

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN JAPAN

April 1st, 2020 to April 30th, 2021

New GEOTRACES or GEOTRACES relevant scientific results

- Nishioka et al. (2020) reported the processes that determine the chemical properties of intermediate water and the uplift of Fe and nutrients to the main thermocline in the North Pacific, which eventually maintains surface biological productivity. In this study, comprehensive observations for investigating Fe and nutrients in the North Pacific and the Okhotsk Sea and the Bering Sea were carried out from 1998 to 2018, including GEOTRACES GP02 data. Nutrient-rich water is pooled in intermediate water (26.8 to 27.6 $\sigma\theta$) in the western subarctic area, especially in the Bering Sea basin. Increases of two to four orders in the upward turbulent fluxes of nutrients were observed around the marginal sea island chains, indicating that nutrients were uplifted to the surface and are returned to the subarctic intermediate nutrient pool as sinking particles through the biological production and microbial degradation of organic substances. This nutrient circulation coupled with the dissolved Fe in upper intermediate water (26.6 to 27.0 $\sigma\theta$) derived from the Okhotsk Sea evidently constructs an area that has one of the largest biological CO₂ drawdowns in the world ocean. These results highlight the pivotal roles of the marginal seas and formation of intermediate water at the end of ocean conveyor belt.

Citation: Nishioka, J., H. Obata, H. Ogawa, K. Ono, Y. Yamashita, K. J. Lee, and I. Yasuda (2020), Subpolar marginal seas fuel the North Pacific through the intermediate water at the termination of the global ocean circulation, Proceedings of the National Academy of Sciences of the United States of America, 117, 12665-12673, doi:10.1073/pnas.2000658117.

GEOTRACES workshops and meetings organized

- PICES 2020 annual meeting topic session, “Atmospheric nutrient deposition and microbial community responses, and predictions for the future in the North Pacific Ocean”, SOLAS-GEOTRACES relevant session, The session had 7 live presentations, 5 recorded oral presentations and 15 electronical poster presentations.
- Domestic GEOTRACES session was held during the fall meeting of The Oceanographic Society of Japan 2020 (November 29, 2020) online for pursuing scientific discussion on recent Japanese GEOTRACES studies. We had 9 oral presentations including those given by students.
- Domestic session entitled “Marine Geochemistry” related to GEOTRACES studies was held during the annual meeting of Geochemical Society of Japan 2020 (November 12 – 26, online). We had 16 presentations including those by 11 students.
- We had a national GEOTRACES symposium in March 23-24, 2021, for promoting scientific discussion on recent Japanese GEOTRACES studies (27 papers were presented). Seven students presented their original results. We also had a business meeting as a GEOTRACES sub-committee meeting under the national SCOR committee (Science Council of Japan) on March 23, 2021. These symposium and meeting were held online hosted by Atmosphere and Ocean Research Institute, the University of Tokyo.

Outreach activities conducted

- On August 17, we had a lecture meeting how to submit our data to IDP2021 for Japanese Geotracer. The lectures were given in Japanese by Dr. Yoshiko Kondo (a member of Standard and Intercalibration Committee) and Dr. Jun Nishioka (a member of Data Management Committee) online.
- The fourth workshop of the WESTPAC WG-06 “A framework for cooperative studies in the Western Pacific Marginal Seas: Energy and materials exchange between land and open ocean” was held on 6-7 October 2020 as a virtual meeting. Thirty experts from eight countries in East and Southeast Asia attended. During this workshop, all participants agreed to submit a proposal of new projects/programme in order for WESTPAC to expand its cooperative activities and contribute to the UN Decade for Ocean Sciences. After the workshop, a ten-year proposal titled “Healthy, Productive and Sustainable Asian Marginal Seas: Understanding changes in the marine environment in response to global climate change” was prepared, submitted and then approved at the 13th Intergovernmental Session of WESTPAC (27-29 April).

