Differences in Biosonar Sound Characteristics between Cetacean Species in the Istanbul Strait

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ABSTRACT
Previous visual observation suggested there is a possibility of difference in habitat use between harbor porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncatus*) in the Istanbul Strait (Bosphorus). However, no direct evidence of difference was recorded, except for the number and area of sightings so far. From 12 April to 1 June 2012, passive acoustic monitoring was conducted with visual observation. The click trains with visual confirmation of species were extracted to compare the difference of inter-click intervals between harbor porpoise and bottlenose dolphins. In the results, the inter-click intervals showed multimodal distribution, which had one peak around 40-50 ms and the other around 100-130 ms in bottlenose dolphins. On the other hand, harbor porpoises showed only one peak around 10-20 ms. These results suggest that two species are using biosonar for different sensing distances even in the same area.

Keywords: passive acoustic monitoring, harbor porpoise, bottlenose dolphin

INTRODUCTION

Where bottlenose dolphins and harbor porpoise live sympatrically, sometimes violent interaction and competition between species are observed (Ross and Wilson, 1996; Barnett et al., 2009; Cotter et al., 2012). For example, in Moray Firth, the evidence of aggressive behavior of bottlenose dolphin towards harbor porpoise was found (Ross and Wilson, 1996). In addition, Spitz et al., (2006) suggested that overlap of prey distribution for both species is happening in the same area. These competitions were considered as one of the factors that caused competition and the difference in the spatial distribution between species (Thompson et al., 2004).

The Istanbul Strait (Bosphorus) is one of the habitats in which bottlenose dolphins and harbor porpoises are observed sympatrically. Previous visual observation study conducted in the strait showed that the number of sightings was different between areas. The bottlenose dolphin was dominant in the north and south parts of the strait. On the other hand, the harbor porpoise was dominant in the middle of the strait. This difference in spatial distribution between species is possibly caused by species competitions (Öztürk et al., 2009). However, no other interpretation to support this hypothesis, such as behavioral difference or habitat use, has been recorded, except for the number and area of sightings so far.

In this study, we examined if there are behavioral differences between these two species in the same area using the sound characteristics of animals recorded passively. Passive acoustic observation has been widely used for cetacean observation in recent years because this method has the advantage that it can continue at night and rough weather conditions, when visual observation cannot be made (Mellinger et al., 2007). In this study, we deployed a hydrophone in the focal area and recorded high frequency pulse sounds of odontocetes. We compared inter-click intervals which can partly represent the underwater acoustic sensing distance (Akamatsu et al., 2010). It is known that the inter-click intervals specifically change in some behavior. For example, minimum inter-click intervals of less than 10ms are used as the indicator of feeding activity (Carlström, 2005). If inter-click intervals showed different characteristics between two species, there is possibility that they are using the same area in different ways.

MATERIALS AND METHODS

Acoustic and visual observation was conducted simultaneously in the middle of the Istanbul Strait from 12 April to 1 June 2012 (Fig. 1). Acoustic observation was continuously conducted days and nights, while visual observation was conducted only during daytime under good weather conditions. Only the sounds of animals recorded both visually and acoustically were extracted for analysis. Visual observation was conducted at the same point with acoustic observation, measuring the distance from the hydrophone to animals and identified species (Fig. 1). Not only bottlenose dolphins and harbor porpoises but also short-beaked common dolphins (*Delphinus delphis*) appeared in this strait. The common dolphin's data were excluded from the analysis based on the visual observation of species confirmation because we only focused on the difference between bottlenose dolphins and harbor porpoises.

We used a stationary acoustic data logger, A-tag (ML200-ASII; Marine Micro Technology, Japan) for passive acoustic monitoring. The A-tag is an event data logger with two hydrophones, CPU, flash memory and batteries. When the sound reaches an A-tag with over preset threshold (138 dB peak-to-peak re 1 μPa), it can record absolute time, sound pressure and arrival time difference in sounds between two hydrophones. The absolute time data were used to calculate inter-click intervals in this study. We defined the boundary of different click trains at 200 ms of click intervals. If click sequences were separated by more than 200 ms, each sequence was considered a different click train (Akamatsu et al., 2007). The average of inter-click intervals in a click train was analyzed.

In addition, maximum acoustical detection distance was calculated as 524 m for harbor porpoise and more than 1000 m for bottlenose dolphin, using source level of bottlenose dolphin, assuming spherical sound propagation and 227 dB peak-to-peak re 1 μPa (Simard et al., 2010), that of harbor porpoise, 201 dB peak-to-peak re 1 μPa (Villadsgaard et al., 2007), and absorption coefficient, 0.024 dB/m (Francois and Garrison, 1982a, 1982b).

Species confirmation was obtained by visual observation. We recorded the time and species sighted. Two observers conducted observations on a bank side from the pier where the A-tag was deployed. Visual observation team was consisted of three persons. Two person covered 90° each from the observation point on the bank. Thus, these two persons were in charge of a 180° sector from the observation point covering entire water surface. One period of observation lasted 30 min, and the position was changed in turn. The remaining observer rested during off-duty periods.

