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Overwintering observation of the long-distance sound wave propagation overwintering in the Antarctic Ocean
南極海における長距離音波伝搬の越冬観測

Shinpei Gotoh[1,2‡], Taiyo Kobayashi[1], Toshio Tsuchiya[1,3], Yoshihisa Hiyoshi[1], Koichi Mizutani[2]
([1]JAMSTEC/ [2]University of Tsukuba/ [3]Tokyo University of Marine Science and Technology)
後藤慎平，小林大洋，土屋利雄，日吉善久，水谷孝一

1. Introduction

The Argo plan which began in 2000, expand the ocean profiling float that can be observed water temperature and salt to depth of the water 2,000m in the ocean of the whole world, and it is possible to provide to the user the observation data in near real-time via satellite.[1),2)] However, in order to capture the details of the marine environment change in recent years, monitoring of a deep sea area is being required than the water depth 2,000m. Therefore, newly developed to the automatically profiling float "Deep NINJA" which can be observed up to the depth of 4,000m in JAMSTEC and TSK from 2010.[3)] This float is the same as Argo, measure the temperature and salinity in the vertical direction while repeating the dive and float by the buoyancy adjustment mechanism, and transmits observation data when having floating at the sea surface.

In this paper, until now, observation conducted variability analysis of the sea acoustic environment under the sea ice in the Antarctic Ocean deep area that has been supposed that it is difficult and there is almost no environmental perturbation.

2. observation area, and the sound speed conversion

In JAMSTEC, it succeeded in the continuous observation (Overwintering) under the winter sea ice which reaches in about six months in the long-term observation which used "Deep NINJA" in the offing of South Pole Adelie Coast from December, 2012. [4)] This time, sound speed structure was presumed with the sound speed conversion by the UNESCO algorithm from the pressure, water temperature, and salinity profile which were observed for one year by December 2012 to December 2013. Fig.1 shows, the sound speed profile up to the depth 4,000m. In this figure, will be seen there is a tendency that the sound velocity is small in near the sea surface. However, it can be seen that influence of the pressure is dominant in the domain that is deeper than depth of the 250m also in the Antarctic Ocean. From this, it is thought sea surface only, the effects of the water temperature and salinity give to the ocean sound speed in the Antarctic Ocean.

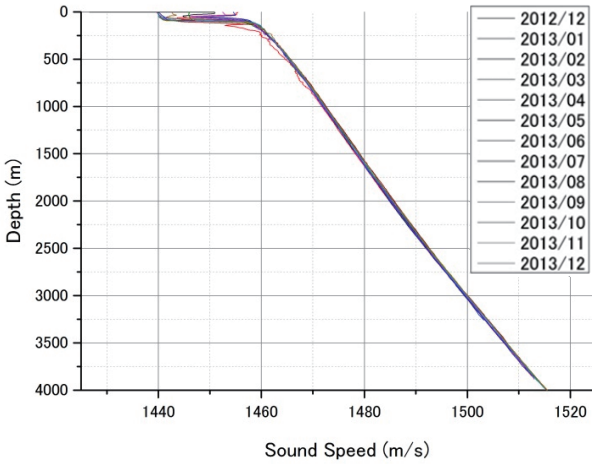
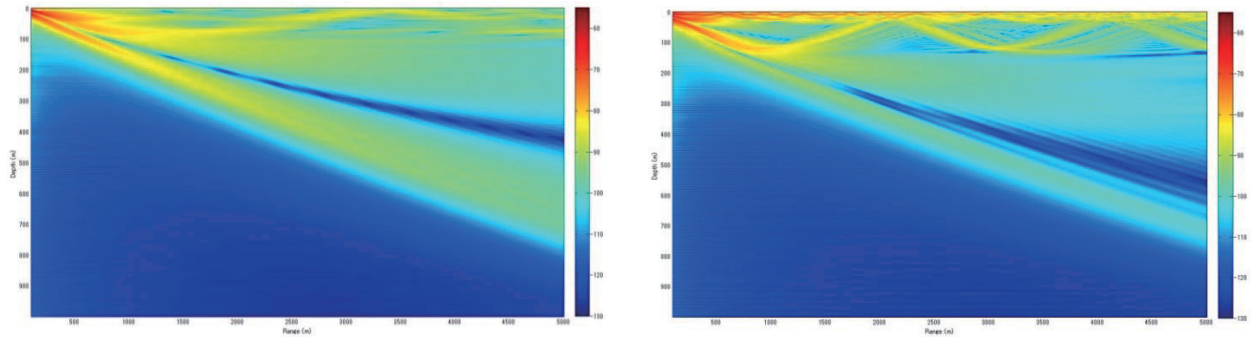


Fig.1 Sound Speed profile

3. Simulation of underwater sound wave propagation

Simulation was performed in order to see the difference in the underwater sound wave propagation of the freezing season and the thawing season in the Antarctic Ocean. This time, from the vertical profile of August (winter) and February (summer) in 2013, Assuming low frequency sonar used in military vessels, the frequency was set to 1kHz, the source depth 10m, the horizontal propagation distance 5000m. Although there are several methods in an underwater sound wave propagation simulation, since there was only one point sound profile data, the normal mode method

E-mail address : gotohs@jamstec.go.jp



(a) 2013/02　　(b) 2013/08

Fig.2 Simulation of underwater sound wave propagation

which can calculate the exact solution of a short distance was used this time.[7] Figure 2 shows, the propagation analysis results of the horizontal distance to 5,000m. As for this graph, a horizontal axis is propagation distance and the vertical axis is depth, and the color bar expresses the amount of attenuation which was set the sound source position to 0 dB.

Looking at the sound field, whereas attenuation is about -65dB at near the sound source in the depth of 10m, in figure 2 (a), the attenuation is large about -90dB at the point of 5,000m in a horizontal direction from the sound source. On the other hand, in the same position in Figure 2, An attenuation region of about -80dB is large and it can be seen that it is about -70dB especially at near the sea surface. From this, it is thought that the sound wave captured by the sound speed inverted layer, propagates to a long distance in near the sea surface by being covered with sea ice in the winter season.

This showed that a difference clear to a propagation course and attenuation arose in a summer and winter in long-distance sound observation in the Antarctic Ocean. Particularly, in winter, it is covered by sea ice, and observation is difficult, but there is little influence of the acoustic noise from the sea surface including the wind and waves. Therefore, in the observation equipment such as passive sonar, it be able to catch the signal of the distant place more because a receiving level becomes bigger than the summer. On the contrary, it is thought that the sound noise near the sea surface which caused by the strong waves also propagate to distant. Therefore, the possibility to affect the predatory behavior of marine mammals using a sound wave because a propagation course fluctuates is thought about in future.

4. Summary

In this paper, long-term observation in the Antarctic Ocean using newly developed profiling float for deep sea "Deep NINJA", it succeeded in the deep sea profiling observation under the winter sea ice for in about six months for the first time in the world. From the data obtained by this, it was analyzed for ocean sound that depth of up 4,000 m in under winter ice in the Antarctic Ocean. In the place deeper than 2,000m that was not observed by the Argo float, it was found that variations in salinity and water temperature is small, and does not affect the sound speed changes therefore. Moreover, in the sea surface, it succeeded in capturing clear seasonal variation in the freezing season and the thawing season. Therefore, the possibility that the sound propagation path and the signal level is different depending on the season was found in the shallow sea area of Antarctic Ocean. From this, the possibility to affect the predation actions of passive sonar or marine mammals is thought about.

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