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Variation on sound propagation caused by topography of seabed in a current rip region
潮目領域における海底地形に起因する音波伝搬の変化

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1. Introduction

Tsushima Warm Current that passed over Tsugaru Straits goes south along the coast of Sanriku, the northeast area of Japan's main island. In addition, the warm eddy in a part of Tsushima warm current is formed on Oyashio that is the cold water mass. The water temperature is consequently varied greatly in the region to which the warm eddy and the cold water mass are bounded, and a current rip is formed. A rapid change of the water temperature in the current rip is generated on both horizontal direction and vertical direction. Therefore, it is impacted on the sound propagation in the current rip region. Then, Tsurugaya et al. examined bi-directional propagation crossing the current rip[1]. And, when the direction is reversed on the current rip, it is reported the configuration of propagation to be quite different. Moreover, Tsurugaya et al. examined the impact on the variation of bottom depth[2]. When the bottom depth becomes shallower than 2000 m, the influence by the bottom reflection is predominated, and the propagation by bottom bounce (BB) is vanished, though the sound channel propagation remains. However, the shape of bottom used for investigation is the flat, but an actual bottom is not always flat in the current rip region. Then, the influence on the sound propagation caused by the inclined bottom is examined.

2. Sound velocity profiles in the current rip region

The water temperature structure and the sound velocity profile along 41 degrees north in the current rip region is shown Fig. 1. In that region, Tsugaru warm eddy (TuWE) and Oyashio (OyCC) are bounded. The above figure is the water temperature structure (WT), and the below figure is the sound velocity profile (SVP) corresponding to the location of the arrow. The warm TuWE is floating on the cold OyCC. The depth of sound channel (SC) axis is around 600 m under TuWE, and about 160 m in OyCC. The sound propagation is investigated from Oyashi area toward the warm eddy.

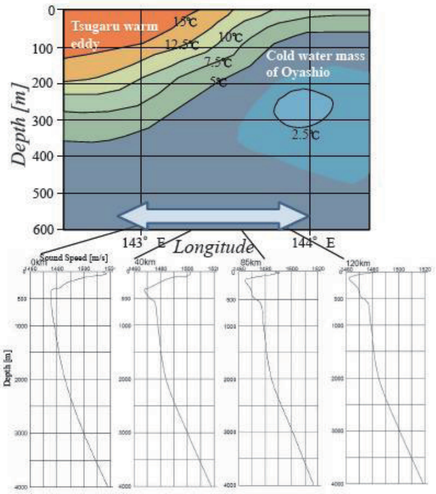

Fig. 1 Vertical temperature structure and Sound speed profile along 41° -N

3. Sound propagation in the flat bottom

Sound propagation in the bottom of 4000 m depth is shown in Fig. 2. Source depth is 100 m, and is in the cold water mass of OyCC. Because SC axis is shallow, and bottom depth is deep, so the sound fields are formed with 3 configurations for propagation; SC, CZ and BB. In SC propagation, the sound is propagated along SC axis, and that depth is reached under the warm eddy. Although BB propagation is generated, SC propagation and CZ propagation are predominated. When the depth of bottom becomes shallow, CZ propagation is disappeared, and BB propagations are increased. Even if bottom depth becomes 1000m, SC propagation exists.

4. Sound propagation for inclined bottom

The bottom depth is 3200m in OyCC area, and is 1230m under TuWE. Then, in the following examination, it is assumed that 3200m in left side on Fig. 2 and 1230m in right side. And bottom's slope is assumed to be decreased monotonically. Other parameters are that of Fig. 2. FOR3D[3] is used for the computation on the sound fields.

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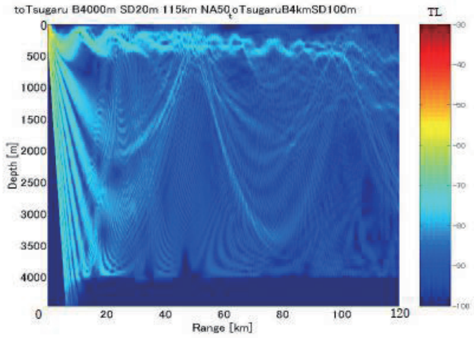

Fig. 2 Sound field in the bottom of 4000 m depth source depth; 100 m

4-1 Comparison on sound fields

The comparison between the sound fields with 4000m flat bottom and the inclined bottom is shown in Fig. 3. Some CZ propagation is disappeares by the inclined bottom. The width of CZ is however decreased, and BB propagation becomes not clear. SC propagation is still existing.

