Characteristics of ship noise in a critical habitat of the world's second largest humpback dolphin population: Implications for conservation

Mingming Liu
Institute of Deep-sea Science and Engineering Chinese Academy of Sciences, China
+86-13976199641
liuming@idsse.ac.cn

SUMMARY

Growing ship traffic worldwide has increasingly led to underwater noise, of which medium-to-high frequency components potentially make adverse impacts on marine mammals. As the critical habitat of the world's second largest humpback dolphin population, little is known about characteristics of underwater noise in Zhanjiang waters yet, where located an important port with busy marine traffics. Whether substantial underwater noises affect humpback dolphins? What components these noises consist of? And what level these noises affect humpback dolphins? We propose to record and analysis characteristics of ship and background noise in Zhanjiang waters to answer these scientific questions.
Project Description

1. General description

Growing ship traffic worldwide has led to increased ship noise with potential adverse impacts on marine lives (Hildebrand, 2009). However, many studies only focused on low-frequency components of underwater noise from ships or other sources (Hermannsen et al., 2014). But for odontocetes, such as the Indo-Pacific humpback dolphin (Sousa chinensis), which generally operates in the medium-to-high frequency, these noise components are likely more of concern (Southall et al., 2007; Li et al., 2015). Indo-Pacific humpback dolphin (locally named Chinese White Dolphin) is a mid-frequency cetacean (Southall et al., 2007). Audiometry data of two rescued individuals has shown that their sensitive hearing frequency approximately ranges from 5 kHz to 120 kHz (Li et al., 2012; Li et al., 2013), which has a certain overlap with medium-to-high frequency underwater noise (Li et al., 2015). As near-shore small odontocetes, Indo-Pacific humpback dolphins distributed in the oceans of the Indo-Pacific region, including the coastal waters of southeast China (Jefferson & Rosenbaum, 2014). Even though Sousa. Spp. was listed as "Near Threatened" (NT) by Red List of International Union for Conservation of Nature (IUCN), the humpback dolphins in Chinese waters, i.e., S. chinensis, would qualify as Vulnerable (VU), if assessed separately (Reeves et al., 2008). Moreover, this species was listed as one of the Grade one National Key Protected Animals by the Chinese State Council, which is similar to the likely extinct Yangtze River dolphin (baiji, Lipotes vexillifer) (Turvey et al., 2007). Due to increasing human activity in the near-shore waters, most known populations face diverse threats such as habitat degradation or destruction, harassment, overfishing, and noise pollution etc. (Jefferson & Hung, 2004). Unfortunately, little is known about these threat factors, especially noise pollution, which makes it difficult to propose and carry out effective measures for humpback dolphins' conservation.

A recent newest study quantitatively estimated that there were about 1500 individuals inhabiting in Zhanjiang waters, identifying this humpback dolphin population as the world's second largest one (Xu et al. 2015). In Zhanjiang waters, two separated hotspots for the sightings could be clearly identified: one is in Leizhou Bay (20°47' - 20°58' N, 110°18' -110°35' E) and another one in the northern entrance of Zhanjiang Port (20°47' - 21°05' N; 110°18' - 110°33' E) (Lin et al., Unpublished). As one of the hotspots, the northern entrance of Zhanjiang Port has a considerable biomass of fish resources because of rapid change in depth between channels and non-channel near-shore waters. Furthermore, there are substantial area overlap between one of these channels, i.e., Longteng channel, and the critical habitat of this humpback population, which was assumed that an unwilling trade-off might exist between mortality or noise risk and forging nearby these navigational channels (Lin et al., Unpublished). On one hand, we have observed not a few interactions between ship and humpback dolphins in the field in our prior study, which primarily include different kinds of boat-avoidance behaviors, such as deep-diving, switching direction of swimming, and speeding up etc.; on the other hand, some individuals could be easily identified with apparent and permanent scares on the body or dorsal fin through our photo identification (PHID) work, which were considered to be injured by ship or propellers. All these visual evidences demonstrate marine

traffic in this busy port actually has brought much of adverse influences to humpback dolphins inhabiting here. However, due to a lack of any underwater acoustic data, now we still do not have enough experiment-based evidences, so as to learn about types and characteristics of underwater noise, as well as to assess what level these noises affect humpback dolphins.

2. Research goals

The following are the main research goals of this project: (1) to learn about what components ship noise contain in Zhanjiang waters; (2) to analyze and describe types and characteristics of these noise; (3) discuss whether potential underwater noises affect humpback dolphins; (4) if potential influences really exist, what level these noises affect humpback dolphins; and (5) make some effective recommendations or measures for conservation.

