Transients in the biogeochemical reaction zone of subterranean estuaries

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Subterranean estuaries are sources of biogeochemically reactive solutes to the ocean, including nutrients and metals. Solute fluxes depend on the volumes of submarine groundwater discharge (SGD), which is a function of the relative amounts of meteoric water recharging coastal aquifers and seawater circulating through subterranean estuaries. Mixing of these two sources enhances fluid-solid reactions by altering pH and redox conditions and sorption kinetics. The salt water/freshwater ratio is thus critical to solute fluxes but varies through time and space depending on the hydraulic head in subterranean estuaries. Periodic short term processes, including wave and tidal pumping, have long been known to increase the salt content of subterranean estuaries, but long-term processes including storm setup, fluctuations of terrestrial groundwater head, and sea level rise also alter the salt water/freshwater ratio. These long-term effects have been documented in the Indian River Lagoon Florida, where salinity of pore water at depths of 1.5 and 2.5 m below the sediment-water interface switched from fresh to brackish 15 m from shore and from saline to brackish 30 m from shore after the passage of Tropical Storm Tammy and Hurricane Wilma. Pore water returned to pre-storm salinity within two months at the nearshore site and six months at the offshore site. At longer time scales, the seaward edge of the freshwater seepage face moved inland approximately 10 m between 2004 and 2007 corresponding to a decrease in recharge to the Surficial Aquifer of about 40 cm. Recently collected data (November, 2013) from the same site indicates that the seepage face has migrated another 10 m toward shore since 2007 reflecting a total reduction in width of around 70% over the past decade. Elevated Fe and Mn concentrations at the fresh water-saltwater interface suggest labile marine organic carbon in recirculated seawater reduces metal-oxides coating the grains. Transient salinity conditions should alter subterranean microbial communities, but whether they shift structures or become dormant with changing salinity is unknown. Changes induced by transient conditions provide a glimpse into effects that may result from sea level rise, which is projected to increase by up to 1 m by 2100.