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Eutrophication and Nutrient Cycling in Loma Alta Slough, Oceanside, California

Karen McLaughlin[1], Martha Sutula[1], Jaye Cable[2] and Peggy Fong[3]

[1] *Southern California Coastal Water Research Project, Costa Mesa, CA*

[2] *Louisiana State University, Baton Rouge, LA*

[3] *University of California, Los Angeles, CA*

EXECUTIVE SUMMARY

The purpose of this report is to summarize the findings of a SCCWRP study conducted to support the development of a eutrophication water quality model in Loma Alta Slough. The study included measurement of primary producer biomass, sediment and particulate nitrogen and phosphorus deposition, benthic dissolved oxygen and nitrogen (N) and phosphorus (P) fluxes, and sediment bulk and pore water N and P.

The purpose of this report is two-fold:

- Provide a summary of SCCWRP study data that will be used to develop and calibrate the water quality model for Loma Alta Slough.
- Synthesize study data to inform management actions to address eutrophication and improve the efficiency of nutrient cycling in Loma Alta Slough.

It should be noted that railroad bridge maintenance that occurred during field data collection may have significantly altered conditions within the Slough and produced some artifacts observed in the data during sampling. We recommend redeploying data sondes downstream of the railroad bridge just prior to and during mouth closure and conducting limited analysis of sediment organic matter and nutrients to support TMDL modeling studies.

Following are the major findings of this study:

1. Loma Alta Slough is highly disturbed with respect to eutrophication
    - Primary producers in Loma Alta Slough were dominated by filamentous algae and cyanobacteria mats, indicating that the Slough is on the extreme end of the disturbance gradient with respect to eutrophication. Total algal biomass was extremely high, with peak values of 364 g dry wt m^{-2} during the summer index period when the Slough was closed to oceanic exchange.
    - Chronic hypoxia (dissolved oxygen (DO) < 2 mg l^{-1}) at the segment site (upstream of the railroad bridge) occurred almost immediately with the closure of the Slough ocean inlet and endured throughout early fall until the Slough was opened in preparation for the storm season. Chronic hypoxia is a consequence of the accumulation and decomposition of live and dead algal biomass. However, the configuration of a main channel with a deeper portion occurring just before the closed inlet would tend to trap salty water at the bottom. This trapped layer would extend the residence time of bottom waters, depleting oxygen and compounding potential problems with hypoxia.

2. Terrestrial loads drive the Slough nutrients budget year round, providing an excessive amount of N and P available to fuel biomass growth.
    - The amount of TN from terrestrial sources was 65 times the amount required to support primary producer biomass during the summer. Despite the fact that the Slough is closed during this period, residual N is likely flowing through or under the sand berm, providing a source of N to the coastal ocean. Benthic exchange of N, as well as other N sources such as N fixation and direct atmospheric deposition provided an insignificant direct load to the Slough relative to terrestrial runoff. The direct input of groundwater to the Slough is unquantified and may potentially be a large source.
    - The contribution of benthic P was significant only during the spring and fall periods. During the summer, sediments took up P, so terrestrial loads provided the majority of P supporting macroalgal biomass. A deficit in the P budget residual indicates that external loads are not sufficient to support the high biomass observed. It is likely that internal recycling of P through the microbial loop plays an important part of maintaining high primary producer biomass within the Slough. Because P appears to be a limiting nutrient in the Slough, understanding the sources of P is critical for managing eutrophication.

3. Despite the high biomass and chronic hypoxia, the straight channel and fluvial hydrology of Loma Alta Slough, a river mouth estuary, lends itself toward scouring of sediments during storm events and effectively prevents the interannual accumulation of organic matter that can occur in more depositional environments (such as lagoons) after the growing season. This self-cleansing function thus resetting the eutrophication "clock" each storm season, making the system less susceptible to eutrophication. Sediment oxygen demand, as measured by benthic dissolved oxygen fluxes, was generally low during all periods of the year. Benthic contributions of N and P were likewise low and small relative to terrestrial runoff.

4. Railroad bridge maintenance caused scouring of sediments downstream of the bridge, thus producing an artifact that will affect measurement of benthic dissolved oxygen and nutrient fluxes during the April, July and October index periods. Maintenance involved placement of a berm downstream of the Railroad bridge, causing ponding of the upstream portion of the Slough and providing a course of terrestrial soils and gravel to the downstream portion. It is not clear what cumulative effect this maintenance has on the hydrology, enteric bacteria and patterns of eutrophication measured during the field season.

Loma Alta Slough, as a river mouth estuary, appears to have the advantage that sediments do not appear to accumulate excessive organic matter with depth. Therefore, options for management of eutrophication in Loma Alta Slough are aimed at reducing the availability of nutrients for primary production during the growing season, or removing biomass from the Slough. Three types of options could be considered:

1) Reduce terrestrial loads in order to limit primary productivity. Emphasis should be placed on reducing both P as well as N from the watershed because primary productivity appears to be P limited.
2) Increase flushing during peak periods of primary productivity, particularly when the Slough is closed to surface water exchange with the ocean during the summer. Clearly this is a trade off with a potential increase in sources of pathogens to the beach during summer. Improved circulation during closed condition could help to limit stratification and therefore ameliorate, to a minor extent, problems with hypoxia. However, limited options exist to increase circulation because of the linear configuration of the Slough.
3) Harvest algal biomass. This option could help to alleviate hypoxia and associated problems. However, the cost-effectiveness of harvesting as a management tool must be carefully considered.

Full Text

ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/630_LomaAltaSlough.pdf