Assessing the Role of Sediment Supply in Mudflat Width at Decadal and Seasonal Time Scales

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Mudflats provide valuable habitat for unique ecosystems such as benthic algae and critical feeding area for migratory bird species. Together with adjacent salt marshes they form a natural defense against wave attack by attenuating waves. In this study, we explore the relationship between sediment supply and mudflat width for the mudflat just south of Dumbarton Bridge in South San Francisco Bay. The width of the mudflat has changed at decadal and seasonal time scales, as documented by repetitive bathymetry surveys. From 1858 to 1931, the mudflat narrowed approximately 200 m. From 1931 to 2005 it widened to a point where it was wider than it was in 1858. The decadal change in mudflat width is correlated with overall sediment losses and gains in the South Bay. Mudflat width appears to respond to suspended sediment load on seasonal time scales as well. In 2010, the cross-sectional averaged suspended sediment concentrations (SSC) at Dumbarton Bridge were two times greater in spring-summer than in the winter (Shellenbarger et al., 2013). The mudflat widened in the spring-summer when SSC was higher and was relatively stable in winter when SSC was lower.

These observations suggest that sediment supply is a controlling factor in mudflat width. We explore this hypothesis using a simple 1D model (Delft3D) forced by tides, waves, and suspended sediment concentration. We report model predictions of mudflat width for simulations with varying suspended sediment concentrations while holding tide and wave forcing constant. In the face of rising sea levels and overall trends of decreasing sediment supply in the San Francisco Estuary, understanding the role of sediment supply on mudflat width may aid in resource management decisions.

Shellenbarger, Wright, and Schoellhamer, 2013, 10.1016/j.margeo.2013.05.007

Keywords: mudflats, sediment transport, interferometric swath bathymetry surveys, sediment exchange

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Climatology of Salinity and Suspended Particulate Matter in San Francisco Bay

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Salinity and suspended particulate matter (SPM) data are documented in a unique 48-year US Geological Survey program monitoring environmental variables in San Francisco Bay. This program started in 1968 and continues to the present. This monitoring program comprises longitudinal surveys of the bay, conducted about once per month. Vertical profiles of salinity and SPM are collected at 36 sampling locations, from the Sacramento River Delta to the southern limit of South Bay. This data set is a valuable source of information, unparalleled in any other estuarine system, and can provide the climatology of spatial variability of salinity and SPM throughout the bay. However, the sampling methodology aimed to provide mainly a spatial distribution of the variables and did not account for tidal variability, which is important in tidal systems like the bay. The longitudinal profile extends for 170 km and a complete survey can take at least 2 days. Additionally, not all stations were sampled in every survey, and many surveys were only carried out in the South Bay. We will discuss the potential bias introduced through tidal variability, along with a method to minimize such biases. With the tidal-bias minimized, the long-term and monthly climatology will be investigated. In particular, we will search for correlations between salinity and SPM with river discharge at the Delta and wind, which are the main forcings of non-tidal variability in the bay.

Keywords: data analysis, hydrology, transport processes

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Sediment Flux Measurements at the Golden Gate:
Progress toward Closing the Sediment Budget for San Francisco Bay

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Sediment is an important resource for San Francisco Bay (SFB), in the context of restoration projects, dredging operations, ecosystem health, and contaminant transport and fate. One way to help manage sediment (and sediment-associated contaminants) in SFB is by developing a sediment budget to account for sources, sinks, and storage of sediment. Previously developed sediment budgets have shown sediment exchange at the oceanic boundary of SFB (Golden Gate) is the most poorly understood element of the SFB sediment budget, owing to logistical challenges that inhibit routine field observations. In this study, field observations of suspended-sediment flux at the Golden Gate were conducted on outgoing (ebb) and incoming (flood) waters during two distinct periods of the WY2016 hydrograph: peak (4000 m^3/s) and low (200 m^3/s) rates of freshwater inflow to SFB. Suspended-sediment flux was estimated from a boat-mounted acoustic Doppler current profiler which provided measurements of discharge and acoustic backscatter (ABS) at a cross-section near the oceanic boundary. Discrete water samples collected *in situ* were analyzed for suspended-sediment concentration (SSC) and related to ABS. During the period of peak freshwater inflow, maximum discharge observed at Golden Gate reached 130,000 m^3/s during ebb tide; observed SSC (20-40 mg/L) were lower than expected compared to upstream conditions. A network of five SSC monitoring stations extending 5-80 km upstream demonstrated a watershed-sourced sediment pulse (SSC reaching 200 mg/L) moved downstream to San Pablo Bay, an observation corroborated by concurrent satellite imagery. This observation, combined with lower SSC toward the Golden Gate, suggests the sediment pulse was trapped within SFB, indicating a freshwater inflow threshold exceeding 4000 m^3/s for sediment export at the oceanic boundary. Previous research proposed a lower threshold (3000 m^3/s); one explanation for this discrepancy is the decreased sediment yield from the watershed since the 19th century, requiring greater flows to export sediment.

