

## Redox dynamics resulting from chemical and physical fluxes in surficial permeable sediments

The upper layers of nearshore permeable sediments are dynamic, active sites of intense redox cycling. Previous research and our preliminary results indicate that vertical redox oscillations in these sediments can be driven by biogeochemical or physical variability, or by episodic events such as severe storms and their associated terrestrial runoff. Further, it can be assumed that each of these forcings operate on different and distinctive time and vertical scales. **We propose to calculate rigorous estimations of biogeochemical fluxes across the hyperactive sediment-water interface (SWI) of permeable sediments, and within the upper 10cm of the sediment, by coupling porewater velocity modeling with fine-scale real time physical (temperature across the SWI, and sediment ripple topography) and chemical measurements (*in situ* voltammetry, pH and Eh profiles).** The research will couple cutting-edge *in situ*, fine-scale chemical and physical sensors, cabled observatory infrastructure and data handling, and pioneering numerical models of porewater motion. This highly interdisciplinary approach aims to provide detailed information on the role that permeable sediments play in biogeochemical cycles of nearshore sediments, and to elucidate the processes that modulate permeable sediment functioning.

The **Intellectual Merit** of the proposed research focuses on its central goals of calculating the fluxes of redox-sensitive chemical species in surficial permeable coastal sediments, and understanding the transformations within the highly responsive “zone of reactivity” in the upper centimeters of these sediments. **We aim to:** (1) improve our understanding of the interaction between these active, carbon recycling sediments and the overlying water column; (2) examine in detail the temporal and spatial variability of key redox-reactive chemical species; (3) quantify the relative contributions of benthic photosynthesis, sand ripple position, currents and waves, and episodic organic loading events to redox oscillations; and 4) integrate fine-scale chemical measurements with porewater velocity modeling to calculate biogeochemical fluxes.

Specifically, **we hypothesize that:** (1) centimeter-scale surficial transport in permeable sediments can be measured and modeled using temperature as a natural tracer; (2) redox-sensitive chemical species ( $O_2$ ,  $Fe^{2+}$ ,  $Fe^{3+}_{aq}$ ,  $FeS_{aq}$ ,  $H_2S/HS^-$ ,  $S_x^{2-}$ ) important to biogeochemical cycling can be measured by solid-state *in situ* voltammetry on spatial and temporal scales relevant to the porewater transport calculations, allowing calculated biogeochemical flux estimates for the upper centimeters of the sediment and across the SWI; and (3) temporal variability of porewater chemical concentrations, rates, and fluxes can be measured, and this variability can be linked to specific forcing mechanisms.

The existing Kilo Nalu Nearshore Reef Observatory and its data acquisition and data dissemination systems provide an ideal facility for studying benthic boundary layer biogeochemistry: (1) it provides easily accessible power and high bandwidth communications for *in situ* instruments; (2) a wide range of physical oceanographic measurements important to this project are already being collected by the observatory; and (3) Oahu’s south shore has a wide and predictable variety of surface wave conditions and land-based inputs that impact the redox-sensitive biogeochemistry of its permeable sediments.

The project’s **Broader Impacts** reflect the interdisciplinary nature of the research. Permeable sediments are important habitats for bottom fish, invertebrates, and other commercially important species, and our proposed research provides information that can be used to support the management of these habitats to help ensure their ecological health. Additionally, the PIs will participate in education and outreach programs to promote the public’s understanding of the key role that permeable reef sediments play in the recycling of carbon and nutrients in reef ecosystems. The project will also support the research of a post-doctoral fellow, an Oceanography graduate student, and a Global Environmental Sciences undergraduate.