3P6-1

Proceedings of Symposium on Ultrasonic Electronics, Vol. 36 (2015)
5-7 November, 2015

Variation on sound field caused by the sound source moving from continental shelf to shelf break
音源が大陸棚から大陸縁まで移動するときの音場の変化

Yoshiaki Tsurugaya[1†], Toshiaki Kikuchi[2], and Koichi Mizutani[3] ([1]Sanyo PT; [2]NDA; [3]Univ. of Tsukuba)
鶴ヶ谷芳昭 [1†], 菊池年晃 [2], 水谷孝一 [3] ([1] 山陽精工, [2] 防衛大, [3] 筑波大院)

1. Introduction

In the sound propagation, the shallow water is a waveguide having boundaries with a sea surface and a bottom. Moreover, in the shallow water around Japan, the temperature gradient is negative from the sea surface to the bottom, containing the thermoclines. Therefore, the emitted sound from the sound source is refracted downward, and reflected at the bottom. Sound field is basically formed with the bottom reflection and the surface reflection. Tsurugaya *et al.* examined the sound propagation formed with the data on the shallow water of East China Sea. When the sound source becomes deep, the sound propagation by the propagation on the turning in the upper part of the thermocline and the bottom reflection is added. As a result, they reported that the duct was formed[1]. Moreover, the sound scattering to the rear side by the change in the bottom was shown, and the phase changes rapidly in the scattering[2]. These study have been limited to the shallow water with the depth of 200m. The shallow water in the continental shelf is ended on the shelf break, and reaches the basin through the continental slope. Then, the sound propagation that the source is moved from the continental shelf to the shelf break is examined.

2. Sound speed structure in East China Sea

The data line of East China Sea obtained from GDEM and the sound speed structure (SSS) are shown in Fig. 1. The data line is shown in the white line. In SSS, a horizontal axis is the sound speed in m/s, and a vertical one is the depth in m. The lines at lower right are SSS's in the range from the northwest edge of the data line. The layered depth (LD) is about 50m. Data is cut on the way because of having reached at the sea bottom. Minimum sound speed in about 1000m depth is shown. Depth of Ryukyu basin is about 2000m. The investigation is performed at 220km from the northwest side of data line to the bottom of the basin. The propagation calculation is performed by FOR3D[3] in PE model.

3. Sound Propagation in the continental shelf

The sound propagation from the northwest data point in the continental shelf to the next point is examined. The sound

1†e-mail address: tusl@mvb.biglobe.ne.jp

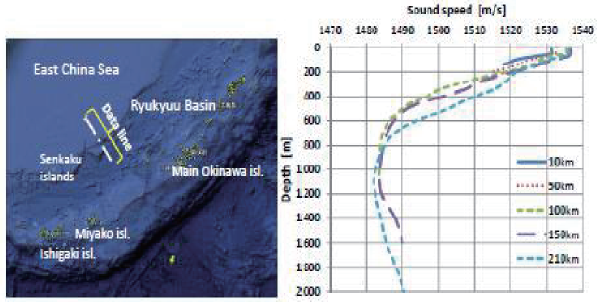

Fig. 1 Data line and Sound speed structures (SSS)

propagation in continental shelf is shown in Fig. 2. A horizontal axis is the range between two points in km, and a vertical axis is the depth in m. a) is indicated transmission loss (TL) in dB, b) is phase angle in radian, and the level is shown in right side scale, respectively. The source depth is 100m, and frequency is 600Hz. The depth about the convergence of sounds is the same as the source depth, and that depth is increased with increasing bottom depth. In the phase angle, the duct is generated between the upper part of thermocline and the bottom. The sound propagation by the surface reflection and the bottom reflection is predominated in shallow source, but the duct propagation between the thermocline and the bottom is clarified by increasing source depth.

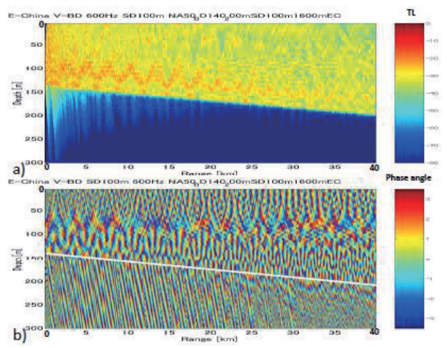

Fig. 2 Sound fields in continental shelf
a)Transmission loss (dB)　b) phase (radian)

