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Verified the acoustic characteristics of the audible area of marine mammals based on the ships noise measured by the hydrophone installed in the sea

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1. Introduction

In recent years, there is a worldwide concern that underwater noise generated by human activities may have impacted marine life. The international community recognizes the underwater radiated noise from commercial ship may have navigation consequences on marine life, especially among marine mammals.[1] In April 2014, IMO approved the "Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Adverse Impacts on Marine Life". These guidelines are non-mandator. Therefore, the Ministry of Land, Infrastructure, Transport and Tourism launched the "Underwater Noise Countermeasures Study Project" with the aim of understanding the current status of underwater noise radiation by ships during their voyages, and is still working on. As part of this project, a hydrophone has been installed in the sea off Ohshima Island since 2020 to measure the noise by ships during their voyages around the hydrophone.

The purpose of this study is to first calculate the source level of ship radiation noise using the normal mode method based on the ship noise data obtained from hydrophone measurements. Then, to simulate the propagation of the calculated source level of ship noise using Parabolic Equation (PE) model with the marine environment of the propagation path as a parameter. Finally, based on the results of the propagation simulation, the impact of the ship noise during their voyages on marine mammals shall be verified.

2. Measurement with the Hydrophone system

Measurement with hydrophone system installed in

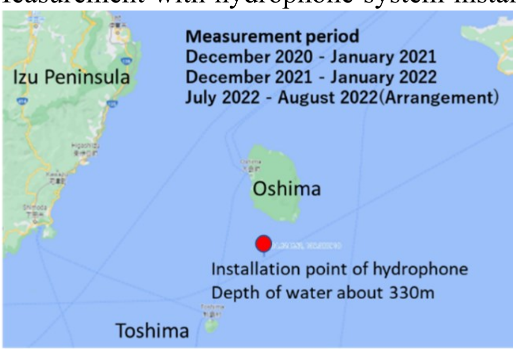

Fig. 1 Measurement Sea area and location of hydrophone system

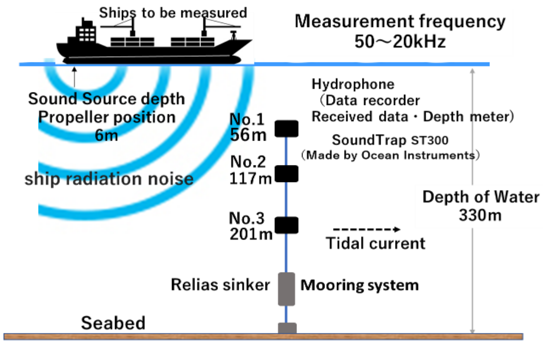

Fig. 2 Measurement with the Hydrophone system

the sea was carried our as a part of the project. The red dot as shown in Fig.1 indicates the location of the hydrophone at South of off Ohshima Island. Shown the measurement system in Fig.2. The measurement method obeyed the standard of ISO 17208-1 defined by the IMO non-compulsory guidelines. The water depth at the measurement point is about 330 meters (m), and the installed water depths of each hydrophone were 56m, 117m, and 201m.The received data by hydrophone recorded the ship noise of approximately 5,000 passing near the hydrophone during the two-month measurement period. In this study, the noise from the roll-on roll-off ship (RORO) ship (15781 tons, 7.62 m draft, 167 m length), which was recorded most frequently on hydrophones, was targeted to estimate the source level and simulate the propagation of it.

3. Estimation of sound source level

First, propagated loss was calculated with the Normal Mode method and the source level was estimated, by adding this calculation result to the

