

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CHINA-BEIJING

May 1st, 2022 to April 30th, 2023

New GEOTRACES or GEOTRACES relevant scientific results

- **UCYN-B dominates the diazotroph community in the western North Pacific**

According to the observational results from GP09, GPpr15 summer and winter cruises, unicellular cyanobacteria UCYN-B was found to dominate the diazotroph community and drive variability in N_2 fixation rates in the western North Pacific. In contrast, we found *Trichodesmium* was only prevalent in regions near the western boundary of the North Pacific, and UCYN-A was dominant at the northern edge of the NPSG where N_2 fixation rates were relatively low. Therefore, UCYN-B is primarily responsible for both the high overall diazotroph abundance and N_2 fixation rates under conditions that characterize the under-sampled western North Pacific.

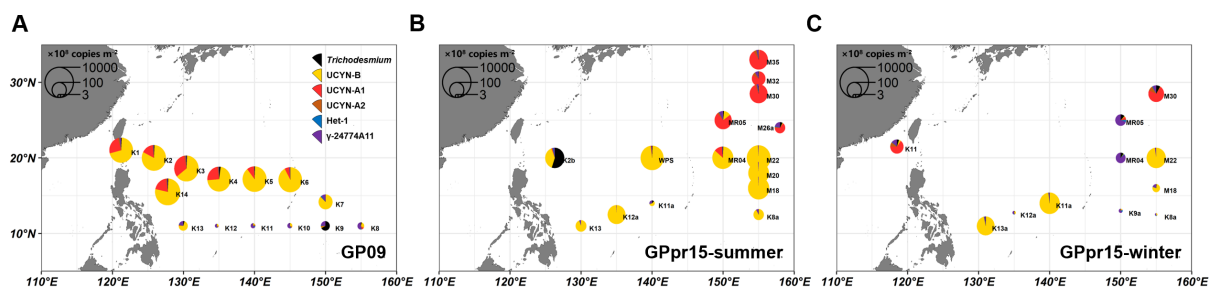


Figure CH-1. Depth-integrated *nifH* gene abundance of six target diazotrophs in the western North Pacific in summer and winter. A. GP09. B. GPpr15 summer. C. GPpr15 winter.

- **Mass Budget of Mercury (Hg) in the Seawater of Eastern China Marginal Seas: Importance of the Sediment-water Transport Processes**

The Eastern China Marginal Seas (ECMS) have been facing a variety of environmental problems, including mercury (Hg) pollution. Although several previous studies have been focused on mass balance of Hg in the ECMS, the contribution of Hg transport at the sediment-water interface remains unclear. This study was aimed to access and quantify the importance of sediment-water transport processes in Hg cycling. Significantly positive correlations were observed between Hg concentrations in the overlying and bottom water and the diffusion rates of Hg from sediment to the water. Approximately 2-3 times higher of THg concentrations in the entire water column were observed in a winter cruise with strong waves which was supposed to strengthen the resuspension process. The mass budget of Hg in the ECMS further showed that diffusion and resuspension processes accounted for approximate 46%, 60%, and 16% of total input Hg in the BS, YS, and ECS, respectively. These results suggest that the sediment-water transport processes play an important role in Hg cycling in the ECMS. As an important ‘pool’ of Hg in the ECMS, the transport of Hg at the sediment-water interface may affect the long-term risk assessment of Hg in these systems.

- **Nonconservative behaviour of dissolved molybdenum and its potential role in nitrogen cycling**

The dissolved Mo (dMo) concentrations and parameters related to Mo distribution and N cycling in surface and bottom seawaters of the Bohai (BS) and Yellow Seas (YS) were examined. The results showed that dMo concentrations ranged from 36.4 nmol L⁻¹ to 125.0

nmol L⁻¹, most of which deviated significantly from the conservative line, indicating nonconservative behavior of Mo relative to salinity. Significant depletion up to 40-50 nmol L⁻¹ of dMo mainly appeared in the BS, NYS and south of the SYS, suggesting the possible removal of dMo by biological utilization and particle adsorption. The similar spatial distribution of dMo and dMn concentrations suggested the possible scavenging by Mn oxide phases for Mo removal. The negative correlation between dMo and Chl-*a* concentrations in surface seawaters suggested that biological uptake was involved in dMo removal. The depleted dMo in most of sites corresponded with the higher nitrite concentrations, implying the possible involvement of nitrate reduction process.