3. Research plan and methods

3.1 Experimental instruments

A broadband record system (Ocean Sonics Ltd., Canada) equipped with an icListen HF smart hydrophone (Reson, Slangerup, Denmark; sensitivity: -170 dB re 1V/μPa; flat frequency response: 0.01–100 kHz ± 3 dB) has been purchased, and put into use steady in our pre-experiment. This system will help us record acoustic signals in a broad frequency band (0.010-200kHz), which contains both traditional low frequency and medium-to-high frequency acoustic components. Automatic Identification System (AIS; FTGMDC Ltd., China) will be mounted on the research boat with an aerial transmitter and a signal receiver, so as to view real-time traffic in a c. 10 n miles on the monitor screen. We can view and record the entire real-time information of ships within the detection range of AIS, which include location (latitude, longitude), distance off the research boat, speed, direction, steering angle, ship name, draught, tonnage, maritime mobile service identify (MMSI) etc. Some other instruments will be also used for helping recoding and judgment, such as telescope (FUJINON Ltd., Japan), depth meter (Honda Electronics Co., Ltd., Japan), rangefinder (Bushnell, U.S.), and Olympus E-M1 digital camera (Olympus Ltd., Japan).

3.2 Field work

The field work of this project will be carried out at the northern entrance waters of Zhanjiang Port (20°47' - 21°05' N; 110°18' - 110°33' E). The record parameters of smart hydrophone (sampling rate, record starting time, recording-time length, and file format etc.) has been set by connecting it with the computer on land in our pre-field work, and all the other instruments and equipment have been insured work normally. A 12-meters-long fishing boat will be rent by us as the research boat. We will firstly arrive at our study waters and then anchor our research boat at a suitable position, so as to keep recording location stationary during our recording period. The smart hydrophone will be lowered into the water at a 3-8 meters depth (approximately middle water layer), and the hydrophone cable will be mounted with 3 kg stone weights in the bottom to minimize vertical movements of the hydrophone caused by waves and swell. Then we turn on the AIS to view real-time marine traffic in the c. 10 n miles waters. If a ship moves close to us at a 100-3000 meters distance with no other moving ship or animals interruption in c. 2 kilometers, we will record the starting and ending time of acoustic recording system, the closest point of approach (CPA distance), nearest other ship at CPA time, ship type, ship name, draught, tonnage, MMSI etc. Furthermore, location (latitude, longitude), distance off the research boat, speed, direction will be also recorded in the pre-designed tables manually every 15 seconds. All recordings are obtained at a sea state below Beaufort 2. We have enough colleagues (at least 1 assistant professor, and 1-3 undergraduate students) to accomplish our field data-collecting work.

3.3 Lab work

Through field work, we can obtain two parts of data, i.e., spatial and temporal data of focal ships, and ship sounds data. Each ship sound file has the only one spatial and temporal recording information correspondingly. We will firstly check the entire ship information on the website of marine traffic (www.marinetraffic.com). After verifying potential recording errors, our original spatial and temporal data will be entered into Excel tables. And then these data files will be put into different folders, dividing groups by ship types, such as cargos, tankers, dredgers, official ships, navy ships, and fishing boats etc. The data of similar ship type will be put into a given name folder "Date-Type" (e.g. 20161005-Cargo).

After pre-analysis work, we can start our lab analysis work. The work of analyzing ship sounds primarily

consist of the following analysis: (1) checking the waveforms and spectrograms (a fast Fourier transform [FFT] of 2048, a hamming smoothing window, a bandwidth of 195 Hz, and an FFT window overlap of 50%) of the recorded broadband sounds made by the focal ships in MATLAB (MathWorks, Natick, MA, USA); (2) analysing the ship sounds in one-third octave sound pressure levels (1/3 octave SPLs) at the CPA using customized MATLAB algorithms for standard frequencies from 1 to 125 kHz (ANSI, 1984), because a 1/3 octave level represents the root-mean-square (RMS) sound pressure in a 1/3 octave band is believed to approximate cetacean auditory bands (Greene, 1995); (3) taking a 1-s time window around the time of the CPA to calculate the received 1/3 octave SPLs, by considering changes in the range and aspect from the boat during the analysis window; (4) using two previously published audiograms from Indo-Pacific humpback dolphins (one each from a young and an old dolphin) (Li et al., 2012, 2013) to compare with the 1/3 octave SPLs of the ship and ambient noise. All the analysis will be performed only for recordings where no other ships are closer to the recording site than 2 km, to ensure recorded noise is in fact from the focal ship.

