associated with each train.

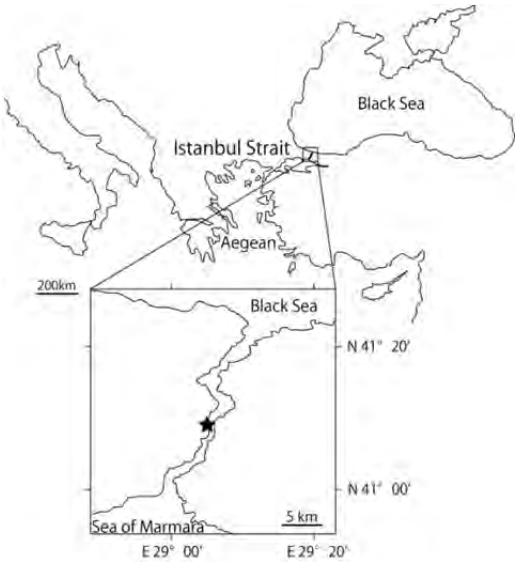

Fig.1. Location of the monitoring station (indicated by star) and the Istanbul Strait. The length of the strait is 31 km. The surface layer of the water always flows from the Black Sea to the Sea of Marmara and bottom layer water flows in the opposite direction.

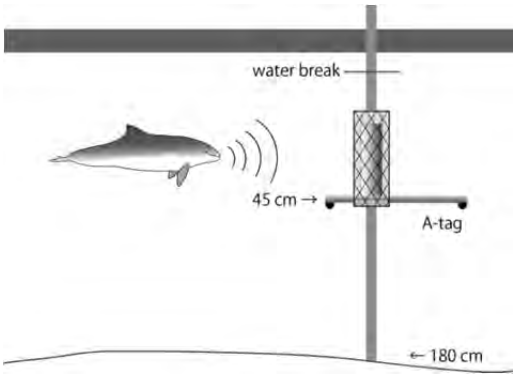

Fig. 2. The passive acoustic monitoring station. Depth from the bank to the bottom is approximately 180 cm. An iron pipe with cage was fixed vertically onto the bank of the strait and the A-tag was deployed to about 45 cm in depth.

RESULTS AND DISCUSSION

We obtained 114 days of effectively recorded acoustic data. In total, 11112 click trains were detected.

Distribution of two band ratio for each month was shown in Fig. 3. Bimodal distribution which includes a large two band ratio component was recorded in March and April. On the other hand, unimodal distribution of the two band ration was recorded in August and September.

Previous field studies conducted in visual observations, showed that harbor porpoises appeared in this area frequently in March and April (Dede et al., 2010). No other Phocoenidae species except for harbor porpoises appeared in the survey area. The data we obtained is consistent with the presence of harbor porpoises during spring time.

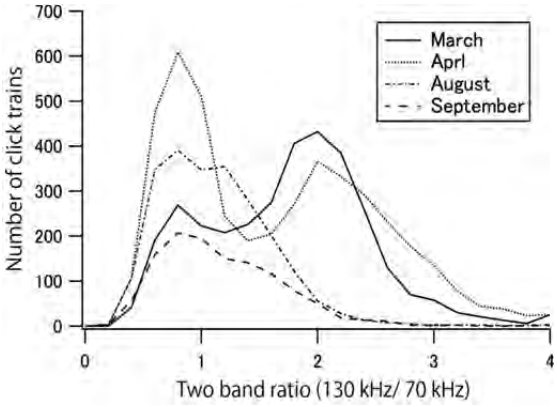

Fig.3. Two band ratio of 130 kHz and 70 kHz recorded each hydrophone of A-tag. There are two peaks around 1 and 2 in March and April. However, only one peak of around 1 appeared in August and September.

Obviously, further studies are needed. Visual confirmation associated with two band acoustic recording is necessary. This validation should be conducted in the wild as well as using captive animals. Discrimination in the performance of two families using two band ratios should be examined.

The two band ratio comparison is a simple method. It can be monitored using various types of sound recording devices. We aim to improve the classification performance using a two band ratio as the index of the odontocetes family in future studies.

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