4-2 Comparison on transmission loss

The impact on transmission loss (TL) when the sound source is approached from OyCC side and receiving point is in TuWE is examined. The comparison on TL between the flat bottom and the inclined one is shown in Fig. 4. The sound source depth is 100 m, and receiving depth is 100 m. In this figure, sign of × is denoted for the case of the inclined bottom. And △, □,and ◇ sign is denoted for the flat bottom in the depth 4000 m, 2000 m and 1000 m, respectively. In □ and ◇ signs, because bottom reflection is predominated, TL becomes small, and TL is decreased according to approaching on sound source to receiving point. Moreover, in the case of 4000m flat bottom, TL is rapidly increased passing through the current rip region. And, when sound source is passing the current rip region and approaching to receiving point, TL is decreased. On the other hand, in the case of inclined bottom, the width of level fluctuation becomes small because of the indistinct impact of bottom reflection. Furthermore, the intensity variation yields as well as the case of 4000m flat bottom in the passage of the current rip region. The width of 2nd CZ is increased by bottom reflection after passing 1st CZ. Therefore, the level becomes large on the comparison with 4000m flat bottom when the sound source approaches to the receiving point from the current rip region.

5. Summary

Sound propagation in the current rip region compared with in the case of flat bottom and in the case of inclined bottom is examined. In the comparison of sound propagation for the flat bottom and the inclined bottom, the sound propagation is suffered by the influence of the depth variation of the bottom. As a result, the variation of intensity level is contributed by the topography of the bottom because the bottom depth is influenced to CZ propagation. And, the influence of bottom reflection for the flat bottom becomes indistinct by the inclination of the bottom. Consequently, the decrease in the intensity level is generated. On the other hand, SC propagation is not influenced by the variation of the bottom depth. In this case, the contribution to the level by the variation of receiving depth is small.

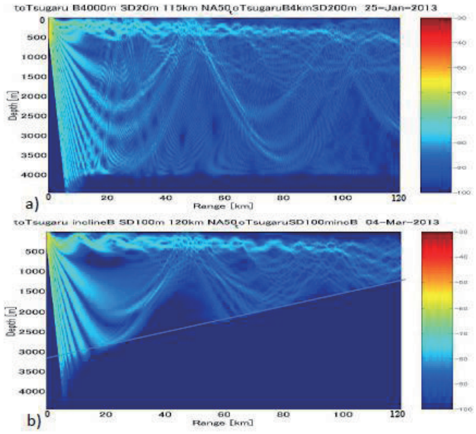

Fig. 3 Comparison on sound fields between the flat bottom (bottom depth; 4000 m) and the inclined bottom (bottom depth; 3200 m → 1230 m) source depth; 100 m

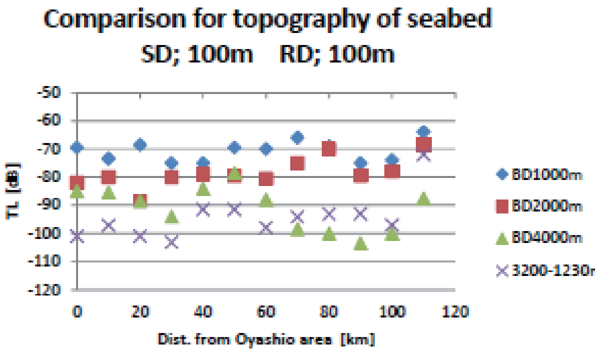

Fig. 4 Comparison on transmission loss for the topography of seabed

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3. D. Lee *et al.*, "*Numerical Ocean Acoustic Propagation in Three Dimension*", World Scientific, (1995)