1P6-6

Variation of back scattering directivity of fish body including bone by difference of source frequency

音源周波数の違いによる骨を有する魚体からの後方散乱波の指向性の変化

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1. Introduction

In recent years, in order to identify of fish species using echo sounder, there is a tendency that higher frequency sound wave is applied at echo sounder using the identify of fish species. In the identification of fish species in the ocean, it has been considered that bone of the fish is almost no influence to scattering wave from a fish. If sound wave at higher frequency is used in echo sounder, the influence of the detailed shape of fish with the bone on the scattered wave is considered. Therefore, it is necessary to take into consideration bone of the fish, which is a strong scatterer, due to high frequency of acoustic waves. We have been analyzed the influence of scattering waves on characteristic of tilt angle - amplitude by bone of the fish in the time domain[1]. From the results, it was confirmed that interference of scattering waves from bones and swimbladder affects the amplitude of scattering wave at the receive point.

In this report, in order to investigate the influence on the scattered wave due to the bone of the fish, we analyze the scattered wave with respect to the tile angle of the fish, when the sound source frequency is changed. The variation at amplitude of scattered waves are obtained using 38 kHz, which is a common frequency of split beam techinices, and 100 kHz, which is a higher frequency against a common echo sounder.

2. Analysis condition

The external shape of the fish model was imitating an ellipsoid, overall, the length of the head to toe (x axis) 96 mm, the length from the back to the belly (y axis) 20 mm, the width (z axis) 16 mm. Swimbladder was a spheroid with 38 mm in the x-axis direction, 4 mm in the y-axis direction and 4 mm in the z-axis direction, and the center of the swim bladder in a place close to 4 mm belly from the center of the fish body. Regarding the bone, a dome-shaped model with a size of 16 mm in the x-axis, 12 mm in the y-axis and 10 mm in the z-axis was set in the portion hitting the skull. In the part hitting the vertebrae, a cylindrical model with a diameter of 2 mm in the x and y axis was set from the end of the skull model to the tail.

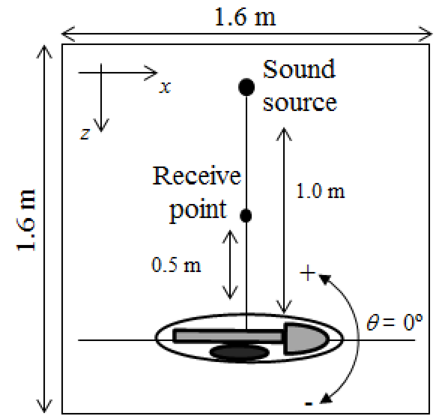
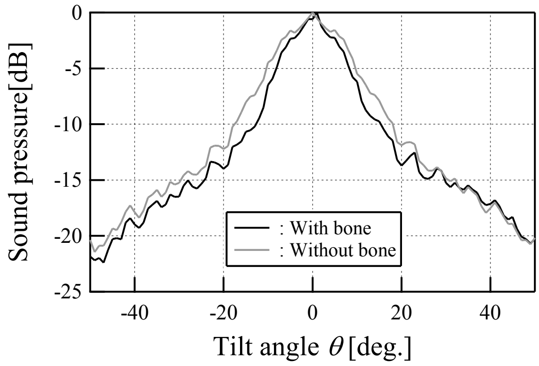


Fig. 1 Model diagram of the area used in this simulation

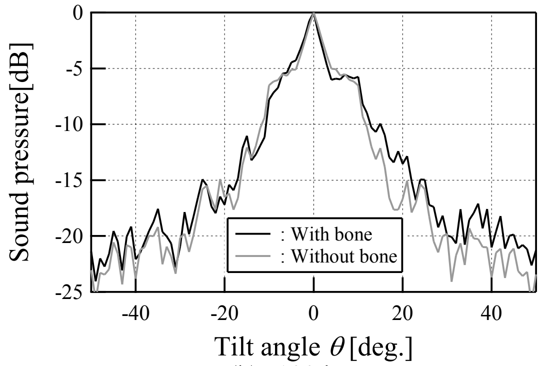
Figure 1 shows a model diagram of the simulation area. In this simulation, three-dimensional analysis was carried out, and the region was set to be 1.6 m in the x, z plane and 1.2 mm in the y plane, in each axis direction. The area is filled undamped water with sound speed of 1500 m/s, density of 1000 kg/m3. In addition, the acoustic parameters of each part of the fish were set to a sound speed of 1570 m/s and a density of 1070 kg/m3 for the fish part, and a sound speed of 2020 m/s and a density of 1090 kg/m3 for the fish bone part2, 3). The center position of the fish model was set at 1.0 m from the sound source and the position in the x, y coordinates is the same as the sound source. The amplitude of scattering wave from the fish model was analyzed by changing the tilt angle θ, when the sound wave was perpendicularly incident on the spine, with the tilt angle ±50˚ from $\theta = 0˚$. The condition of sound source was used a pulse wave with a center frequency of 38 kHz, a pulse width of 40 μs. Another condition of sound source was used a pulse wave with a center frequency of 100 kHz, and a pulse width of 50 μs. The receive point of the scattered wave is 0.5 m away from the center of the object.