Other GEOTRACES activities

- The GEOTRACES Subcommittee of the SCOR Subcommittee of the Earth and Planetary Science Committee in Japan was held online on March 23, 2021. At the committee, recent activities of GEOTRACES-SSC, DMC, S&I meetings were reported by Dr. Hajime Obata (a member of SSC Committee), Dr. Jun Nishioka (a member of DMC Committee), and Dr. Yoshiko Kondo (a member of S&I Committee), respectively. In addition, a brief explanation about Japan GEOTRACES cruise (GP22) scheduled from May to August 2022 was given by Dr. H. Obata.

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

During the past year Japan GEOTRACES investigators published a total of 23 peer-reviewed journal articles. The underlined first author is the ECR.

- Escobar, M. T., N. Takahata, H. Obata, and Y. Sano (2021), Observation of the deep Indonesian Throughflow using helium isotopes. *Journal of Oceanography*, 77, 93-101.
- Fujiwara, Y., M. Tsujisaka, S. Takano, and Y. Sohrin (2020), Determination of the tungsten isotope composition in seawater: The first vertical profile from the western North Pacific Ocean. *Chemical Geology* 555, 119835, doi: <https://doi.org/10.1016/j.chemgeo.2020.119835>.
- Inoue, M., R. Takehara, S. Hanaki, H. Kameyama, J. Nishioka, and S. Nago (2020), Distribution of radiocesium and radium isotopes in the western Bering Sea in 2018, *Marine Chemistry*, 225, 103843, doi.org/10.1016/j.marchem.2020.103843.
- Kanna, N., S. Sugiyama, Y. Fukamachi, D. Nomura, and J. Nishioka (2020), Iron supply by subglacial discharge into a fiord near the front of a marine-terminating glacier in northwestern Greenland, *Global Biogeochemical Cycles*, doi.org/10.1029/2020GB006567.
- Kenyon, J., K. Buesseler, N. Casacuberta, M. Castrillejo, S. Ootosaka, P. Masqué, J. Drysdale, S. Pike and V. Sanial (2020), Distribution and evolution of Fukushima Dai-ichi derived ¹³⁷Cs, ⁹⁰Sr, and ¹²⁹I in surface seawater off the coast of Japan, *Environmental Science & Technology*, 54, 15066-15075.

