Sediment: Checks and Balances

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Sediment in the San Francisco Estuary is ever changing. Consisting of a range of coarse- and fine-grained particles that create predominantly muddy or sandy subtidal substrate, the San Francisco Bay floor is habitat to numerous subtidal flora and fauna. Human activities in and around the Bay have direct and indirect impacts on both the biological components of the estuarine system, but also the physical components of the system such as the tidal prism, sediment transport and dynamics, erosion, accretion, tidal fluctuations, among others. Several human activities influencing sediment dynamics include maintenance dredging, aggregate mining, sediment placement at beneficial reuse sites, and sediment disposal in or out of the Bay. Climate change and sea level rise add complexity to our understanding of sediment dynamics. Management of sediment in a way that balances the concerns of both resource agencies as well as those concerned with sediment availability and the ability of marshes to keep pace with rising sea levels requires a comprehensive understanding of sediment sources, sinks, and influencing factors.

Here, we present a visual summary of some of the major players in the sediment story. From maintenance dredging and sand mining, to multi-benefit flood control and restoration projects, large volumes of fine and coarse-grained sediment are naturally or manually being transported throughout the Bay. Dredged material may be used for restoration, returned to the Bay, or dumped in the ocean depending on its quality, and managers around the Bay are striving to work together to meet each others' sediment needs in the face of rising seas.

Keywords: Sediment, dredging, beneficial reuse, accretion, management, sea level rise, restoration

Poster Topic: Sediment Transport

Observations and Modeling of Dumbarton Mudflat Evolution at Decadal Time Scales

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Estuarine tidal flats are rich habitats that evolve morphologically in response to changes in climate and sea level. Their shape and width is determined by a number of factors including the interplay of wind waves, tides, and sediment availability. To explore the processes governing tidal flat evolution, we use a combination of observations and 1D process-based modeling (Delft3D) of the tidal flat-channel system at Dumbarton Bridge in South San Francisco Bay, CA. At the decadal time scale, bathymetric surveys collected approximately every 30 years from 1858 to 2005 document that tidal flat width varied from 550 to 900 m. Width is correlated with net deposition/erosion of lower South Bay, defined as south of Dumbarton Bridge. Tidal flats, which are concave up near the shore and convex up at their bayward edge, widened during periods of net sediment import and narrowed during net sediment export. Experimental model runs with constant sediment supply, waves, and tide forcing show bayward widening of tidal flats and slow development from a flat bed towards a concave-up equilibrium within 5 years. Equilibrium consists of similar erosion and deposition rates, maintaining locally high sediment concentrations above the tidal flat. Sensitivity analysis is carried out with respect to forcing conditions and sediment characteristics. Important research questions are to what extent rare, extreme wave events determine the profile compared to typical conditions and whether forcing and sediment availability change too rapidly for the system to reach equilibrium. This study will also improve our ability to assess possible impacts of ongoing restoration projects and sea level rise on tidal flat morphology.

Keywords: mudflats, modeling, sea level rise, sediment supply, intertidal equilibrium

Poster Topic: Sediment Transport

Sediment Source Analysis to Inform Sediment Management Actions for Wildcat Creek, California

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High rates of erosion in the Wildcat Creek Watershed have led to instability in Wildcat Creek and tributary channels, sediment accumulation in Jewel Lake and Lake Anza reservoirs managed by the East Bay Regional Park District (EBRPD), and sediment deposition in the downstream and urbanized reach that has reduced flood conveyance. Management concerns related to increased sediment supply and transport include impacts to resident fish (including native rainbow trout, three-spine stickleback, and Sacramento perch), degradation of infrastructure and recreational facilities in the upper watershed managed by EBRPD, and reduced flood conveyance in the lower watershed.

