Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 401-402
13-15 November, 2012

An influence of frequency on sound propagation in a current rip region

潮目領域の音波伝搬に対する周波数の影響

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

A current rip is generated in a region where a cold water mass (CWM) and a warm water mass are bounded. Tsushima warm current that passed over Tsugaru Straits goes south along the coast of Sanriku. A part of warm current is formed the warm eddy outside of Tsugaru Straits. Therefore, a current rip with large water temperature gradient occurs in the region that Tsugaru warm eddy (TuWE) and the cold water mass of Oyashio (OyCWM) are bounded. Because, in the current rip, the water temperature variation to the range is large, sound propagation is influenced. Tsurugaya et al. examined propagation in the current rip region and reported that the form of propagation is fully different depending on the propagation direction[1]. And, in the case where the sound source is approaching from OyCWM toward TuWE, the receiving level was decreased rapidly when sound source passed the current rip[2]. By the way, the relation between the dimension of environmental variation and acoustic wave length is influenced to sound propagation. Then, the influence on sound field according to the frequency is examined in the current rip region.

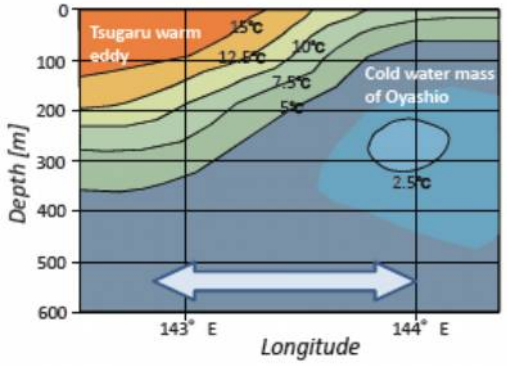

Fig. 1 Vertical temperature structure in the current rip region along the line of 41° north.

2. Temperature structure in a current rip region

In the region at the east of Tsugaru Straits, TWE and OyCWM are bounded, and the current rip is generated. The water temperature structure in November along 41° North line is shown in Fig. 1. The number in this figure is the water temperature (℃). TuWE is put on OyCWM. A large horizontal arrow is a range used for examining. To examine the sound propagation, the bottom depth is assumed to be 4000m and has a flat bottom.

3. Bidirectional sound propagation

In this temperature structure, bidirectional sound propagation is shown in Fig. 2. The vertical axis is a depth in m, and the horizontal axis is a distance in km. The above figure is the result of the propagation of sound wave from left side (TuWE side) of Fig. 1. FOR3D[3] is used for the propagation calculation. The frequency is 100Hz, and source depth is 100m. The thickness of Layer Depth (LD) for trapping the sound wave of 100Hz is 480m or more. Therefore, surface duct (SD) propagation is not generated because LD is shallow, nearly 100m. The sound wave radiated from sound source that reflects by the surface becomes convergence zone (CZ) propagation. Because sound speed gradient under the warm eddy is large, other one is refracted to the bottom, and is reflected at the bottom. The result of the sound propagation from right side (OyCWM) of Fig. 1 is shown in the lower figure. The difference to the above figure is to

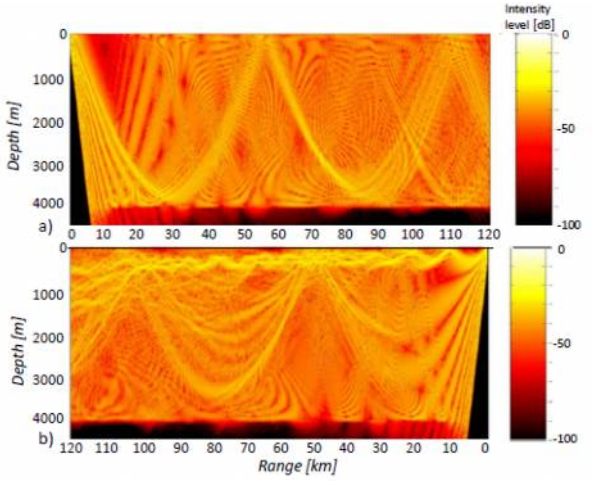

Fig. 2 Sound field for bidirectional sound propagation along the line of 41°N a) propagation from TuWE toward OyCWM b) that of opposite direction

tsul@mvb.biglobe.ne.jp

generate sound channel (SC) propagation. The sound wave trapped by SC is increasing the depth, and is propagated under TuWE. Thus, when the propagation direction is varied on the boundary region of the current rip, the propagation form is also greatly different.

