RESEARCH PROPOSAL
Sources of Fine Sediment to the Southern California Coast – Computation of a "Mud Budget"

Investigator: Jonathan Warrick

Introduction: The California Coastal Sediment Management Workgroup (CSMW) has requested proposals from the U.S. Geological Survey (USGS) Western Coastal and Marine Geology Team (WCMG) to evaluate the transport and fate of fine sediments discharged into California coastal waters. The rationale for this proposed work is a need to better understand the environmental consequences of beach nourishment and, to a lesser degree, harbor dredging. Specifically, it is not currently known how long fine sediments introduced from these activities persist in the water column, where fine sediments will settle on the seabed, and what processes dominate the transport of fine sediments.

Below we propose a study of the sources and sinks of fine sediment in coastal southern California. This study will document the natural inputs and fate of mud, thus resulting in a mass balance (or "budget") of fine sediment to and within the coastal California waters over many scales of time and space. Further, investigations will specifically focus on the influence of human alteration on the mud budgets, since these activities can both dramatically increase or decrease sediment production and transport. Although this project will not actively investigate beach nourishment, mud budget results will provide the natural and human-influenced *context* for which to compare proposed nourishment projects.

Background: An abundance of fine sediment, which is defined to be particles smaller than sand (i.e., less than 63 μm), is provided to California coastal waters from natural sources such as rivers and bluffs. Unfortunately, little is known about the amounts and timing of fine sediment inputs from natural sources, largely due to the focus on quantifying sand and gravel inputs into littoral cells (e.g., Inman and Jenkins, 1999; Warrick and Milliman, 2003; Willis and Griggs, 2003). Thus, it is difficult to quantify the relative inputs and potential impacts of fine sediments from human activities (such as beach nourishment and harbor dredging), when the natural sources have not been adequately characterized.

Fortunately, information exists to quantify the natural inputs and sinks of fine sediment material to the California coast. For example. the USGS has been collecting discharge and suspended sediment concentration data in numerous coastal drainages for decades (Willis and Griggs, 2003). This information can be integrated with information of the sediment contributions from coastal bluffs (e.g., Benumof et al., 2000; Moore and Griggs, 2001) to produce fine sediment budgets from the California landscape, detailing both the amounts and timing of fine sediment discharge. Further, information about the eventual deposition of this material in the marine environment can be accumulated from marine mapping techniques and sedimentological sampling (e.g., Slater et al., 2002; Alexander

and Venherm, 2003). Lastly, this data record begs to be integrated in source-to-sink budgets so that full accounting of discharge budgets can be developed.

Experiment: We propose to compute a "mud budget" of the fine sediment sources and sinks of the southern California coast, using historical information and characteristics of the California landscape and coastal seafloor. The study will be limited to the southern two-thirds of the California coast (from the San Francisco Bay region to the Mexican Border) to focus on a region most likely to have future coastal engineering projects and to make the data collection and analysis tractable. Results of this work will detail the amounts, variability and seasonality of fine sediment delivery to California coastal waters. These results can be used to detail the inherent variability of fine sediment delivery to California coastal waters, which is important when considering how coastal projects alter the timing and amount of fine sediment entering the coastal waters.

Sediment Source: Fine sediment inputs from both rivers and bluffs will be quantified using a combination of historical information and landscape characteristics. Fluvial inputs will be quantified using a combination of river discharge and suspended sediment data provided by the USGS. Adequate data exists to quantify the fine sediment discharge along the southern California coast as evidenced by the work on sand and gravel discharge by Inman and Jenkins (1999) and Willis and Griggs (2003). River data will be integrated with the use of sediment rating curves that include quantification of errors (e.g., Warrick and Milliman, 2003). Regions without river discharge information will be evaluated with discharge information from the surrounding landscape with similar characteristics (e.g., Warrick, 2002; Willis and Griggs, 2003).

Bluff inputs will be characterized from published erosion rates (e.g., Benumof et al., 2000; Moore and Griggs, 2001; Hapke and Collins, 2003) and characteristics of the California coastal bluffs such as height, geology and wave climatology. Further, we will integrate bluff erosion findings of ongoing research by G. Griggs (UCSC) and C. Hapke (USGS) as they are made available. Although bluff erosion is typically reported in long-term average rates (e.g., Benumof et al., 2000; Moore and Griggs, 2001), actual bluff failures can be catastrophic events forced by wave erosion, soil water content and/or earthquakes. We will include an evaluation of the timing of bluff sediment inputs using accepted statistical techniques based upon the forcing mechanisms of failures.

Sediment Sink: Fine sediment is dominantly deposited on continental shelves in the "mid-shelf mud belt", although in southern California there is also considerable deposition offshelf in ocean basins. To quantify rates of this mud deposition we will assemble and integrate records that characterize recent (seasonal to decadal) and long-term (Holocene) sediment accumulation within the study region. Recent marine sedimentation is commonly measured with radiometric isotopes (e.g., ^{7}Be, ^{137}Cs and ^{210}Pb) profiles within sediment cores (e.g., Alexander and Venherm, 2003). These powerful measures of accumulation rates have been obtained for many regions of the seafloor off California and can be combined with sediment grain-size information (e.g., World SeaBed Data Browser, 2004) to evaluate mud accumulation. Other measures of recent sediment accumulation exist offshore southern California, including the varved

(i.e., layered) sediments of the Santa Barbara Basin, which record annual inputs of mud. These combined records will be used to compute the time history of sediment accumulation with emphases on the spatial variability of rates and mass accumulation.

Holocene sedimentation can be evaluated from seismic seafloor mapping techniques. Seismic surveys exist for much of coastal California (e.g., Slater et al., 2002), and we will compile a representative set of records for the study region. Measurements of Holocene sediment accumulation will be obtained from these records and will allow us to extend the source and sink records through the last transgression of sea level. Thus, the Holocene records will allow us to compare mud accumulation during the geologic past with that from the recent past.

Project Synthesis: Records of fine sediment discharge and accumulation will be integrated into a source-to-sink mud budget for the southern portion of California. We will provide evaluations of this budget by measuring spatial and temporal variability in the computed rates and compare these results with terrestrial and marine characteristics. For example, the depth and rate of mud deposition will be compared to regional wave climatology and known circulation patterns, while sediment source budgets will be compared with landscape characteristics (including geology, climate and human impacts).

Communications: We will have close communications with CSMW throughout this proposed work. Bi-monthly written project updates will be presented to CSMW and will include recent findings, project status and future directions. During the week following delivery of the updates, the USGS will meet with CSMW (either by teleconference or in person, as needed) to discuss the contents of the update and upcoming research plans. A interim project report will be delivered to CSMW in October 2005 for the CSMW reporting needs. The focus of this report will be results of the source portion of the mud budget. Final results will be written into a USGS Open-File Report, which will be completed by the end of the second year of funding. Lastly, results will also be presented at national and regional scientific conferences (including AGU and H2O) and will be published in peer-reviewed scientific journals.

Budget. We propose the following budget:

Activity	***Year 1***	***Year 2***
Post-doc (Research Geologist) salary	$75,000	$78,000
Traveling and incidentals	$5,000	$5,000
Overhead (50% of net)	$40,000	$41,500
TOTAL COSTS	**$120,000**	**$124,500**
U.S. Geological Survey cost share	$25,000	$25,000
PROPOSAL REQUEST	$95,000	$99,500

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