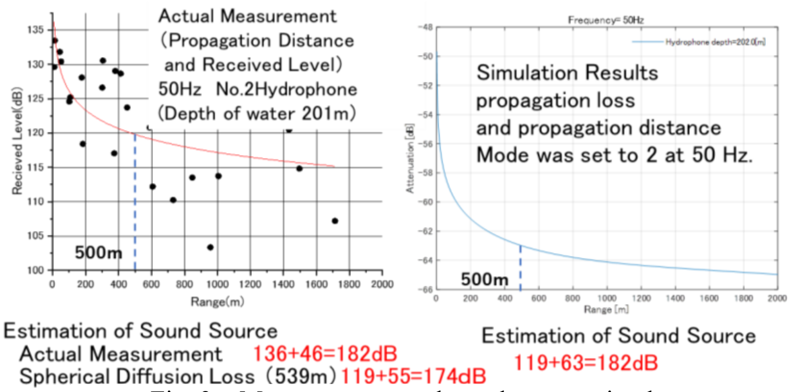

Fig. 3 Measurement results and propagation loss by Normal Mode method

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received level at any distance measured by the hydrophone. The low frequency band of ship noise from 50Hz to 200Hz is the same used on marine life, especially by the Baleen whales. Therefore, in this study, the source level was estimated for ship noise in this frequency band. Left of Fig.4 shows the received level at 50Hz of RORO ship measured with hydrophone No. 3 at a water depth 201m. The black dot indicates the received wave level measured by the hydrophone system and the red line indicates the curve fit obtained from the measured variance data. Fig. 3 right shows the propagated loss calculated by the normal mode method that the mode was set to 2 at 50 Hz. As shown in Fig. 3, the received level at 0 m was 136 dB. Adding 46 dB that the propagated loss of the distance between the sound source (propeller at 6 m depth) and No.3 hydrophone, the sound source level can be estimated to be almost 182 dB. The amount of propagated loss at the 500m point can be read as 61dB from left of Fig.4 calculated with Normal Mode method and the received level at 500m of horizontal distance can be read as 119dB, the measured value in right of Fig. 4 then it was possible to estimate the sound source level 119+63=182dB. Comparing the values obtained by the Normal mode method with those obtained from actual measurements, it is shown that there is almost the same. We were shown that almost similar results were obtained not only with 50Hz but also with 100Hz and 200Hz.

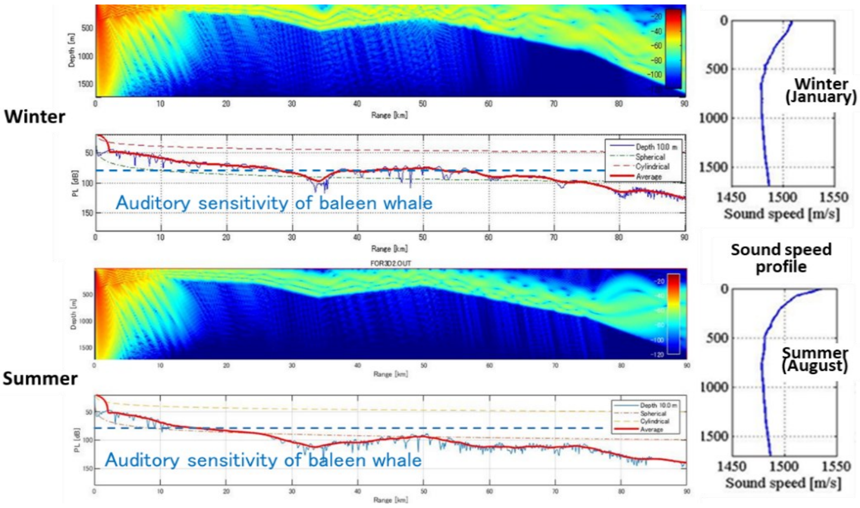

Fig. 4 Comparison of propagated loss in different seasons
(Propagated distance is 90 km, Seabed sediment is sand, Frequency is 50 Hz)

4. Ship Noise Propagation Simulation

Next, simulated noise propagation to the south of Ohshima Island when the noise source is ship noise during their voyages off Ohshima Island where the hydrophone was installed. Simulated the propagation of sound source level (182dB) of RORO ship by using Parabolic Equation (PE)model “FOR3D” [2] taking account to the environmental parameters (bathymetric profiles, seabed sediment, sound speed profiles). The parameters of the simulation were the distribution of sound speed profile in summer or winter, the case where the seabed sediment is all sand or contains basalt and bathymetric profiles with the sea of Ohshima off. Fig. 4 shows the propagated loss pattern with the sound speed profile [3] in the winter and in the summer at the case of seabed sediment is all sand and the relationship between propagation distance and propagated loss for the received wave at a depth of 10 m, which is the swimming depth of large baleen whales. It can be seen from Fig. 5 that the overall propagated loss is about 10 dB lower in the winter than in the summer. The reason for this is thought to be the greater gradient of the sound speed profile near the surface in summer. Propagation loss at both seasons were found to be lower when the seabed sediment contained basalt than when the seabed sediment is all sand.

The audible sound pressure level of baleen whales at 50 Hz is 110 dB, which means that they are not affected by ship noise if the propagated loss is more than 72 dB (182 dB - 110 dB). When the distance from the source of ship noise is longer than about 30 km in winter and about 20 km in summer, the ship noise becomes inaudible and the effect on the baleen whale's hearing is expected to be low.

5. Conclusion

Our study showed that using the Normal Mood method, it was possible to calculate the source level of ship radiation noise based on the data obtained measurement of hydrophone system installed in the sea. Furthermore, the propagation simulation using PE of noise sources by RORO ship allowed us to verify the distance that affects the baleen whale's hearing.

References

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