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A study of the influence that a high power air gun sound source of MCS gives to a marine mammal

MCSのエアガン音源が海棲哺乳類に与える影響に関する研究

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1. Introduction

In recent years, earthquake source surveys and seabed resource exploration under the seabed is becoming popular. Exploration by crustal structure exploration system (Multi-Channel Seismic reflection survey: MCS) is frequently carried out, it began to be built many research vessels. However, concern has been shown from environmental protection organizations that the air gun sound source of high-output and low-frequency to be used for MCS affects the ecosystem of marine mammals. Therefore, guidelines obliged to stop using the air gun has been created when finding the marine mammals which are swimming. However, this guideline has been limited to within the range that can be monitored from a ship. In this study, we analyzed the distribution of sound wave propagation attenuation and the shape of the received wave pulse to investigate the influence on marine mammals which swimming in 300 km distant sea surface neighborhood at the different sea area of the sound speed profile. The analysis, JAMSTEC has targeted the air gun sound source of global resource exploration ship under construction [1].

2. Conditions of simulation

Fig.1 shows the conditions of propagation simulation. An air gun as a sound source (230 dB / 1 μPa, center frequency 50 Hz ± 25 Hz, depth 5 m), the propagation distance is 300 km and water depth of sound source area was set at 300 m. From this, it investigated the sound wave propagation conditions using a typical sound speed profiles around the Japanese waters (8 ºN, 30 ºN, 47 ºN). In addition, it was calculated assuming when there was seamount of water depth 500 m on the way to propagation path (180 km). Here, at a distance 500 m from air gun , and the maximum monitoring distance 17 km and were analyzed by simulating the changes in the sound pressure and receiving pulse. In the calculation, it was using a sound ray theory, and Parabolic Equation (PE) method that can be adapted in the long distance propagation [2].

3. Simulation Results

(1) Analysis by ray theory

Fig.2 shows the analysis results by the sound ray method the relationship between arrival times of sound waves propagation distance 300 km at a radiation angle (± 5 °). As shown in this figure, even if the radiation angle is changed, the difference in propagation time is about 300 ms, and the difference of the path distance is extremely small with about 500 m. Because this set the sound source depth to 5m, almost none of the courses propagating the sound channel exists. Therefore, even if radiation angle is changed, each sound rays is considered to come through the propagation path where reach the seabed.

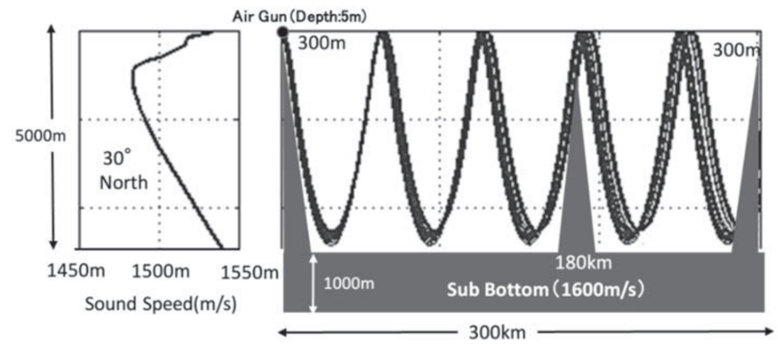

Fig.1 Simulation Settings sea area

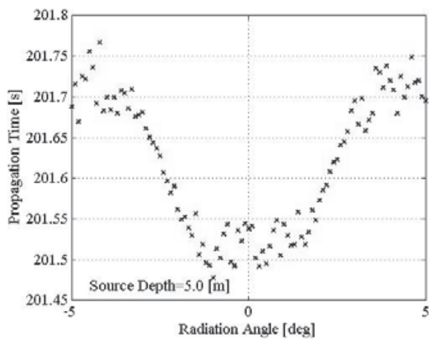

Fig.2 The sound source radiation angle and the propagation time

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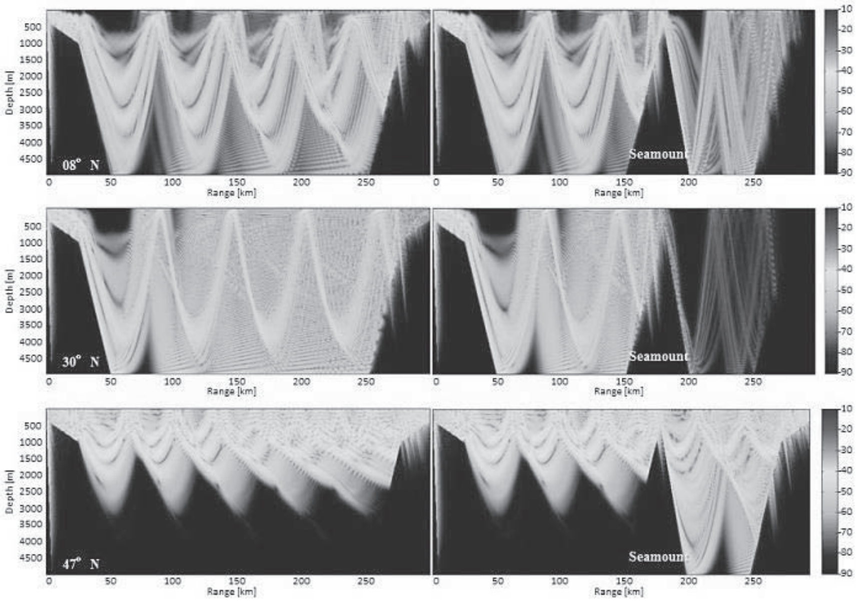

