CALIFORNIA OCEAN
PROTECTION COUNCIL

Staff Recommendation
June 14, 2007

San Francisco Bay Hydrodynamic and Sediment Transport Modeling

Developed By: **Abe Doherty**

RECOMMENDED ACTION: Consideration of the development of a San Francisco Bay hydrodynamic and sediment transport model and possible: 1) determination that it is a high priority project and 2) authorization for the secretary to take actions necessary to provide up to $858,000 for its implementation.

NEAREST OCEAN OR COASTAL LOCATION: San Francisco Bay

AGENCY OR ENTITY RECOMMENDING PROJECT: California Coastal Conservancy

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EXHIBITS

Exhibit 1: Project Location Map

Exhibit 2: South San Francisco Bay Salt Pond Restoration Project Map

Exhibit 3: Letters of Support

RESOLUTION:

"The Ocean Protection Council finds pursuant to Sections 35600 *et seq.* of the Public Resources Code that the development of a modeling framework and three-dimensional hydrodynamic and sediment transport model for San Francisco Bay by University of California, Berkeley and Stanford University, as herein described, is of high priority for ocean conservation and authorizes the secretary to take actions necessary for its implementation, including the allocation of $858,000 for the purposes of this project."

PROJECT DESCRIPTION:

Staff recommends the Ocean Protection Council determine that the development of a modeling framework and a hydrodynamic and sediment model for San Francisco Bay is a high priority for ocean conservation. The benefits of this modeling effort, to be undertaken by the University of California at Berkeley and Stanford University are:

- Reduced risk to San Francisco Bay resources from well-intentioned restoration actions. The Coastal Conservancy is currently working with a broad range of other partners to

plan or implement restoration of 35,000 acres of publicly owned baylands in various locations in San Francisco Bay to improve habitat for fish and wildlife, flood control capacity, and water quality. The proposed hydrodynamic and sediment model is crucial to evaluate various scenarios for restoration design and the potential effects of these restoration actions.

- Reduced costs of restoration project management by informing and improving future decisions.
- Improved understanding of the continually evolving San Francisco Bay and its inter-relationship with the near-shore Pacific Ocean.
- Improved management of San Francisco Bay's bottom and shoreline. The San Francisco Bay Conservation and Development Commission's (BCDC) Strategic Plan, adopted on October 20, 2005, includes an objective to manage the extraction of mineral resources from the bay using the most up-to-date scientific information. BCDC's Strategic Plan specifically identifies research on sediment dynamics in the bay as a priority task to assist with this objective.
- Improved ability to understand and respond to global climate change including sea level rise.

The proposed funds will support the work of three principal investigators (Mark Stacey at UC Berkeley, Jeff Koseff and Oliver Fringer at Stanford University) and graduate research assistants working with them over a period of approximately three years. The project will build on the work of these investigators and a collaborative process to develop an integrated modeling framework for San Francisco Bay. Agencies and research institutions that are participating in the development of a modeling framework for San Francisco Bay include:

- National Oceanic and Atmospheric Administration
- U.S. Geological Survey
- U.S. Army Corps of Engineers
- California Coastal Conservancy
- San Francisco Bay Conservation and Development Commission
- California Department of Water Resources
- San Francisco Bay Regional Water Quality Control Board
- California State University Center for Integrative Coastal Observation, Research and Education
- Central Coast Ocean Observing System
- UC Santa Cruz
- UC Berkeley
- UC Davis – Bodega Marine Lab
- UC Los Angeles
- San Francisco State University – Romberg Tiburon Center
- Stanford University
- San Francisco Estuary Institute
- Monterey Bay Aquarium Research Institute
- Jet Propulsion Laboratory

- Santa Clara Valley Water District

This project will support workshops involving agencies and research institutions on the development of inter-disciplinary models of San Francisco Bay. One of the key elements of these workshops will be the identification and evaluation of modeling approaches to address priority management needs and uncertainties, such as contaminant mobilization and transformation, estuarine ecosystem dynamics, geomorphology and habitat development.

