Safeguarding from Sulfide: Can Pescadero Estuary be restored?
Chandra M. Richards and Céline Pallud
Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA

Introduction

Intertidal estuaries are dynamic environments characterized by the aperiodic formation of a sandbar at the estuary’s mouth (1). Common on the California coast (2), these spatially and temporally complex systems act as transition zones between ocean and land, and nursery habitats for ecologically and economically important species. However in recent years, 67% of estuaries in the U.S. have degraded due to eutrophication, dissolved oxygen (DO) depletion, and disease (3). In intermittent estuaries globally, fish kills are often associated with the transition from closed to open, likely resulting from the direct and indirect effects of hydrogen sulfide (H\textsubscript{2}S), a product of microbial sulfate (SO\textsubscript{4}\textsuperscript{2-}) reduction under anoxic conditions (4).

Since 1995, fish kills have occurred nearly annually with the aperiodic breach of the sandbar in the Pescadero Estuary located on the California coast (3), leading to its inclusion on the CA Clean Water Act list of impaired waters (6). The cause, though unclear, is likely an environmental issue relating to poor water quality (6). In order to understand the effects of the estuary biogeochemical dynamics on water quality, we investigated the spatial heterogeneity of microbial sulfate reduction in sediment and hydrogen sulfide release to water and the variables controlling these biogeochemical processes in the closed and open states at Pescadero (Fig. 5).

Hypotheses: In the closed state, microbial SO\textsubscript{4}\textsuperscript{2-} reduction increases due to low DO, increasing H\textsubscript{2}S column and iron sulfide precipitates in sediment. In the open state, microbial SO\textsubscript{4}\textsuperscript{2-} reduction decreases slightly as the estuary is drained and iron sulfide precipitates are oxidized, further depurifying DO in the water column. Long periods of breached conditions, coupled with breaching events, worsen water quality and increase fish kill events.

Study Site: Pescadero Natural Marsh Preserve

Results

Figure 3. a) Pescadero Estuary (CA), and location of the four sites sampled in August 2013 (closed state) and February 2014 (open state), b) Federally-threatened steelhead trout with sulfide-rich sediments in its mouth and gills, after a natural breaching event.

Figure 4. Geochemical characteristics and near in situ rates at four Pescadero sites in the closed and open states: a) water H\textsubscript{2}S\textsuperscript{2-} concentration, b) sediment H\textsubscript{2}S\textsuperscript{2-} content, c) near in situ SRR, d) near in situ SReR. The sites exhibit a salinity gradient from the Pacific Ocean to the Butano Creek.

Conclusions

This study investigated microbial sulfate reduction, hydrogen sulfide release, and hydrogen sulfide precipitation using flow-through experiments on intact sediment cores of Pescadero Estuary in the closed and open states. FTR experiments revealed a link between near in situ rates and field concentrations of SO\textsubscript{4}\textsuperscript{2-} and H\textsubscript{2}S. Consistent with our hypotheses, sulfate reduction predominates in the closed state, only outweighed slightly by hydrogen sulfide oxidation pathways in the open state.

Acknowledgments

We acknowledge undergraduate field and laboratory assistance from Kyle Cartajal, James Heke, Hose Ngo, and Vu Ngo. We would like to thank Heather Dong (Silver Lab) for assistance with the C:N analyzer, Stephanie Carlson and Mark Stacey for their collaboration, and fellow Pullab Lab members, Kathrin Schilling, Scanet Matzen, and Linden Schmidt for their advice during the study. This research was supported by SeaGrant and the UC Berkeley Department of Environmental Science, Policy, and Management.

Works Cited