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Effects of water temperature inversion layer on underwater sound propagation in the East China Sea

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1. Introduction

In the northern side of East China Sea it exists Tsushima Current into the East Sea through the Korea Strait that a branch of Kuroshio Current moving from the Western Kyushu in Japan are coming up to the north. The others pass through the western coastal sea of Jeju island, performing Yellow Sea Warm Current into the Yellow Sea. A part of Yellow Sea Warm Current turns lockwise round in the western coastal sea of Jeju island. This becomes to Jeju Warm Current passing to the Korea Strait[1]. The complicated ocean processes are existed in East China Sea on account of large fresh water inflow from landside[1]. The area to meet a different water mass is called coastal upwelling[2], and near these area the boundaries show complicated ocean physical characteristic such as temperature front.

This study was analyzed the temperature inversion phenomenon by tidal current and Jeju Warm Current of the western coastal sea of Jeju island into the complicated northern coastal sea of East China Sea, and researched the underwater sound propagation by the temperature inversion.

2. Data & method

The study was examined ocean physical environment with the research vessel, Eardo on April 21th to 26th 2015 at the western coastal sea of Jeju island that is northern part of East China Sea. The water temperature was observed by XBT(T-10) and calibrated using CTD data in the some area.

The underwater sound propagation was caculated by a model of BELLHOP based on acoustic ray theory. This model is a proper method for high frequency. The input data of the acoustic propagation model set up the source frequency of 7.5kHz and the source level of 230 dB. The study was carried out by range dependent condition which could be designed each for caculating the underwater sound propagation.

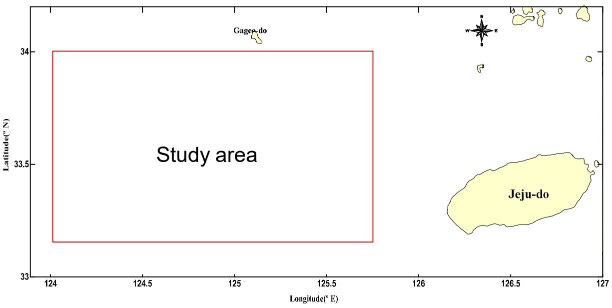

Fig. 1 Distribution of observation area and sediment type.

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3. Result & discussion

3.1 Water temperature profiles

Fig.2 presents the vertical water temperature profiles of the major classified stations. As the depth increased, in general the temperature decreased. In the upper side of Fig.2, the temperature is distributed around surface layer of 12 degree, middle layer of 10 degree and bottom layer of 10 degree. In the lower side of Fig.2, the temperature on the station occuring temperature inversionis still high in spite of increasing depth; surface layer of 13 to 14 degrees, middle layer of 11 to 13 degrees and bottom layer of 14 degree.

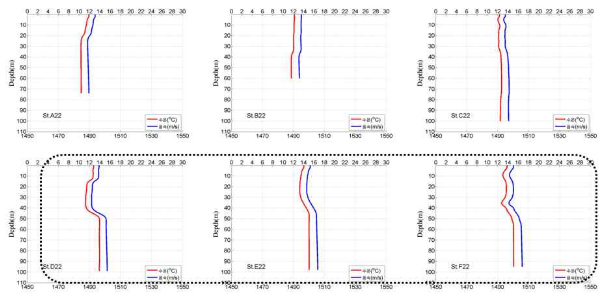

Fig. 2 Water temperature profiles. Upper side is common temperature. Lower side is temperature inversion condition.

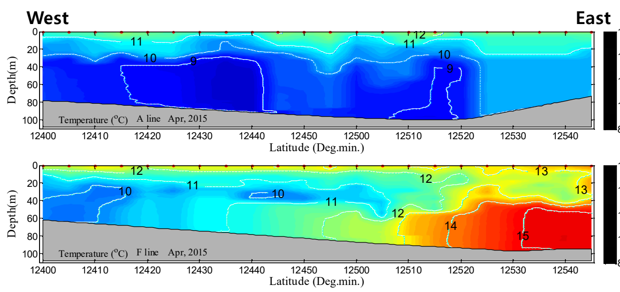

Fig. 3 Section of vertical temperature of common temperature region and temperature inversion region.