The project will result in the development of an open source, flexible, three-dimensional hydrodynamic and sediment transport SUNTANS model (Stanford Unstructured Nonhydrostatic Terrain-Following Adaptive Navier-Stokes Simulator, Fringer et al., 2005, http://suntans.stanford.edu). The model will be used to predict how restoration actions in San Francisco Bay will interact with the existing estuarine system, including changes in local tidal dynamics, salinity and suspended sediment concentrations. The SUNTANS model is designed to allow for highly resolved studies in and around particular restoration sites without compromising complete bay coverage (through variable grid spacing).

While the initial modeling efforts will focus on the tidal and wind-forced dynamics, and their influence on transport of salinity and suspended sediments, this modeling approach provides a necessary foundation on which other, inter-disciplinary modeling efforts can be built. For example, modeling the mobilization of metals and their transformation into bioavailable forms relies heavily on an understanding of how sediment moves through the system due to the strong association of these contaminants with sediments. Ecologically, primary productivity in the estuary is sensitive to the penetration of light into the water column, so understanding and predicting how the turbidity (suspended sediment concentration) will change following restoration activity is a necessary first step. In each case, the aim is to provide the physical "infrastructure" on which interdisciplinary models can be layered through an overall San Francisco Bay modeling framework.

For the development of the SUNTANS hydrodynamic model, the project first will pursue an analysis of sediment transport in the region south of the Dumbarton Narrows (the Far South Bay) and the influence of annual variability in sediment supply. This activity would consist of both numerical development and continued analysis of data sets collected in conjunction with the South San Francisco Bay Salt Pond Restoration Project. The data sets address the detailed dynamics of Coyote Creek adjacent to early breaches in the project (the Island Ponds) and evaluate flows and transport through a breach in detail. The data analysis would be focused on developing an understanding of the basic physical processes that dominate sediment transport and establishing a reliable calibration and verification data set for the numerical activity at the scale of interest. Next, the project will pursue modeling and analysis of a second site of similar scale to the Far South Bay modeling effort. The specific choice of a site would be based on what data are available for calibration and verification purposes, most likely a San Pablo Bay restoration site. Finally, in both of these modeling efforts, the project will evaluate the performance of the model in Central Bay using existing measurements of currents, salinity, temperature and suspended sediment (Fram et al., 2006). This final effort is motivated by the interest in using the modeling approach to examine the effects of restoration at the scale of the entire estuary; the Central Bay data sets provide a rigorous test of the model's ability to extend to those spatial scales. To summarize these activities:

- Transport analysis and modeling south of the Dumbarton Narrows, including annual variability;
- Transport modeling at a second restoration site to be determined (likely to be in San Pablo Bay);
- Evaluation of model performance in Central Bay near the Golden Gate.

The project would extend for three years and would be led by three principal investigators: Mark Stacey, Jeff Koseff, and Oliver Fringer, who would be supported by graduate student researchers. The resulting SUNTANS product would be available for use and improvement by other researchers in support of an increasing array of management questions.

Project Background

Changes, some planned and some unplanned, are ahead for San Francisco Bay. To understand the implications of the changes we make to the system and to help guide those changes, we must have predictive tools, both models and a modeling framework, to guide us. Historically, marshlands were ubiquitous around the San Francisco Bay estuary, with large portions of South San Francisco Bay, San Pablo Bay and Suisun Bay fringed by tidal marsh habitat. Over the past century, these marshes have been "reclaimed" for development, including commercial salt ponds.

Recently, restoration of diked baylands to recover ecosystem function is being pursued at an accelerating pace. Over the past five years, approximately $300 million has been spent by federal, state and local public agencies and private partners on the acquisition, planning and restoration of San Francisco Bay wetlands. It is anticipated that another $400 million will be spent on wetland restoration in the Bay Area over the next five years.

The largest single restoration project is the South San Francisco Bay Salt Pond Restoration Project, which involves more than 15,000 acres of salt ponds acquired by the state and federal governments (Exhibit 2). Other restoration projects throughout the estuary include Bair Island near Redwood City, and several projects around the perimeter of San Pablo Bay including the Napa Salt Ponds, Cullinan Ranch and Hamilton Field/Bel Marin Keys. In each case, the success of the restoration project, as well as the condition of existing estuarine ecosystems, will be shaped by the interaction between the new wetlands and the physical and biological processes of the bay.

