学 位 論 文 内 容 の 要 旨

博士（環境科学）　　氏 名 ブイ チ グォク オアン

学 位 論 文 題 名

Dissolved methane distribution in seawater and its controlling factors in the polar regions
（極域における海水中メタンの分布とその制限因子に関する研究）

Methane (CH_4) is a potent greenhouse gas and plays significant roles in both tropospheric and stratospheric chemistry. During the last two centuries, mixing ratio of atmospheric CH_4 has increased by 1000 ppb and reached to 1834 ppb in 2015 as a result of anthropogenic activities. It is known that ocean acts as one of the sources of atmospheric methane and the methane flux depend on the oceanic region owing to the difference in biological activities and physical condition. For example, the region characterized by high productivity releases more CH_4 to the atmosphere than the other regions because CH_4 is produced via microbial methanogenesis in anaerobic environments from bacteria in organic particles or the gut of zooplankton. Until now, some works have implemented to measure CH_4 concentration in the polar regions where the impact of climate change is believed to be strongest in the world ocean. However, the data scarcity causes the uncertainty of the CH_4 distribution in the polar oceans, its controlling factors and the contribution of the polar oceans to global CH_4 sea-air fluxes. We, therefore, used the high-resolution dataset to detect oceanic CH_4 in seawater to reduce the uncertainty from the previous estimations.

The Southern Ocean is one of the most biologically productive regions among the world's oceans, where is characterized by high biomass of zooplankton, Antarctic krill, and salps, from which large amount of CH_4 production could be expected. A cavity ring-down spectroscopy (CRDS) system coupled with a shower-head type equilibrator was used to obtain quasi-continuous underway measurements of the mixing ratio of oceanic CH_4 in seawater during legs 2 and 3 of cruise MR12-05 of R/V *Mirai* in the Southern Ocean from late November 2012 to mid-February 2013. High CH_4 saturation ratio (*SR*, %) occurred in the lower latitudes including coastal area north of sub-antarctic front (SAF). *SR* decreased gradually and monotonously between SAF and southern limit of upper circumpolar deep water (SBDY), and occasionally decreased lower than 100% due to vertical mixing/upwelling in high latitudes south of polar front (PF). A good correlation between *SR* and apparent oxygen utilization (AOU) was found south of PF, $SR = -0.294 \times AOU + 100.093$ ($n = 1549$, $r^2 = 0.89$). On the basis of *SR*-AOU relationship, we have calculated the sea-air CH_4 flux during December to February in the entire of the Southern Ocean (south of 50°S). The sea-air CH_4 emission was estimated to be 0.027 Tg-CH_4/yr in December, 0.04 Tg-CH_4/yr in January, and 0.019 Tg-CH_4/yr in February. From our estimation, south of 50°S, the

average flux of CH_4 in austral summer is 0.024 Tg-CH_4/yr, which is account for a minor contribution (less than 1% of the global oceanic release of 4-15 Tg/yr) of CH_4 to the atmosphere.

The Arctic Ocean is particularly the most sensitive to global warming, for example, Arctic sea ice thickness and extent are declining, due to increasing sea-surface temperature (IPCC, 2007). The presence of eddies which are generated as a result of instability of Alaskan Coastal Current through Barrow Canyon. A coherent mesoscale eddy is one of the possible mechanisms for transporting the shelf-water from Chukchi Sea into the Canada Basin interior across the continental slope. In the Arctic Ocean, a massive CH_4 hydrates from marine sediments release (Ruppel, 2011; Fisher et al., 2011) and/or methanogenic CH_4 producing in anaerobic environment with the presence of high organic matter on the seafloor (Reeburgh, 2007) and then diffusion into water column was examined. However, the vertical profile of CH_4 distribution is still scarce, so it is needed to be examined for comprehension of CH_4 dynamics in water column. We examined vertical profiles of methane (CH_4) distribution inside and outside of a warm-core eddy, which had been observed during R/V *Mirai* (MR15-03 Leg. 1) in the Arctic Ocean in late summer/early fall 2015. Warm-core eddies are generated as a result of the instability of shallow current through Bering Strait from the Bering Sea into the Canada Basin crossing Barrow Canyon. A coherent mesoscale eddy is one of the possible mechanisms for transporting shelf-water from the Chukchi Sea into the Canada Basin interior. In this study, the existence of the warm-core eddy that it would carry nutrients as well as dissolve CH_4 and impact on CH_4 distribution. Thus, seawater samples were collected to detect detailed vertical profiles of CH_4 distribution in the southwestern Canada Basin. We caught high CH_4 concentration at the bottom of shelf water, where lied outside of the warm-core eddy, reaching to 947 (%). We found that sub-surface CH_4 peaks inside of the radius of eddy's velocity maximum broadly spread in-depth in comparison with that outside of the eddy. Vertical mixing associated with the velocity shear is likely the controlling factor to explain the sinking mechanism inside of warm-core eddy. Our study indicates that eddies play a crucial role in controlling CH_4 distributions in the euphotic zone and both lateral and vertical transporting CH_4.