- **Dynamic mobilization of redox sensitive elements Mo, U and V in seasonal hypoxic sediments off the Changjiang Estuary**

The profiles of porewater and solid redox sensitive elements (RSEs) and their chemical speciation and diffusive fluxes at the sediment water interface (SWI) of five sites off the Changjiang Estuary in two seasons were measured. The results showed that porewater and solid RSEs displayed the corresponding profile variations. The porewater Mo and U concentrations generally decreased with depth, attributed to the reductive removal. Particularly, the removal of Mo may be mediated by the Fe-S phase, and the removal of U appears to be via the microbially-mediated reduction. Porewater V, U and Mo were removed successively with depth, corresponding to the peaks of dissolved nitrate, Fe²⁺ and acid volatile sulfur (AVS). However, porewater V increased again in the deep layers due to its complexation with dissolved organic matter. The upward shift of RSE peaks in porewater and transformation depths of their oxidation states based on the model from spring to summer reflected the occurrence of hypoxia in summer. The downward diffusive fluxes of RSEs at hypoxic site in summer indicated their hypoxia-induced enrichment. The Mo-U covariation suggested that the seasonal hypoxic sites off the Changjiang Estuary were more favorable for the accumulation of authigenic U.

- **Building a new biogeochemical model including iron cycle**

We are developing a new biogeochemical model including iron cycle. The CoSiNE-Fe model has five phytoplankton groups including picoplankton, diatom, and three diazotrophs (unicellular cyanobacteria, *Trichodesmium*, diatom-diazotroph associations (DDA)). The new Iron cycles including soluble Fe, colloidal Fe, strong ligand Fe, weak ligand Fe, strong ligand, and weak ligand, in which atmospheric depositions of Fe, N, P, and lithogenic particles, and parameterized Fe sources from sediments and hydrothermal vents are accounted. In addition, we introduce a new light attenuation scheme with a dual-band model and phytoplankton photoacclimation parameterization to the model. The CoSiNE-Fe model has been coupled with ROMS model for the Pacific Ocean to simulate interactions among physical, biological, and biogeochemical processes.

GEOTRACES or GEOTRACES relevant cruises

- 2022 Northwest Pacific Ocean Multidisciplinary Cruise, surficial and core samples were collected to analyze Hg species and isotopes during this cruise.
- 2022 Kuroshio Extension Cruise, profile samples were collected from the northern edge of NPSG and Kuroshio Extension area with a GEOTRACES standard rosette sampling system to analyse dissolved iron during this cruise.

New projects and/or funding

- Integrated Study on the Multiscale Material Cycling at the Sea-Air Interface in the West Pacific (Integrated Project of the NSFC Major Research Plan Program, 2023-2025, leading PI: Zhimian Cao)
- Impact of iron cycle on the carbon fixation and its future projection under climate change in the North Pacific Ocean (National key research and development program, 2023-2025, leading PI: Peng Xiu)

Other GEOTRACES activities

- The distribution of Ra isotopes (^{223}Ra , ^{224}Ra , ^{226}Ra and ^{228}Ra) in the Sanmen Bay and Dongshan Bay was investigated and used as tracers to determine submarine groundwater discharge carbon and nitrogen to the bays;
- The distribution of ^{210}Pb in the Qinzhou Bay and ^{210}Po , ^{210}Pb and ^{234}Th in the Taiwan Strait and East China Sea was investigated and used as tracers to evaluate the particle dynamics.