Keywords: sediment, SSC, dynamics, flux, sediment budget, supply,

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Primary Sediment Supply, Pathways and Transport Mechanisms to the Central Sacramento-San Joaquin Delta

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Changes to the Sacramento-San Joaquin Delta began in the late 1800s and numerous changes have occurred including aquatic species population declines and changes to water management. One species of concern is the endangered Delta smelt which requires a turbid environment for feeding, migratory cues, and to avoid predation. When turbid water enters the Central Delta it is a favorable environment for Delta Smelt. These conditions coincide with increased smelt observations at the pump facilities in the South Delta which results in mortality. Furthermore, efforts to restore significant aquatic habitat throughout the Delta are in progress, but water management and landscape-scale restoration activities require an understanding of the hydrology, sediment quantity, and transport mechanisms. Cooperatively, the USGS and DWR have an extensive network of flow stations throughout the Delta where we also monitor turbidity. Turbidity is used as a surrogate to compute suspended-sediment concentrations and sediment fluxes are computed from the product of cross-sectionally averaged suspended-sediment concentrations and flow. The primary source of sediment to the Delta is the Sacramento River which delivers pulses of sediment during the winter and early spring. From our network of stations, we analyze the primary pathway of sediment from the Sacramento River to the Central Delta and describe travel times and mechanisms that lead to increased turbidity in the south Central Delta. We found the sediment concentrations in Georgiana Slough to be correlated to concentrations from Sacramento River at Freeport. Approximately 96% of the sediment transport down Georgiana Slough is advected into the interior Delta towards the large pump facilities. This has important implications for native fish and water management alike. We detail transport times of peak sediment concentrations during the first flush, present sediment flux analysis, and describe the sediment transport mechanisms once this sediment source reaches the Central Delta.

Keywords: sediment, turbidity, Central Delta, Georgiana Slough,

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Wave Attenuation across China Camp Tidal Marsh

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As the potential for nature-based coastal protection becomes more widely recognized, it is critical to understand how and to what extent tidal marshes attenuate wave action. Here we study wave attenuation across the edge of the salt marsh at China Camp State Park in San Pablo Bay. A field campaign was carried out during seasonally high ("king") tides in December 2014 and January 2015 and was then repeated during high tides in June 2016. High-frequency pressure sensors and optical turbidity sensors were deployed at eight stations along a 150 m cross-shore transect; the transect started on the mudflat 50 m outside the edge of vegetation, ran through the cordgrass-dominated zone (*Spartina foliosa*), and ended in the pickleweed-dominated zone (*Salicornia pacifica*). Using the winter and spring deployments, we compare the seasonal variation driven by the differing weather regimes, wave climates, and vegetation characteristics. Wave statistics were calculated from high-frequency pressure data, and wave attenuation was modeled as an exponential decay. Under winter conditions, the decay coefficients were an order of magnitude greater in the vegetated marsh than over the mudflat. Waves were completely attenuated 78 m into the vegetation. The reduction in wave energy also allows sediments to drop out of suspension and settle onto the marsh platform, where they contribute to vertical accretion and marsh sustainability. By quantifying wave attenuation under a range of conditions, the results from this study will inform designs for coastal hazard mitigation and efforts to restore and protect this vital habitat.

Keywords: wave attenuation, tidal marsh, sediment transport, nature-based coastal protection

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