ANNUAL REPORT ON GEOTRACES ACTIVITIES IN SOUTH KOREA

May 1st, 2022 to April 30th, 2023

New GEOTRACES or GEOTRACES-relevant publications (published or in press)

- Vertical profiles of ^{228}Ra (half-life: 5.75 years) in the ocean provide valuable information on water mixing and ages of the upper ocean. However, its application is hampered by extremely low levels of ^{228}Ra in the deep ocean. In this study, Cho H.M. et al. (2022) measured high-resolution ^{228}Ra/^{226}Ra ratio profiles (>21 depths) in the East Sea (Japan Sea) by mooring Mn-fiber. Using the measured ^{228}Ra profile from ^{228}Ra/^{226}Ra ratios and ^{226}Ra activities, together with other previously published data, we estimated the vertical eddy diffusivity (8.7–9.6 cm^2 s^{-1}) in the permanent thermocline and water ages (10–15 years) in the upper 500–1000 m range (Figure KOR-1). The estimated decomposition rate of organic carbon based on oxygen utilization rates using Ra-ages between 100 and 1000 m was 4.4 ± 0.8 mol C m^{-2} yr^{-1} (Figure KOR-2). Our results show that ~50% of the upward nutrients through 100 m support export production, and that dissolved organic carbon accounts for ~20% of carbon export (Figure KOR-2). This ^{228}Ra approach provides a holistic understanding of carbon and nutrient cycles in the ocean.

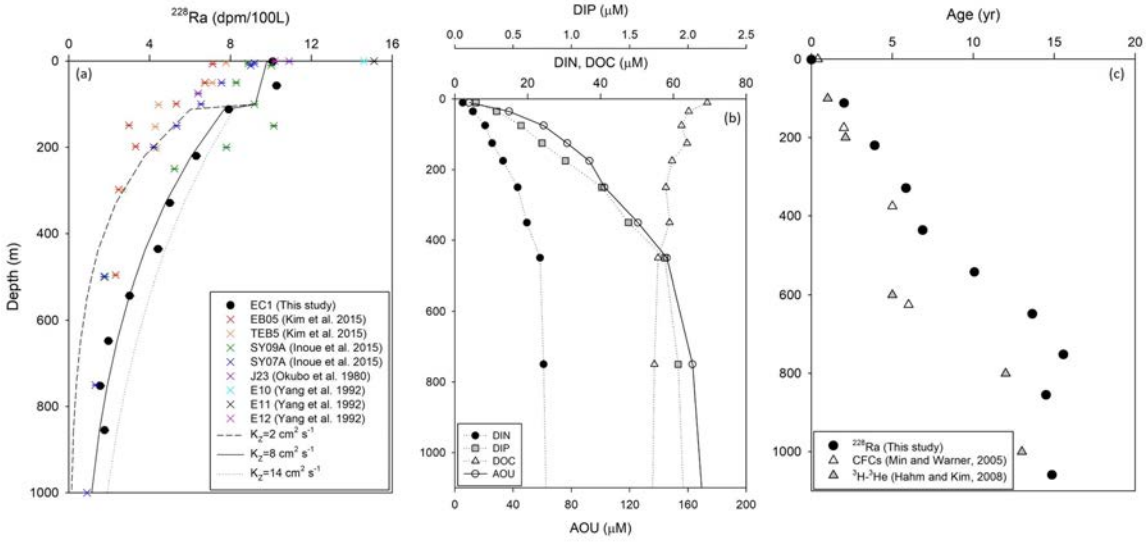

Figure KOR-1. *(a) Model estimates of K_z fitted to the ^{228}Ra profiles in the Ulleung Basin (UB). (b) Vertical profiles of apparent oxygen utilization (AOU), dissolved inorganic nitrogen (DIN) and phosphorus (DIP), and dissolved organic carbon (DOC) from 2006 to 2017 in the UB, East Sea. The dataset is available at the JOISS portal system (http://joiss.kr) which collects and provides marine research data in Korea. (c) Comparison of ^{228}Ra-ages (circles; this study), CFC-11/CFC-12 ratio ages (white triangle; Min and Warner, 2005) in the UB, and ^{3}H-^{3}He ages in the Japan Basin (Hahm and Kim, 2008).*

