Significance of recirculated saline groundwater discharge in Moune Bay, Japan: water flux, nutrient transport, and effects on biological production

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The coastal sea is one of the important areas in the global ocean due to high primary productivity. While riverine loading of nutrients is a major source for sustaining primary productivity, it is now recognized that submarine groundwater discharge (SGD), which includes the discharge of meteoric fresh groundwater (FSGD) and recirculated saline groundwater (RSGD), supplies comparable nutrients from land to coastal seas. The Sanriku ria coast is characterized by numerous drowned valleys and a narrow shelf. In the region, it is well known that the Oyashio Current supplies large amounts of nutrients into coastal embayment. On the other hand, the ria coast is a hot spot influenced by groundwater discharge. However, the magnitudes of nutrient fluxes through the groundwater, and the fraction of FSGD and RSGD, as well as a comparison with oceanic nutrient transport, has not been assessed. In this study, we conducted 5 sampling campaigns in different seasons (June, August, October 2018, January, and March 2019) and monitored the groundwater level near the coast in the head of Kesennuma Bay (Moune Bay). We rely on the combined approach of Darcy’ s low and Ra mass balance model to quantify water and nutrient fluxes of FSGD and RSGD as well as river and offshore seawater.
The estimated mean FSGD flux was 8.8% and 1.5% of total freshwater flux and SGD flux to Moune Bay, respectively. The inflow of offshore seawater dominates (> 99.4%) water budget in Moune Bay and mean contribution rates of DIN, DIP, and DSi fluxes were 83%, 93%, and 80%, respectively. RSGD-derived nutrient flux was the second-largest input in the Moune Bay. Mean contribution rates of DIN, DIP, and DSi fluxes derived from RSGD were 15%, 6%, and 13%, respectively, and each contribution rate varied in season. When nutrient fluxes from offshore seawater were minimum in October, RSGD-derived DIN, DIP, and DSi flux increased to 37%, 18%, and 19%, respectively. The stronger contribution of RSGD could result in higher abundance and productivity of phytoplankton (Nakajima, unpublished data). These results suggest that recirculated saline groundwater might have a significant impact on biological productivity in Moune Bay as well as oceanic nutrients.

Keywords: Submarine groundwater discharge, Ra isotopes, Coastal seas, Nutrients