Fig.3 Calculation results of the sound wave propagation of distance 300 km by PE method. (Left: flat seabed, Right: seamount (500 m) at a distance of 180km)

(2) Analysis by Parabolic Equation

The ray theory, it can't be calculate only a sound wave propagation path and the propagation time. Therefore, sound field analysis was tried by PE method suitable for long-distance propagation analysis. Fig.1 and in the following conditions, the calculation of the propagation attenuation was analyzed using a sound speed profile in each sea area. (A) If the seabed is flat. (B) If the seamount (top of depth 500 m) exist. These results show in Fig.3. It can be seen that the propagation path is greatly changed by the change of the sound speed profile. In the low-latitude and mid-latitude sea area, it can be seen that propagation path is changed and attenuation is large in the distant place than seamount. On the other hand, in the high-latitude sea area, sound wave does not reach to the depth 300 m. In addition, sound wave propagating in near the sea surface has excellence, and sound waves propagating through the shallow waters to propagate over the seamount. In addition, the sound wave has diffracted at the top of the seamount (500 m) and arrived at seabed. This originates in that a sound channel axis exists near the sea surface, and influence is concerned in high latitudes that baleen whales are many habitat. Fig.4 shows the analysis result of the propagation attenuation by Douglas method [2]. Looking at the damping characteristics in depth 100 m, diffusion characteristics are spherical diffusion and air gun sound source (230 dB) is received at the nearly 120 dB. In view of the noise of the sea area S/N ratio is 48 ~ 31 dB, it would not significantly affect cetaceans in the 300 km distant sea area. In addition, it was analyzed reception pulse at 300 km in the case of transmitting the sound source pulse f_0 = 50 Hz (±25 Hz, 10 ms) air gun from the sound field data analyzed by the PE method. The dive depth of the baleen whale was assumed, and receiving depth was set to 100 m. Even if a very short pulse is oscillated like an air gun, the pulse is stretched in the propagation process, it can be seen from Fig.5. However, because this shape is largely determined by the sea area, in order to investigate the effects on marine mammals, it is necessary to sufficiently pay attention.

4. Summary

A long range propagation pulse of a sound wave by the air gun sound source in the vicinity of sea surface was calculated, and influence to the mammals which swims in the sea surface neighborhood was investigated. As a result, it was suggested. In the future, in an attempt to measure in real sea area, we want to do the impact study of the marine mammals.

References

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[2] D.Lee, M.H.Shultz, "NUMERICAL OCEAN ACOUSTIC PROPAGATION IN THREE DIMENSION", World Scientific, 1995

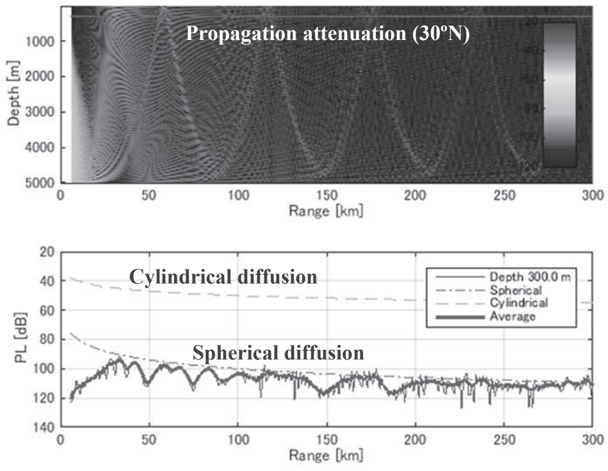

Fig.4 Propagation attenuation characteristics

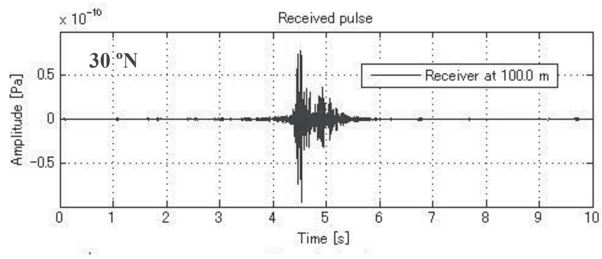

Fig.5 The received wave pulse shape (wave receiving depth 100m)