- Kondo, Y., R. Bamba, H. Obata, J. Nishioka, and S. Takeda (2021), Size-fractionated natural organic Fe-binding ligands in the eastern and western subarctic Pacific, *Scientific Reports*, 11, 2053, doi.org/10.1038/s41598-021-81536-6.
- Liao, W.-H., S. Takano, S.-C. Yang, K. -F. Huang, Y. Sohrin, T. -Y. Ho (2020), Zn Isotope composition in the water column of the northwestern Pacific Ocean: The importance of external sources, *Global Biogeochemical Cycles*, 34, e2019GB006379, doi:10.1029/2019GB006379.
- Mashio, A. S., H. Obata, H. Fukuda, and H. Ogawa (2020), Spatiotemporal variations of platinum in seawater in Otsuchi Bay, Japan after the 2011 tsunami, *Science of the Total Environment*, 708, 134659; doi:10.1016/j.scitotenv.2019.134659.
- Mashio, A. S., T. Tanimura, H. Hasegawa, S. Takeda, and H. Obata (2021), Budgets and sources of dissolved platinum in the inland seas of Japan. *Estuarine, Coastal and Shelf Science*, 253, 107293.
- Misumi, K., J. Nishioka, H. Obata, D. Tsumune, T. Tsubono, M. C. Long, K. Lindsay, and J. K. Moore (2021), Slowly sinking particles underlie dissolved iron transport across the Pacific Ocean, *Global Biogeochemical Cycles*, 10.1029/2020GB006823.
- Miura, H., T. Ishimaru, Y. Ito, Y. Kurihara, S. Ootosaka, A. Sakaguchi, K. Misumi, D. Tsumune, A. Kubo, S. Higaki, J. Kanda, and Y. Takahashi (2021), First isolation and analysis of caesium-bearing microparticles from marine samples in the Pacific coastal area near Fukushima Prefecture. *Scientific Reports*, 11, 5664.
- Nakaguchi, Y., Y. Ikeda, A. Sakamoto, L. Zheng, T. Minami, Y. Sohrin (2020), Distribution and stoichiometry of Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb in the East China Sea, *Journal of Oceanography*, <https://doi.org/10.1007/s10872-020-00577-z>.
- Nishioka, J., H. Obata, H. Ogawa, K. Ono, Y. Yamashita, K. J. Lee, and I. Yasuda (2020), Subpolar marginal seas fuel the North Pacific through the intermediate water at the termination of the global ocean circulation, *Proceedings of the National Academy of Sciences of the United States of America*, 117, 12665-12673, doi:10.1073/pnas.2000658117.
- Nishioka, J., H. Obata, T. Hirawake, Y. Kondo, Y. Yamashita, K. Misumi, and I. Yasuda (2021), A review: Iron and nutrients supply in the subarctic North Pacific and its impact to phytoplankton production, *Journal of Oceanography*, 10.1007/s10872-021-00606-5.
- Ootosaka, S., S. Kambayashi, M. Fukuda, T. Tsuruta, T. Misonou, T. Suzuki, and T. Aono (2020), Behavior of radiocesium in sediments in Fukushima coastal waters: Verification of desorption potential through the pore water, *Environmental Science and Technology* 54, 13778-13785.
- Tanaka, T., D. Hasegawa, I. Yasuda, D. Yanagimoto, S. Fujio, H. Nakamura, R. Inoue, and J. Nishioka (2021), Enhanced vertical turbulent nitrate flux in the intermediate layer of the Kuroshio in the Tokara Strait, *Journal of Oceanography*, doi.org/10.1007/s10872-020-00581-3.
- Takano, S., W. -H. Liao, H. -A. Tian, K. -F. Huang, T. -Y. Ho, and Y. Sohrin (2020), Sources of particulate Ni and Cu in the water column of the northern South China Sea: Evidence from elemental and isotope ratios in aerosols and sinking particles. *Marine Chemistry*, 219, 103751. 10.1016/j.marchem.2020.103751.
- Tsujisaka, M., S. Nishida, S. Takano, M. Murayama, and Y. Sohrin (2020), Constraints on redox conditions in the Japan Sea in the last 47,000 years based on Mo and W as

palaeoceanographic proxies, *Geochemical Journal*, 54, 6, 351-363. 10.2343/geochemj.2.0606.

- Tomonaga Y., K. Yagasaki, J. Park, J. Ashi, S. Toyoda, N. Takahata, and Y. Sano (2020), Fluid dynamics along the Nankai Trough: He isotopes reveal direct seafloor mantle-fluid emission in the Kumano Basin (southwest Japan), *ACS Earth and Space Chemistry*, 4, 2105-2112, 10.1021/acsearthspacechem.0c00229.
- Yamashita, Y., T. Tosaka, R. Bamba, R. Kamezaki, S. Goto, J. Nishioka, I. Yasuda, T. Hirawake, J. Oida, H. Obata, and H. Ogawa (2021), Widespread distribution of allochthonous humic-like fluorescent dissolved organic matter in the intermediate water of the North Pacific, *Progress in Oceanography*, 191, doi.org/10.1016/j.pocean.2020.102510.
- Yamazaki, E., S. Taniyasu, X. Wang, N. Yamashita (2021), Per- and polyfluoroalkyl substances in surface water, gas, and particle in open ocean and coastal environment, *Chemosphere*, 272, 129869.
- Wiwit, K. -H. Wong, H. Fukuda, H. Ogawa, A. S. Mashio, Y. Kondo, J. Nishioka and H. Obata (2021), Wide range detection of Cu-binding organic ligands in seawater using reverse titration, *Marine Chemistry*, 230, 103927: doi.org/10.1016/j.marchem.2021.103927.
- Wong, K. -H., H. Obata, T. Kim, Y. Kondo, and J. Nishioka (2021), New insights into the biogeochemical cycling of copper in the subarctic Pacific: Distributions, size fractionation, and organic complexation, *Limnology and Oceanography*, 66, 1424-1439, <https://doi.org/10.1002/lno.11695>.