While the goal of restoring native habitats and associated ecosystem function carries great benefits, restoration of tidal marsh habitat on this scale is not without its risks. These risks include effects both within the projects and external effects of the projects on other, existing habitats. Within the project areas, negative outcomes may include an incomplete recovery of marsh habitat (due to, say, insufficient sediment supply or a lack of vegetation recruitment) or poor quality habitat, which could be due to the detailed spatial structures of the restored habitat and its connection with adjoining habitats, the mobilization of contaminants at the site or other perturbations to the habitat that reduce its ecosystem function.

The uncertainty that surrounds the prospects for restoration success is compounded by uncertainties in the driving natural and anthropogenic processes, particularly at the decadal timescales of interest. Climate change (and variability) is likely to alter oceanic conditions, both through sea level rise and changes in the temperature and biota associated with oceanic waters.

Further, the hydrology of the watersheds surrounding the estuary is likely to adjust in response to climate change, including the amount and timing of freshwater flows and the associated sediment supply. In an urban setting like the San Francisco Bay Area, sediment supply will also be altered due to shifts in land use over the decadal timescale of interest. Finally, policies that govern how humans interact with the restored habitats will be dynamic, and create additional uncertainty for the success of the projects.

Each of the restoration projects noted above has engaged in analysis of its effects, but there is not a modeling framework or sufficiently robust open source hydrodynamic and sediment transport model to predict those effects on an ongoing basis as the projects evolve.

On January 19, 2007 a monitoring and modeling workshop regarding San Francisco Bay was conducted by the Coastal Ocean Currents Monitoring Program, NOAA, and the South Bay Salt Pond (SBSP) Restoration Project. The workshop was well-attended by a wide array of coastal and San Francisco Bay researchers and managers (see list of participants on page 2). The proceedings are being prepared. Priority actions identified at that meeting were:

- Develop a three-dimensional hydrodynamic and sediment transport model of the bay, beginning with high resolution in limited geographic areas (Far South Bay and North Bay) and expanding over time.
- Develop an ensemble of models as needed to address the broad array of management questions regarding San Francisco Bay.
- Institute periodic collection of bay-wide bathymetry data (~ five to ten year intervals) as a base from which all modeling can proceed.
- Maintain and systematically enhance collection of sediment flux data bay-wide, beginning at Dumbarton Narrows.
- Expand ecological monitoring in the bay.

This project would accomplish the first of these priority actions and begin accomplishment of the second.

Grantee Description

Mark Stacey of UC Berkeley, and Jeff Koseff and Oliver Fringer of Stanford University are well-respected specialists in the field of hydrodynamic and sediment modeling. In addition, they are associated with leading universities in the San Francisco Bay area and as such bring local experience and capability to bear on this unique system.

PROJECT FINANCING

Possible Funding Sources:

Ocean Protection Council (Coastal Conservancy)	$858,000
UC Berkeley and Stanford University (In-kind)	$155,000
Total Project Cost	**$1,013,000**

Funding in the amount of up to $858,000 is expected to come from an appropriation to the Coastal Conservancy from the "Water Security, Clean Drinking Water, Coastal and Beach

Protection Act of 2002" (Proposition 50), which is to be used for coastal watershed protection and associated planning and administration costs.

A related proposal which may provide matching funds is pending with NOAA for "CenCOOS Bays" which is intended to extend the CenCOOS monitoring network into San Francisco Bay and other bays along the coast. This monitoring would assist in the development of numerical models for San Francisco Bay. The Principal Investigator on that proposal is John Largier of UC Davis. UC Berkeley, Stanford University and the South San Francisco Bay Salt Pond Restoration Project are all partners in that proposal.

CONSISTENCY WITH OCEAN PROTECTION COUNCIL'S FIVE-YEAR STRATEGIC PLAN:

"Goal D" calls for the OPC to "significantly improve the quantity and quality of ocean and coastal habitat in California." Through the development of a sediment and hydrodynamic model and modeling framework, the project will support management efforts to restore habitats in San Francisco Bay. The project is consistent with "Goal D," Objective 1: Habitat Restoration, which states that the OPC should "restore and maintain valuable ocean and coastal habitats and resources" and "Goal D" Objective 2: Regional Sediment Management, which states that the OPC should "support the implementation of regional sediment management throughout California as a means of protecting, restoring, and enhancing California's coastal sediment and beach resources".