EBRPD conducted a sediment and erosion control analysis to locate, prioritize, and develop multi-objective solutions to reduce erosion in the Upper Wildcat Creek Watershed. EBRPD facilitated local stakeholder involvement to guide development of sustainable and multi-objective sediment management solutions that also support desired habitats and land uses. EBRPD located and mapped significant sources of sediment in the Upper Wildcat Creek Watershed, created a sediment source Geographic Information System (GIS) database, developed multi-objective conceptual design solutions, and identified methodologies for erosion control. Next, EBRPD assessed each conceptual design solution for feasibility, cost, sediment reduction, habitat benefit, and long term sustainability. Lastly, EBRPD developed recommendations for implementation of the highest ranked sediment control conceptual design for the long term, programmatic maintenance of the Upper Wildcat Creek Watershed. The highest ranked conceptual sediment designs include bypassing Jewel Lake with a restored channel that provides passage for native rainbow trout and repairing storm water outfalls that have developed into large gullies along Wildcat Canyon Road. EBRPD conducted this study to maintain healthy, sustainable ecosystems throughout the upper watershed and to improve sediment management both in the upper watershed and downstream.

Keywords: Wildcat Creek, sediment, conceptual design, channel restoration, watershed management

Poster Topic: Sediment Transport

High-resolution Field Measurements of Cohesive Sediment Characteristics and Dynamics in Northern San Francisco Bay

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Cohesive sediments play an essential role in estuaries like San Francisco Bay by affecting primary productivity through turbidity effects on in-water light levels. However, current management decisions are based on imperfect knowledge of the relationship between flow, suspended sediment, and light. Because we lack understanding of fundamental physical processes, there is a need for high-resolution data that can only be collected using fieldwork. Our work addresses this gap through advanced field measurements of currents and turbulence (Teledyne RDI ADCP, Rockland Scientific VMP-200), primary particle and floc size distributions (Beckman Coulter LS 13 320, Sequoia Scientific LISST-100X), and background water quality and light conditions (Seabird Electronic 19+ CTD-PAR). We quantify the relationship between tidally-driven flow and suspended cohesive sediment properties such as floc sizes, density, and settling velocity. Results from stationary and transect measurements collected in northern San Francisco Bay show flocculation (floc aggregation and break-up) to be important in determining sediment settling velocity. Ultimately, a careful understanding of the physics controlling flocculation will help improve sediment transport predictions and facilitate accurate development of sediment models.

Keywords: Cohesive sediment, flocculation, sediment transport, turbulence, light availability

Poster Topic: Sediment Transport

Implementing Fine Sediment TMDLs on Private Lands with the Voluntary, Incentive-based Fish Friendly Farming Environmental Certification Program

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The Fish Friendly Farming (FFF) Environmental Certification Program was designed to implement source control of fine sediment on private agricultural lands. It is the most rigorous certification program in California. In the Napa River and Sonoma Creek watersheds over 78,000 acres have enrolled. The fine sediment TMDLs for these two watersheds recognize the FFF program as a compliance measure. The Ca Land Stewardship Institute (CLSI) runs the FFF program and completes detailed farm conservation plans for the entire parcel including the agricultural lands. All potential sources of fine sediment are assessed including farmed areas, roads, all concentrated flow outlets, all creeks and other sites. The FFF program also called Napa Green, is very popular with growers demonstrating that farmers will voluntarily improve the environment. Each farm plan lays out the management measures needed to: reduce fine sediment generation and delivery to streams; reduce use of chemicals with high toxicity to fish and wildlife; reduce water use and assure water sources do not negatively affect endangered fish species; remove invasive non-native plant species along creeks and uplands and restore riparian corridors; evaluate geomorphic features of creeks and change management practices and restore natural form to creeks. Certification is done by agencies - National Marine Fisheries Service and the County Agricultural Commissioner. Each site is re-certified every 5 years and CLSI completes numerous restoration projects with growers. The restoration of the Napa River between the Oakville Crossroad and Oak Knoll Ave currently managed by Napa County began with growers certified in the FFF program and a detailed concept plan completed by CLSI. The FFF program also called Napa Green, is very popular with growers demonstrating that farmers will voluntarily improve the environment. Currently the FFF program operates in 9 counties and there is interest in setting up the program in the Delta.

Keywords: Agriculture, TMDL, fine sediment, pollution, salmon restoration, Napa River restoration

Poster Topic: Sediment Transport