Completed GEOTRACES PhD or Master theses

- Ma Teresa Lumantas Escobar (2020), “Study of deep fluids near subduction zones using helium isotopes”, PhD. Env. Thesis, The University of Tokyo.
- Akito Ichimura (2021), “Establishment of highly sensitive and accurate Pd analysis method in seawater using ID-ICP-MS”, M. Eng. Thesis, Kanazawa University.
- Daiki Miura (2021), “Iron supply processes in the eastern south Pacific and Southern Ocean”, M. Env. Thesis, Hokkaido University.
- Fumito Sakuragi (2021), “Investigation of composition and geochemical cycles of rare earth elements in Kuroshio Waters”, M. Env. Thesis, The University of Tokyo.
- Siteng Zhu (2021), “Quantification of diapycnal/isopycnal mixing and material transport in the subtropical northwest Pacific using multiple chemical tracers: interaction between the Kuroshio and surrounding waters.” M. Sci. Thesis, University of Toyama.
- Taiki Tanimura (2021), “The distributions and geochemical cycles of Pt in coastal area, Japan”, M. Eng. Thesis, Kanazawa University.
- Yudai Sunahara (2021), “Distribution of organic Fe-binding ligands in the Pacific Ocean and East China Sea”, M. F. Sc. Thesis, Nagasaki University.
- Yutaka Watanabe (2021), “The role of the southern Sea of Okhotsk on determine chemical properties of Coastal Oyashio water”, M. Env. Thesis, Hokkaido University.

GEOTRACES presentations in international conferences

- Escobar M., N. Takahata, K. Shirai, T. Kagoshima, K. Tanaka, H. Obata, and Y. Sano (2020), Helium and CO₂ fluxes in Wakamiko caldera, JpGU Meeting 2020, Online Poster, July 2020.
- Fukazawa, T., H. Obata, and K. Norisuye (2020), Development of a method for determination of dissolved Te species in open ocean water. Goldschmidt Conference 2020, Online, June 2020.
- Nishioka, J., H. Obata, and I. Yasuda (2020), Importance of intermediate water formation for supplying iron and macro-nutrient in the North Pacific, Goldschmidt Conference 2020, Online Talk (INVITED), June 2020.
- Norisuye, K. (2020), Distributions of Bi and Pb isotopes in the Sea of Japan, Goldschmidt Conference 2020, Online, June 2020.
- Snyder, G., N. Zhang, S. Bowden, Y. Kakizaki, N. Takahata, K. Tanaka, Y. Sano, and R. Matsumoto (2020), Are Japan Sea gas hydrate chimneys an analogue for potential microbial habitats on Mars and other planets? JpGU Meeting 2020, Online Poster, July 2020.
- Snyder G., A. Yatsuk, N. Takahata, R. Shakirov, Y. Kakizaki, H. Tomaru, K. Tanaka, A. Obzhirov, Y. Sano, and R. Matsumoto (2020), Seawater chemistry and helium isotopes in the Tatar Strait, Far Eastern Federal District, Russia, AGU Fall Meeting 2020, Online Oral, December 2020.
- Yamanaka, K., Y. Kondo, N. Fujita, Y. Sunahara, and H. Obata (2020), Fe redox status and its bioavailability in the East China Sea shelf break area, PICES 2020 Virtual Annual Meeting, Online Poster, October 2020.

Submitted by Yoshiko Kondo (yoshikondo@nagasaki-u.ac.jp)