Fig. 3 showes the common temperature region and the temperature inversion region. The warm water mass which was founded at the temperature inversion region is determinded to be developed by warm temperature and high salinity water mass incerted toward middle and bottom layer of water. The tempterature inversion layer was made by two water mass boundaries. The result is similar to Kim and Yeg(1983) [3].

3.2 Acoustic propagation model result

Figs.4 and 5 show the signal excess results calculated by acoustic propagation model. The white lines show that signal excess value is zero. Fig.4 shows the common temperature case. The maximum sound propagation range is shorten along with downward refraction of sound wave affected strongly when the sound source existed on 6m or 30m depth. Fig.5 shows the case of the temperature inversion. When the sound source was located on the depth of 6m or 30m, the sound was trapped in the temperature inversion layer showed a tendency to propagate. Thus, when transmitter depth was located in the tempterature inversion layer, the sound which is trapped in the tempterature inversion layer is well propagated far.

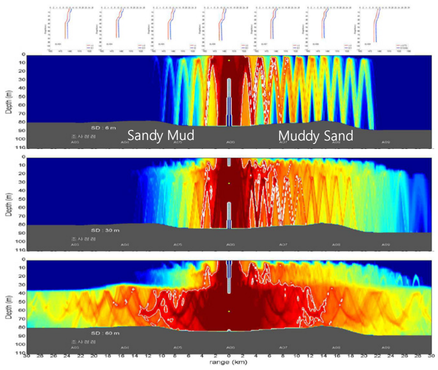

Fig. 4 Calculation signal excess(SE) results at common temperature case. Upper is temperature profile, 2nd is SE of source depth 6 m, 3rd is case of 30 m and 4th is of 60 m.

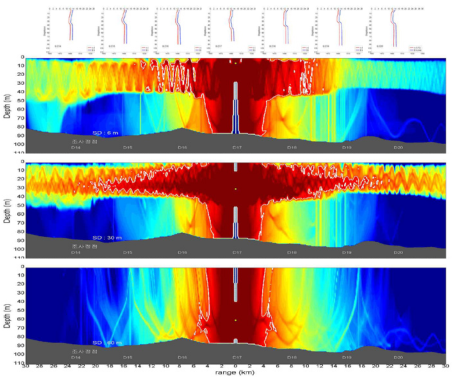

Fig. 5 Calculation signal excess(SE) results at temperature inversion case. Upper is temperature profile, 2nd is SE of source depth 6 m, 3rd is case of 30 m and 4th is of 60 m.

In Fig.6(a), the temperature inversion shows a tendancy to extend in the southeast region of study area. Fig.6(b) shows that maximum distance is shorten in the southeast region. Therefore the temperature inversion occurred in shallow water is shown that in the sound source is located nearby the temperature inversion layer depth the sound is well propagated far. This result was similar to the structure of sound wave poroagation characteristic shown as SOFAR channel in the deep sea[4].

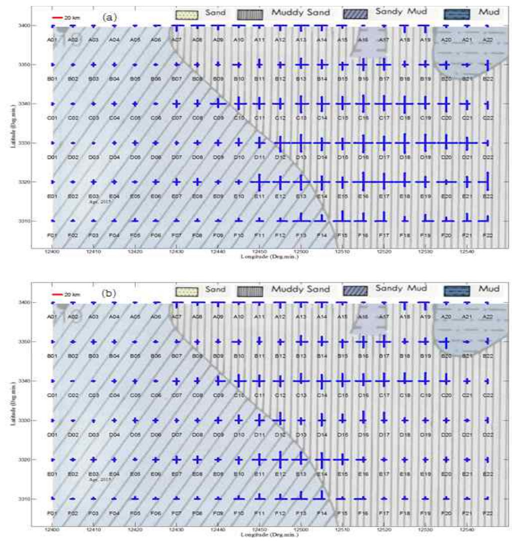

Fig. 6 Calculation signal excess result. (a) is maximum range at depth 30 m and (b) is in case of depth 60 m.

Acknowledgment

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