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Removal fluxes of iron and manganese in the western Pacific surface waters estimated by Th-234 and U-238 disequilibrium

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Iron (Fe) and manganese (Mn) in seawater are essential micro-nutrients for marine phytoplankton. In the western subarctic Pacific, it is well known that iron-deficiency limits the phytoplankton growth. Since Fe and Mn have similar sources in the ocean, they are often investigated simultaneously. However, Fe is a highly particle-reactive element in the oxic open ocean, and some of Fe is removed by sinking particles from the water column during the lateral transportation. Therefore, the Fe supply processes are complicated and have not been adequately revealed yet. To estimate sinking particulate flux in the ocean, the Th-234 and U-238 disequilibrium method has been used in the surface ocean. The rapidly sinking particles in the surface ocean produce deficit of Th-234 in the surface waters which could be a good indicator of scavenging rate of particle-reactive trace metals, like Fe and Mn (e.g. Hayes et al., 2018; Black et al., 2019; 2020).

In this study, we measured labile particulate Fe and Mn in the subarctic and subtropical western North Pacific during GEOTRACES GP22 cruises. During the research cruises, we also revealed the Th-234 and U-238 disequilibrium and particulate Th-234 distributions in the surface layers at the same stations. By combining the particulate data of Fe, Mn and Th-234 and the disequilibrium, we estimated the removal fluxes of Fe and Mn in the western subarctic and subtropical North Pacific. The results indicated the highest removal fluxes of particulate Fe and Mn at the subarctic Pacific station. The residence time of the trace metals can also be estimated from the fluxes and the average concentration of total dissolvable trace metals. The residence times of Fe and Mn in surface waters were estimated as 15 – 32 days and 40 - 387 days in the subtropical North Pacific, but 9.8 and 42.8 days in the subarctic Pacific, respectively. To clarify the time variation of these trace metals, we will need more frequent observations at the stable oceanic station.