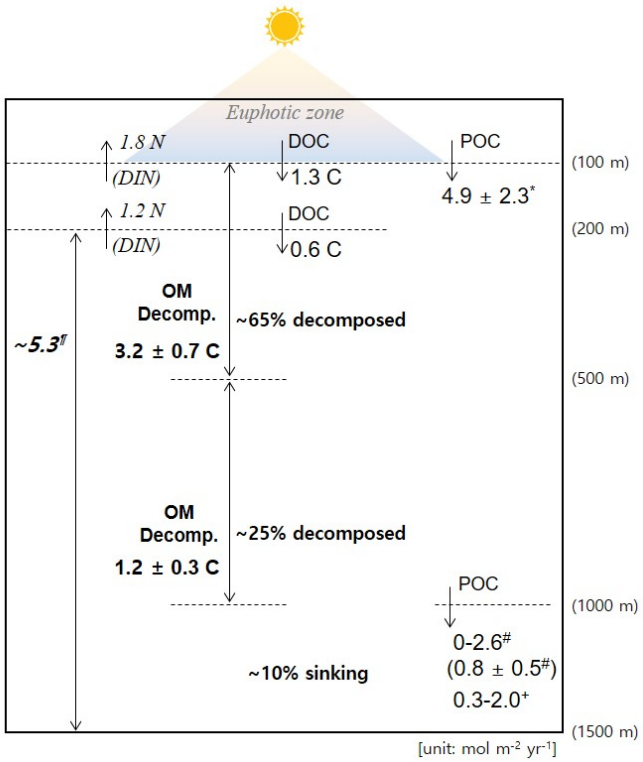

Figure KOR-2. *A schematic of the vertical fluxes of dissolved inorganic nitrogen (DIN) and organic carbon in the upper East Sea. The vertical fluxes of DIN and dissolved organic carbon (DOC) are based on the DIN and DOC gradients and the estimated eddy diffusivity. OM Decomp. denotes the decomposition rate of organic matter/carbon, which is estimated based on the Ra-age-based oxygen utilization rates (OUR). The downward fluxes of particulate organic carbon (POC) are from previous studies: #Sediment trap (at 1000 m, Kim et al., 2020), +Sediment trap (at 1000 m, Kwak et al., 2017), *234Th method (Kim et al., 2011), and ¶carbon export production using 3H and 3He tracers (Kim and Hahm, 2001).*

- Seo J.H. et al. (2022) examined particulate organic carbon (POC) export using ^{238}U-^{234}Th disequilibrium in the eddy-rich northwest Pacific Ocean in Septembers 2019 and 2020 (Fig. 1). In 2019, excess ^{234}Th activities with in acticyclonic eddy were observed caused by horizontal particle transport into the eddy core at the early stage of eddy formation (Figure KOR-3). However, this transport was not observed in an anticyclonic eddy in 2020 since the nutrient-depleted layer was so deep (~ 120 m) that water advection did not help to bring nutrients up from below. In the upper 500 m layer, Th flux at 300 and 500 m depths were not so low and comparable with that at more productive Station Papa (Figure KOR-3). This result suggests that POC flux to the ocean interior in the oligotrophic region may be higher than expected, presumably because production in the deep subsurface chlorophyll maximum layer and a small vertical density gradient. Thus, the examination of POC export at 100 m depth may have been underestimated in the extremely oligotrophic ocean.

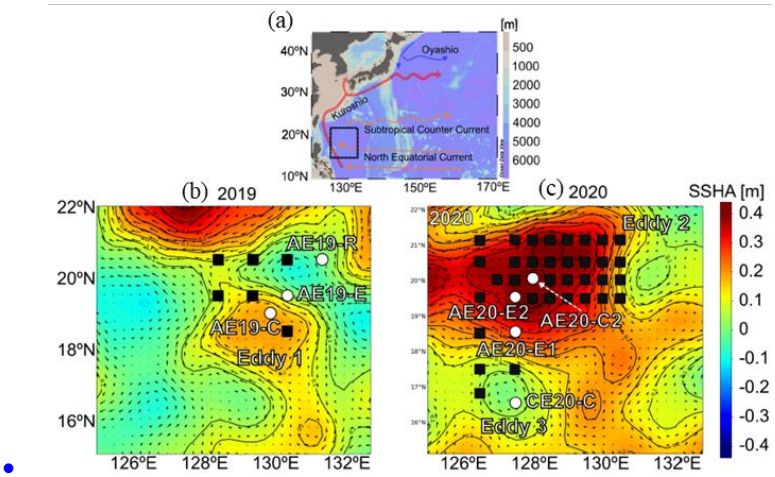

Figure KOR-3. *(a) Map showing the study region (black rectangle) and surface currents in the tropical northwest Pacific (modified from Gallagher et al., 2015). Blow-up map showing (b) the sampling stations (Eddy 1) in September 2019 and (c) sampling stations (Eddy 2 and Eddy 3) in September 2020. Circle (white) and squares (black) represent particulate and hydrography sampling, respectively. The background color shows the sea surface height anomaly (SSHA) averaged over the sampling period. The black arrows indicate the geostrophic current.*

New GEOTRACES or GEOTRACES-relevant publications (published or in press)

- Seo, J., Kim, G., Park, J. H., Seo, H., Na, T., Kang, S. K., & Hwang, J. (2022). Export of particulate organic carbon (POC) in the eddy region of the tropical northwest Pacific. *Frontiers in Marine Science*, *9*, 976201.
- Cho, H. M., Han, Y., Kim, Y. I., Baek, C., & Kim, G. (2022). Tracing the depth-dependent changes in organic carbon and nutrient fluxes using high-resolution ^{228}Ra profiles in the upper East Sea (Japan Sea). *Frontiers in Marine Science*, *9*, 987315.

Completed GEOTRACES PhD or Master theses

- Seo, H. Ph.D. in Earth and Environmental Science, Seoul National University, Republic of Korea, 2022. Dissertation: *"Sources, fluxes, and behaviors of trace elements and radionuclides in the marginal seas of the northwestern Pacific Ocean"* (Advisor: Guebuem Kim)

GEOTRACES presentations in international conferences

- I. Kim, H. Lee*, (2022.12.) Distribution of dissolved trace elements in the northwest Pacifi c marginal seas around the Korean Peninsula *(poster)*, AGU 2022 Fall meeting, Chicago, USA
- I. Kim, J. Lee*. H. Lee, (2022.12.) Annual distribution and atmospheric deposition of ^{210}Po in aerosol in Busan, the largest port city in Korea *(poster)*, AGU 2022 Fall meeting, Chicago, USA
- H. Lee*, J. Lee, H. Lee, I. Kim (2022. 7.) Sectional distributions of trace elements in the East/Japan Sea (*poster*), Goldschmidt 2022, Hawaii, USA (online presentation)
- J. Lee*, H. Lee, H. Lee, I. Kim (2022. 7.) Annual distribution and atmospheric deposition of ^{210}Po and ^{210}Pb in aerosols from Busan, the largest port city in Korea (*poster*), Goldschmidt 2022, Hawaii, USA (online presentation)

Submitted by Dr. Intae Kim, KIOST (ikim@kiost.ac.kr).