4. Sound propagation by the source crossing the shelf break

4.1 Sound propagation from continental shelf to ocean basin

The sound propagation radiating the sound on the continental shelf is shown in Fig. 3. A horizontal axis is the range from sound source in km, and a vertical axis is the depth in m. The source depth is 100m. Upper figure a) is frequency 600Hz, and lower figure b) is 300Hz. In 600Hz, the thickness of LD is 43.5m or more in the condition of SD propagation[4]. LD is 50m, and SD propagation is generated in 600Hz. And, in 300Hz, the depth of LD necessary for SD propagation is 69m or more, and as a result the SD propagation is not generated. However, the sound field shows the same configuration on the pattern. Even if the frequency is lowered further, the sound field is shown the same patterns. Propagation by the bottom reflection and the turning is predominated , and it is finally shifted to the sound channel (SC) propagation.

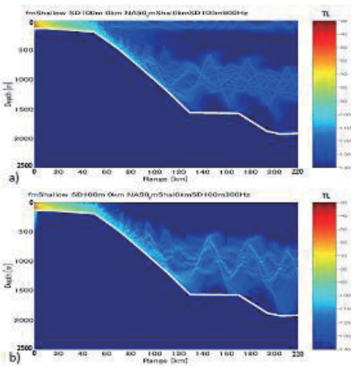

Fig. 3 Comparison of TL in shelf break by frequency a) 600Hz b) 300Hz

4.2 Change in sound field by moving sound source

At the sound source existing in the continental shelf, the patterns of the sound field from a continental slope to the bottom of the basin doesn't change greatly. The transmission loss is decreased by the sound source approaching to the continental shelf edge. The propagation of sound from the continental shelf to a continental slope is shown in Fig. 4. The source depth is 100m. The representation is the same as Fig. 3. In upper figure a), the sound source is 30km, the sound source is in the continental shelf. Middle figure b), the sound source is 50km at the shelf break. Lower figure c), the sound source is 70km in the continental slope. At the figure a), the sound is propagated in the continental shelf, and went out to the continental slope. The sound is increasing the depth along the continental slope. In the shelf break, the region of convergence in the sound field is widened though the sound is descended on the continental slope. In the continental slope, the region of convergence is further broadened though the sound is propagated along the continental slope, and shifted the propagation. The same trend on TL in roughly 130dB is shown the receiving depth up to 300m. When the receiving depth becomes deep, TL is further decreased, and becomes roughly 90dB.

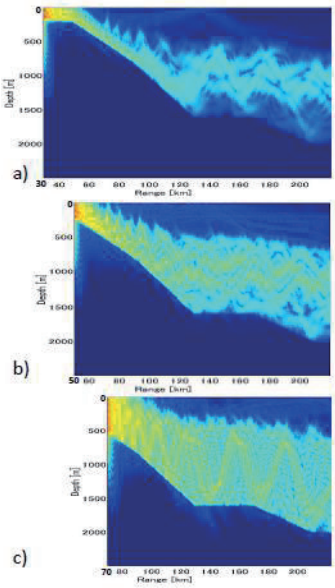

Fig. 4 Comparison of sound fields by source passing shelf break a) source in continental shelf, b) at shelf break, c) in continental slope

5. Summary

The sound propagation from the continental shelf in East China Sea to Ryukyu basin is examined by using the GDEM data. In shallow water of the continental shelf, because the sound speed structure is having a negative gradient, the sound is refracted downward. Therefore, the sound field in shallow water is formed by the surface reflection and the bottom reflection. When the sound source becomes deep, the propagation by the turning in the upper part of the thermocline and the bottom reflection is added. As a result, the duct propagation between the thermocline and the bottom is generated. The sound from the shelf break is propagated to the bottom of the basin along the continental slope. Afterwards, it is shifted to propagation centered on the SC axis. The width of propagation is widened though the pattern of the sound field shows the same trend even if the source moves from the shelf break to the continental slope. Although TL at the shallow receiving depth becomes 130-140dB, TL at the deep receiving depth is decreased to 80-90dB. Therefore, it is necessary to deepen the receiver depth for the detection of the signal.

References

1. Y. Tsurugaya, T. Kikuchi, and K. Mizutani, Proc. Autumn Meeting Acoust. Soc. Jpn. (2013) 1223
2. Y. Tsurugaya, T. Kikuchi, and K. Mizutani, Proc. Spring Meeting Acoust. Soc. Jpn (2014) 1287
3. F. B. Jansen *et al.*: *COMPUTATIONAL OCEAN ACOUSTICS* (AIP PRESS, 1994)
4. R. J. Urick: *SOUND PROPAGATION IN THE SEA* (DARPA, 1979)