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

- Zhou, Z., Wang, H., Li, Y. (2023). Mercury stable isotopes in the ocean: Analytical methods, cycling, and application as tracers. *Science of the Total Environment*, 874, 162485.
- Chen, L., Liu, C., Yin, Y., Liu, G., Li, Y., Cai, Y. (2022). Mass Budget of Mercury (Hg) in the Seawater of Eastern China Marginal Seas: Importance of the Sediment-Water Transport Processes. *Environmental Science & Technology*, 56, (16), 11418-11428.
- Liu, J., Yu, X., Du, J. (2022). Tidally driven submarine groundwater discharge to a marine aquaculture embayment: Insights from radium and dissolved silicon. *Marine Pollution Bulletin*, 178, 113620.
- Yu, X., Liu, J., Chen, X., Huang, D., Yu, T., Peng, T., Du, J. (2022). Submarine groundwater-derived inorganic and organic nutrients vs. mariculture discharge and river contributions in a typical mariculture bay. *Journal of Hydrology*, 613, 128342.
- Zhong, Q., Li, L., Puigcorb , V., Huang, D., Yu, T., Du, J. (2022). Contrasting behaviors of ^{210}Po , ^{210}Pb and ^{234}Th in the East China Sea during a severe red tide: Enhanced scavenging and promoted fractionation. *Acta Oceanologica Sinica*, 41(8), 5-21.
- Zhong, Q., Puigcorb , V., Chen, X., Rodellas, V., Wang, X., Yu, T., Du, J. (2022). Unexpectedly high dissolved ^{210}Pb in coastal groundwaters: Is submarine groundwater discharge important in coastal sea? *Chemical Geology*, 614, 121165.
- Zhong, Q., Guo, W., Wang, H., Ji, J., Lin, J., Du, J., Huang, D., Yu, T. (2023). ^{210}Po and ^{210}Pb as tracers for particle cycling in a shallow semi-enclosed bay of Taiwan Strait. *Deep Sea Research Part II: Topical Studies in Oceanography*, 207, 105228.
- Cao, A., Zhang, J., Zhang, H., Chen, Z., Cui, G., Liu, Z., Li, Y., Liu, Q. (2023). Dissolved rare earth elements in the Northwest Pacific: Sources, water mass tracing, and cross-shelf fluxes. *Frontiers in Marine Science*, 1135113.
- Kong, X., Zhang J., Li, Y., Otsuka, S., Liu, Q., He, Q. (2023). Selenium in the liver facilitates the biodilution of mercury in the muscle of *Planiliza haematocheilus* in the Jiaozhou Bay, China. *Ecotoxicology and Environmental Safety*, 258.

- Che, H., Zhang, J., Liu, Q. He, M. Zhao, Z. (2022). A driving factor for harmful algal blooms in the East China Sea coastal marine ecosystems — Implications of Kuroshio subsurface water invasion. *Marine Pollution Bulletin*, 181, 11387.
- Wang, X., Zhou, P., Yang, W., Chen, M., Cheng, H., Chen, G., Cai, Y. (2023). Enhanced mesopelagic particle export in the northern South China Sea derived from $^{210}\text{Po}/^{210}\text{Pb}$ disequilibrium. *Chemical Geology*, 634, 121582.

Completed GEOTRACES PhD or Master theses (please include the URL link to the pdf file of the thesis, if available)

- Master thesis: Temporal and spatial distribution characteristics and ecological risks of heavy metals and total petroleum hydrocarbons in the Bohai Sea and its typical bay Laizhou Bay.
- Master thesis: Speciation and bioavailability of heavy metals in the sediment of Laizhou Bay and Jiaozhou Bay.
- PhD theses: Submarine groundwater discharge borne nutrients in the coastal aquaculture ecosystem and its environmental effects.
- PhD theses: A comparative study of submarine groundwater discharge and its-derived nutrients in typical bays under the influence of anthropological activities.
- Master theses: Carbon fluxes via submarine groundwater discharge in a typical coastal saltmarsh wetland-nearshore-estuary continuum.
- PhD thesis: Trophic dynamics and interactions of mercury and selenium in the food web of Jiaozhou Bay and assessment of their health risk exposure.
- Master thesis: Distribution characteristics and tracing of dissolved rare earth elements in the Northwest Pacific Subtropical Gyre during summer and winter.
- PhD thesis: On the particle dynamics in the tropical western North Pacific as elucidated by U-series nuclides: Dust deposition, Lateral transport and Boundary scavenging.

GEOTRACES presentations in international conferences

- Yanbin Li. Low system efficiency of producing methylmercury controls the current and future risk of mercury in China Coastal Seas. The Sixth Xiamen Symposium on Marine Environmental Sciences, January 12, 2023, Xiamen, China

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