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Measurement of underwater radiated noise from a ship using self-recording hydrophones

Bong-Chae Kim[1†], Bok Kyoung Choi[2], Byoung-Nam Kim[1], and Cheolsoo Kim[3]
([1]Maritime Security Research Center, Korea Institute of Ocean Science and Technology;
[2]Marine Safety Research Center, Korea Institute of Ocean Science and Technology;
[3]Advanced Ship Research Division, Korea Research Institute of Ships and Ocean Engineering)

1. Introduction

Inhabited environment of marine animals such as whales is gradually worse by increase of ocean noise[1]. The greatest cause of the increase of ocean noise has been reported to be ships. Recently, the International Organization for Standardization has established a standard for general requirements for the measurement of underwater radiated noise by ships in deep sea[2]. Three methods, that is, support-vessel deployed, bottom anchored, and remote transmitted, have been introduced as typical hydrophone deployment configurations in this standard. Hydrophone cable as a medium for transmitting acoustic signals detected by hydrophones is used in all these methods. In these methods, the cable is inconvenient to handle to be multiplexed and heavier if the number of hydrophone increases. To solve the disadvantages of hydrophone cable installed, the measuring system without hydrophone cable is developed to measure underwater radiated noise by ships. Here, the developed system is introduced and the measured results of the underwater radiated noise by a ship is discussed.

2. Measuring System

The measuring system for underwater noise radiated from a ship using the self-recording hydrophones is developed in order to solve the disadvantages of measurement system with hydrophone cable. The developed system is shown in **Fig. 1**. The system is composed of three self-recording hydrophones and depth sensors, an acoustic release, a weight, a surface buoy with a GPS receiver, a sub-surface buoy, buoys and auxiliary ropes. The self-recording hydrophone is a device for measuring underwater noise radiated by a ship and the depth sensor is a device for measuring depth of hydrophone. The GPS receiver mounted on the surface buoy is a device for measuring position of self-recoding hydrophones. The model TC4032-2 provided by the Teledyne RESON was used in the self-recording hydrophone as a hydrophone sensor and the model TDR-2050 provided by RBR Ltd. was used in the self-recording hydrophone as a depth sensor. And the model AKN-1M provided by the Ascen Global Co. was used in the measuring system as a GPS receiver.

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bckim@kiost.ac.kr

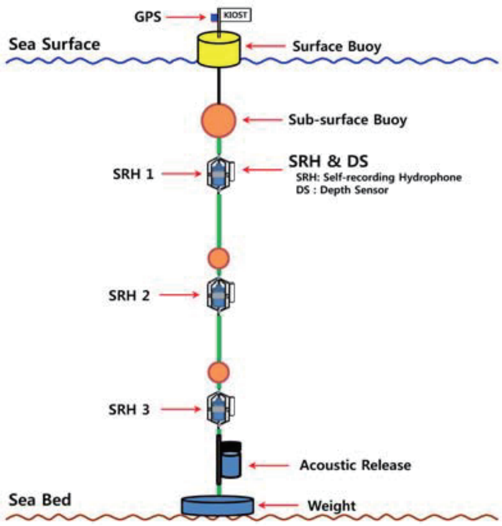

Fig. 1. Measuring system for underwater radiated noise by ships using self-recording hydrophones.

3. Measurement Results

The underwater noise radiated by a 50,000-ton container was measured to test the developed measuring system in late March 2014 at the Korea Strait. The water depth of this area is about 105 m, and the self-recording hydrophones were moored to be positioned at depths of 20 m, 50 m, and 80 m, respectively. The position depths of the self-recording hydrophones measured by the depth sensor are shown in **Fig. 2**. The target ship was sailing with the underwater radiated noise under the conditions of MCR(maximum continuous rating) and port approach to the measuring system. The each position data of the surface buoy and the target ship were obtained by the each GPS receiver mounted on the buoy and the ship. The distances between the buoy and the ship were calculated from these position data at every second interval. The distances with time were shown in **Fig. 3**. And the ship's speed and the CPA(closest point of approach) were 14.1 knots and 155 m, respectively.

The analysis section of the noise measurement data from the start position to the end position was determined on the basis of the ISO standards. In other words, here, it was used the measurement data between ± 22 s for the analysis to the time when the closest distance.

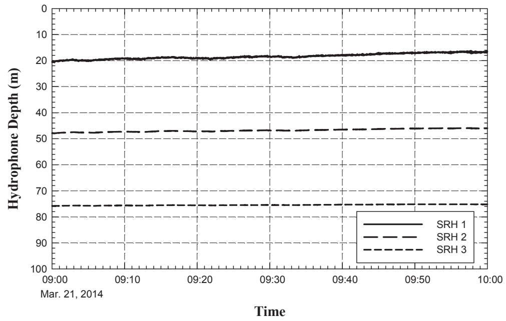

Fig. 2. Position depths of self-recording hydrophones measured by depth sensors.