4. Meaning and significance of this research

Marine mammals are of special concern, when assessing potential impacts of anthropogenic underwater noise, as they are critically dependent on sound to navigate, communicate, and in the case of toothed whales, to forage by echolocation. All the marine mammals have been protected in Chinese waters since 1988. However, we have little knowledge and understandings about anthropogenic activities e.g. underwater noise before. Therefore, it seems difficult for us researchers to arise any conservation measures or actions if there are no evidence-based studies. In our project, we want to quantitatively assess underwater ship noise and its potential influences upon small odontocetes, i.e., the Indo-Pacific humpback dolphin (Sousa chinensis). Based on field study and experimental data, more details will be understood for us about how to mitigate potential adverse influence.

5. Timeline

This project is to be completed during 2016-2017, according to following schedule:
Jul 2016-Aug 2016: Pre-field work (testing and setting instruments);
Sep 2016-Oct 2016: Field work (carrying out field experiments);
Nov 2016-Feb 2017: Lab work (data analyzing);
Mar 2017-Apr 2017: Writing (paper writing);
May 2016: Final report (report writing and submitting)

6. Budget (Maximum $1500)

Land transportation: $300 (round trip tickets: $100/person, a total of 3 people in plan);
Renting research boat: $600 (renting fees: $150/day, a total of 4 days in plan);
Hotel: $180 (hotels: $15/day/room, a total of 3 rooms* 4 days in plan);
Meals: $180 (meals: $15/person/day, a total of 3 people* 4 days in plan);
Publishing: $240;
Total of funds requested: $1500.

7. Other funds available for this project

National Natural Science Foundation of China (Y410012): purchasing broadband recording system (Ocean Sonics Ltd., Canada)——$34000
Ocean Park Conservation Foundation of Hong Kong (OPCFHK, Nos.MM02-1516): purchasing Automatic Identification System (AIS; FTGMDC Ltd., China)——$500
“Hundred Talents Programme” of the Chinese Academy of Sciences (SIDSSE-BR-315 201201, Y410012): purchasing telescope, depth meter, rangefinder, and Olympus E-M1digital camera etc.——$4000
Informatizational special fund of the Chinese Academy of Sciences (No.XXH12504-3-20): purchasing MATLAB 10.0 software (MathWorks, Natick, MA, USA)——$2000

8. Legal permits

This project will be performed in accordance with current Chinese regulations and laws regarding marine mammals. Moreover, the Institute of Deep-Sea Science and Engineering, Chinese Academy of Sciences have approved and stood by our laboratory research work upon Indo-Pacific humpback dolphin (Sousa

chinensis) in waters around Hainan Island and other marine mammals in the South China Sea. All of our projects and plans upon marine mammals will be submitted to local fisheries administration, which is responsible for management and conservation of marine mammals in China.

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10. Short Curriculum Vitae

¬ Name: Mingming Liu
¬ Gender: Male
¬ Nationality: People's Republic of China
¬ Born: April 15, 1993
¬ E-mail: liuming@idsse.an.cn
¬ Address: 28# Luhuitou Road, Sanya, Hainan, 572000, China
¬ Current occupation: pursuing master degree in Marine Mammal and Marine Bioacoustics Laboratory, Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences; supervised by Prof. SH Li (e-mail: lish@idsse.ac.cn)
¬ Primary research interests: Marine Biology, Conservation Biology, and Marine Bioacoustics
¬ Education Background: 2014 Sep - 2015 Jun, College of Earth Sciences, University of Chinese Academy of Sciences; 2010 Aug - 2014 Jul, College of Marine Technology and the Environment, Dalian Ocean University, bachelor degree in Marine Fisheries
¬ List of Publications:

Mingming Liu, Mingli Lin, Samuel T. Turvey, Songhai Li*. Fishers' knowledge as an information source to investigate by-catch of marine mammals in the South China Sea. Animal Conservation (Major revision)
Mingming Liu, Mingli Lin, Songhai Li*. How socio-economic indicators affected fishers' conservation awareness about marine mammals? (Ready to submit)
Mingli Lin, Mingming Liu, Sovan Lek, Rodolphe E. Gozlan, Songhai Li*. Distribution and habitat use of the world's second largest Indo-Pacific humpback dolphin population. (Ready to submit)
Mingli Lin, Sovan Lek, Mingming Liu, Xiao Xu, Kuan Li, Songhai Li*. Is it worth the risk? Habitat selection of Indo-Pacific humpback dolphin under human-caused disturbance stimuli. (Under review)
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