4. Behavior of sound fields by frequency

The left side of Fig. 1, i.e. propagation toward TuWE from OyCWM, is used for investigation. As for the frequency, 50Hz, 100Hz, and 200Hz are used. Wavelength is twice and 1/2 times of 100Hz respectively. The sound field by the difference of the frequency is shown in Fig. 3. The source depth is 100m. A horizontal axis is the distance from the sound source in km. From the upper of the figure, a) 50Hz (wavelength; 300m), b) 100Hz (150m) and c) 200Hz (75m) are shown. Converging the sound field becomes clear as the frequency increased. 2nd CZ doesn't reach the surface in 200Hz though it reaches the surface in 50Hz, and becomes submerged CZ in 200Hz. The intensity distribution in the source depth 200m (under SC axis) and the receiving depth 300m is shown in Fig. 4. The symbol of ◇ is represented the frequency 50Hz, ○ is 100Hz, and × is 200Hz. The sound source is moved from OyCWM toward TuWE. The sound speed structure showing a large variation is in the range from 70 to 50km. In this region, the propagation configuration is changed from SC propagation to CZ one, and finally shifts to BB propagation. The intensity level is high up to 80km because of the SC propagation. However, the level variation is different from the relation between the converging sound field and the receiving depth when the frequency is different. In 100Hz, the propagation configuration is changed from SC propagation to CZ propagation in 70km point. The intensity level is decreased by the result of the disagreement between the receiving wave point and the converging point of the sound field. In 50Hz and 200Hz, a high intensity level is occurred the agreed of the converging point for sound fields and the receiving point. However, in 50km point, the propagation configuration is changed to BB propagation from SC propagation, so the level is decreased.

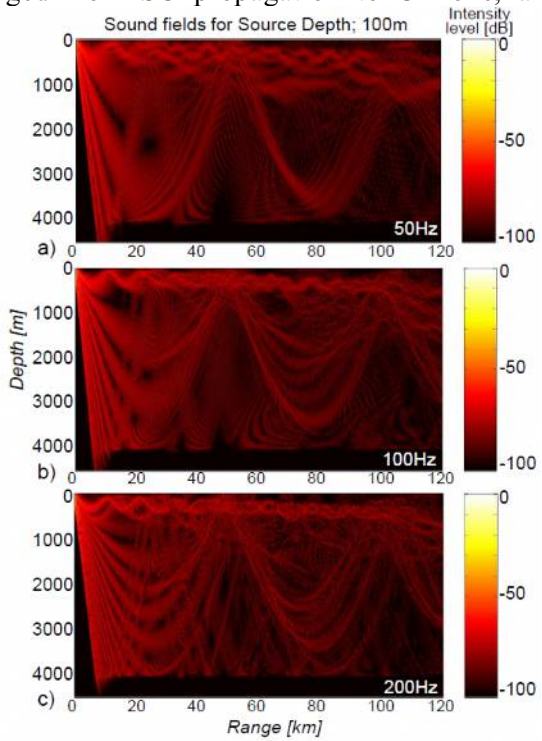

Fig. 3 Comparison of sound field for variation of frequency a) 50Hz b) 100Hz c) 200Hz

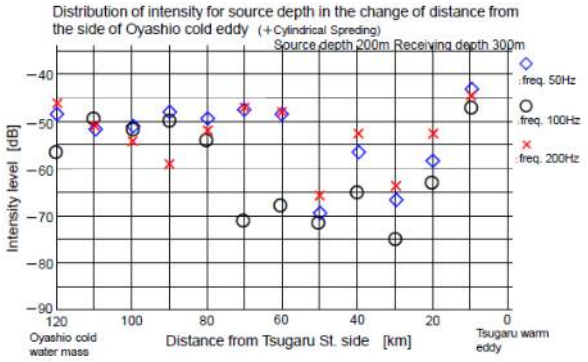

Fig. 4 Comparison of intensity levels on range to frequency ◇;50Hz ○;100Hz ×;200Hz

5. Summary

The behavior of sound fields in the current rip region (from OyCWM toward TuWE) was examined by the variation of the frequency. In the current rip region, the propagation configuration is changed from SC propagation to CZ one, and finally it shifts to the BB propagation. However, because the configuration of sound fields is different depending on the frequency, the level variation for each range is different. The three reasons exist on the difference by the frequency: 1) is the difference of the converging degree of the sound field in SC propagation that occurs by the difference of the frequency. 2) is the difference of sound fields in the CZ propagation by the frequency. 3) is the relation between the receiving point and the converging region of sound fields.

References

1. Y. Tsurugaya *et al.*, Proc. The 32th of Symposium on Ultrasonic Electronics (2011) 571. (in Japanese)
2. Y. Tsurugaya *et al.*, Proc. Meet. Marine Acoust. Soc. Jpn., (2012) 97. (in Japanese)
3. D. Lee *et al.*, "*Numerical Ocean Acoustic Propagation in Three Dimension*", World Scientific, (1995).