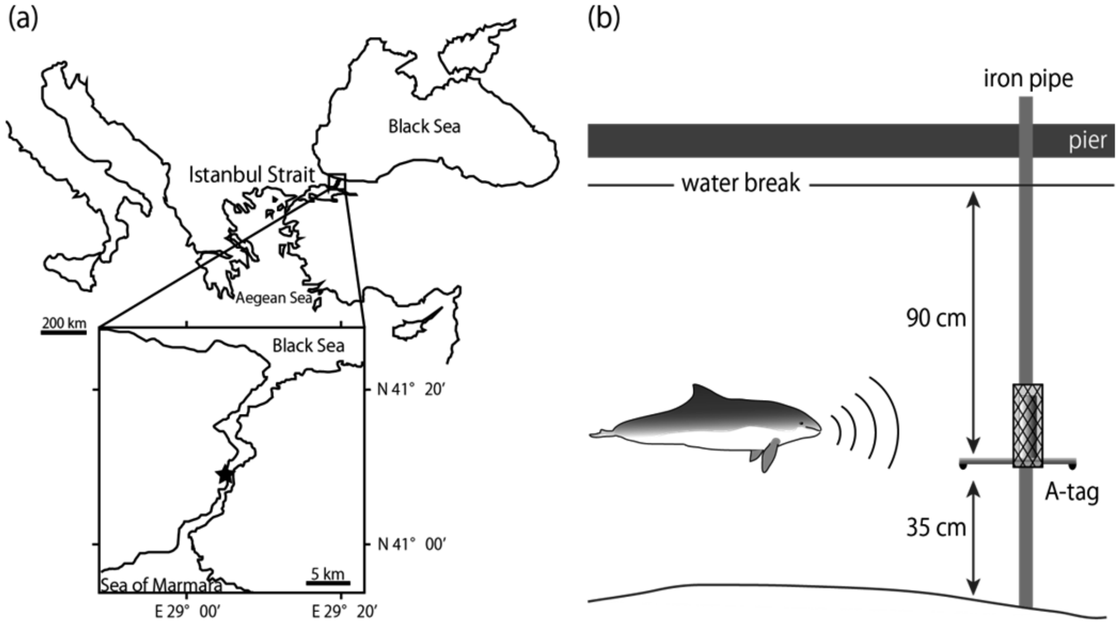

Fig. 1 (a) Location of the study area. Length of the Istanbul Strait is 31 km, width is 0.7-3.2 km. Acoustic and visual observations were conducted at the place indicated by star (★), which is the middle of the strait. The distance to the opposite shore is approximately 850 m at this point. (b) Diagram of A-tag deployment. An A-tag was fixed at the pier using an iron pipe. The tidal change is small enough not to expose the A-tag in the air.

RESULTS AND DISCUSSION

The recordings of 344 click trains from bottlenose dolphins and 59 click trains from harbor porpoises were analyzed. The shortest average of inter-click intervals was 5.1 ms in bottlenose dolphins and 9.3 ms in harbor porpoises. The longest value was 186.0 ms in bottlenose dolphins and 165.5 ms in harbor porpoises. The frequency distribution of average inter-click intervals is shown in Fig. 2. The average of inter-click intervals showed multimodal distribution which has one peak around 40-50 ms and the other around 100-130 ms in bottlenose dolphins. On the other hand, harbor porpoises showed only one peak around 10-20 ms.

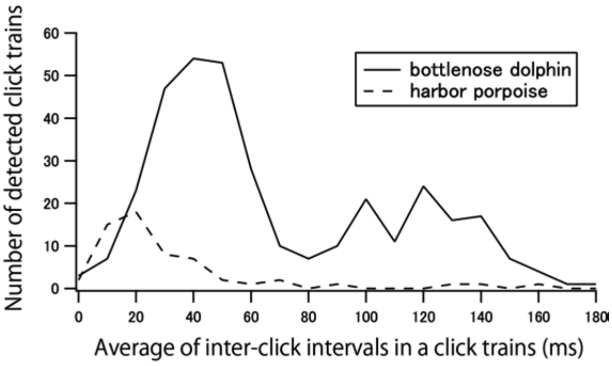

Fig. 2 The frequency distribution of average inter-click intervals

Inter-click intervals can be an index of their acoustical sensing distance of animals (Au, 1993). From the results, it turned out that harbor porpoises were sensing shorter distance than bottlenose dolphins. In addition, bottlenose dolphins might switch their biosonar use between short range sensing and long range sensing during the observation period. These differences could reflect their intentional behavioral control in the observed area or the physical acoustical difference between species such as sound source level. It is true that the sound source level of harbor porpoise is smaller than that of harbor porpoise. This could limit the maximum sensing distance of harbor porpoises. However, a previous study conducted on wild harbor porpoise shows that they still used clicks with longer inter-click intervals up to 150 ms (Akamatsu et al., 2007). Therefore the difference we showed here could be explained by behavioral difference rather than physical difference between species. Note that the present study shows preliminary results which were recorded in a limited area over a short period of time. Further study is necessary to reveal if there is conflict or different feeding strategies between two species in the Istanbul Strait.

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