3. Result

Figure 2 (a), (b) show the difference of the characteristic of the tilt angle - maximum amplitude of scattering wave by bone of the fish. and the changed of the center frequency (38, 100 kHz).



(a) 38 kHz



(b) 100 kHz

Fig. 2 Characteristic of the tilt angle – maximum amplitude

As shown in the **Fig. 2(a)**, when the frequency is 38 kHz, the scattering wave amplitude characteristic becomes symmetric in the model with and without bone. As shown in the **Fig. 2(b)**, when the frequency is 100 kHz, the scattering wave amplitude characteristic becomes asymmetric in the model without bone. In order to investigate the scattering wave amplitude characteristics influenced by tilt angle of fish, the received waveform is analyzed by FFT algorism. **Figure 3(a) - (c)** show tilt angle characteristics of scattered waves of each frequency component. From As shown in the **Fig. 3(b)**, it is seen that the model with bone becomes asymmetric characteristics when the tile angle is around 5°. In **Fig. 3(c)**, the dip was suppressed near the tile angle at 30°, and the amplitude of scattering wave changed by tile angle became gentle. From these results, it is found that the higher frequency components of sound wave as 70 kHz, 100 kHz have asymmetric characteristics by bone of the fish. It is assumed that the detailed structure at bone of the fish influenced the scattering amplitude characteristic by the frequency resolution was improved.

4. Conclusion

In this report, we investigate that the amplitude of scattered waves are influenced by the difference of sound source frequency and bone of the fish. If the fish model has considering bone of the fish, it was confirmed that the detailed structure at bone of fish influence the scattered wave as the higher frequency. In future work, subjects will further analyze scattered waves directivity influenced by the tilt angle at bone of the fish using higher frequency sound waves.

References

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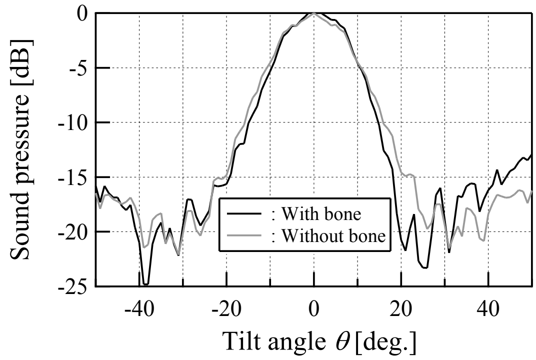
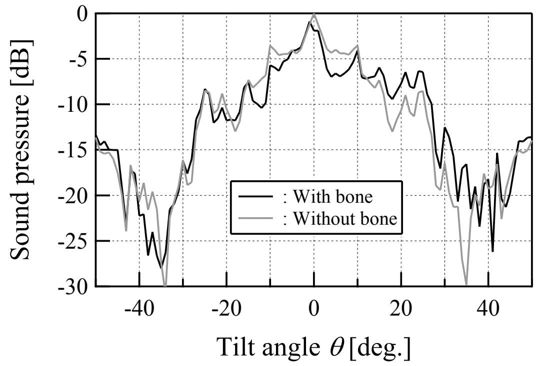
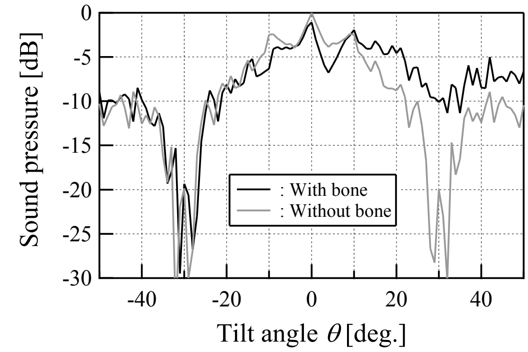


(a) 38 kHz



(b) 70 kHz



(c) 100 kHz

Fig. 3 Tilt angle characteristics of scattered waves by the existence of bone