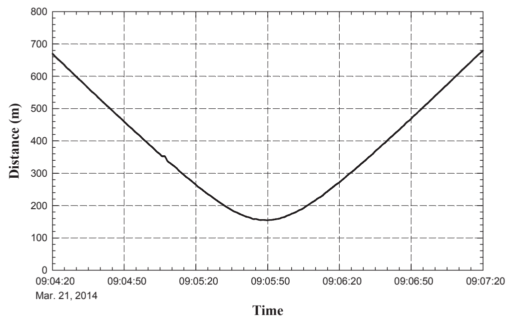

Fig. 3. Distances between surface buoy and ship under test with time, which are calculated from position data by GPS receivers.

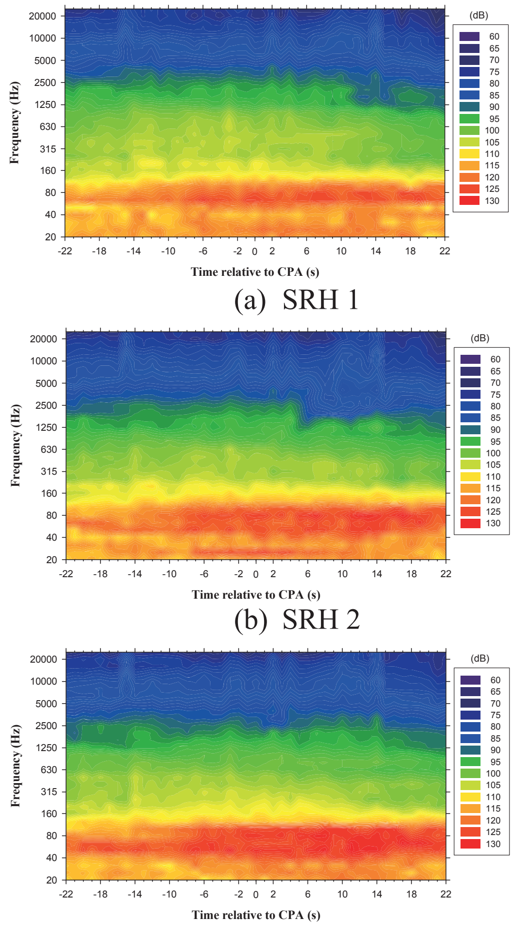

Fig. 4. Measured noise spectrum level radiated by a ship with time in case of MCR port approach.

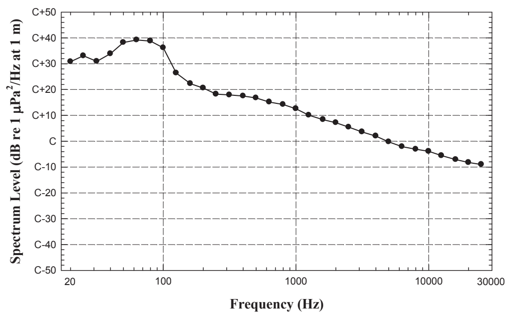

Fig. 5. Calculated noise spectrum source level radiated by a ship in case of MCR port approach.

The analysis level of the each noise was obtained with one-third octave band at every second interval, and it was compensated for the hydrophone sensitivity and amplifier's gain. Then each of the spectrum level of the center frequency of the one-third octave band was calculated. As a result, the measured noise spectrum levels are showed in **Fig. 4** in the case of MCR port approach. According to the figure, the spectrum level was similarly measured regardless of the position depth of hydrophone. The spectrum level at the frequency band between 40 Hz and 100 Hz was largely measured than those of other frequency band, and it was less measured as the frequency increases. By compensating the spreading loss and absorption loss from the spectrum levels shown in **Fig. 4**, the noise spectrum source level radiated by the target ship were obtained. Then, the levels obtained by three hydrophones averaged to calculate the noise spectrum sound level from the ship in the case of MCR port approach. The underwater radiated noise spectrum source level of the ship determined in this way was shown in **Fig. 5**. The noise spectrum source level by the ship was greatly measured at the frequency band of 40 Hz to 100 Hz, and it was gradually decreased with increasing frequency above 100 Hz.

4. Summary

The measuring system for underwater noise radiated by ships using self-recording hydrophones was developed. And the developed measuring system was useful to measure the unwater radiation noise from ship.

Acknowledgment

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References

1. M. F. McKenna, S. M. Wiggins and J. A. Hildebrand: Scientific Reports **3** (2013) 1760.
2. ISO/PAS **17208-1** (2012).