

SAND MINING IMPACTS ON SHORELINE EROSION IN SOUTHERN MONTEREY BAY

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MINING OPERATIONS

Southern Monterey Bay has been the most intensively mined shoreline (with sand removed directly from the surf zone) in the U.S. Mining started in 1906 at the mouth of the Salinas River and expanded to seven commercial sites at Marina and Sand City (Magoon, et al 1972). Six of the mining operations used draglines that scraped sand directly from the surf zone. A seventh operation at Marina hydraulically mines a dredge pond just in back of the berm on the beach (Figure 1). These sites are mined for the coarse sand deposits, which have a high commercial value. Sand mining was not regulated until 1968, when the State Lands Commission began regulating and licensing sand mining operations below the mine high waterline (MHWL) through the issuance of leases. In addition, the Corps of Engineers began asserting jurisdiction over mining operations below MHWL in 1974 under the Rivers and Harbors Act of 1899. Both the State Lands and Corps of Engineers leases expired in 1988. The leases were not renewed as it was determined the sand mining contributed to shoreline erosion, stopping the dragline mining operations. Based on State Lands lease records and company records, the total annual amount of sand mined ranged 75K to 230 K m³/yr with a mean of 150K m³/yr. This amounts to more than halve the annual erosion in southern Monterey Bay. The only remaining operation is the dredge pond in Marina that is above MHWL, which effectively intercepts all sand transported both south and north as sand is carried over the berm at high tides by the swash of storm waves refilling the pond each year. The dredge pond operation has increased its mining to 150K m³/yr as the other mines were shut down.

SEDIMENT BUDGET FOR SOUTHERN MONTEREY BAY

The sandy shoreline southern Monterey Bay is backed by extensive dunes that exceed 40 m in height. Sediment contributions to the southern littoral cell are by the Salinas River, erosion of the dunes and possibly from offshore. The dunes are eroding with average dune top recession rates ranging 0.5-2 m/year. The shoreline recession in southern Monterey Bay is the highest rate in California (Hapke et al., 2006). Long-term erosion rates were measured using T-sheets, stereo-photogrammetry, LIDAR, and walking the dune edge with GPS. Erosion events are episodic and occur when coincident storm waves and high tides allow swash to undercut the dune with sand slumping onto the beach. Erosion events are enhanced during El Niños periods when prolonged storm waves erode the protective beach and berm, exposing the dune to wave run-up. The calculated volume loss of the dune during the 1997-98 El Niño winter was almost seven times the historical mean of 270K m³/year. Grain size and petrology evidence suggest that sediment contribution by the Salinas River to the south is small (<40K m³/year).

Hence, sand slumping onto the beach due to erosion of the dune is the primary source of sediments to the beaches. Alongshore variation in long-term erosion appears correlated with the alongshore variation in mean wave energy.



Figure 1. Dredge mining operation at Marina, California, October 2005.

The primary loss of sand is due to sand mining. The yearly averaged amount of mined sand since 1940 is 150K m³/year, which is more than fifty percent of the yearly average erosion during this period. Other losses of sand are wind blowing sand onshore, sea level rise and losses to the offshore, which are not well estimated, and are used to balance the sand budget. The sediment budget for 1940 to the present is shown schematically in Figure 2.

MANAGEMENT IMPLICATIONS

A number of measures are being investigated to mitigate the erosion of the shoreline. However, beach nourishment would not seem to be an economical mitigation measure if the sand mining is to continue at the present rate as the beaches would have to be replenished at least at the rate that sand mining is occurring just to maintain the present shoreline.

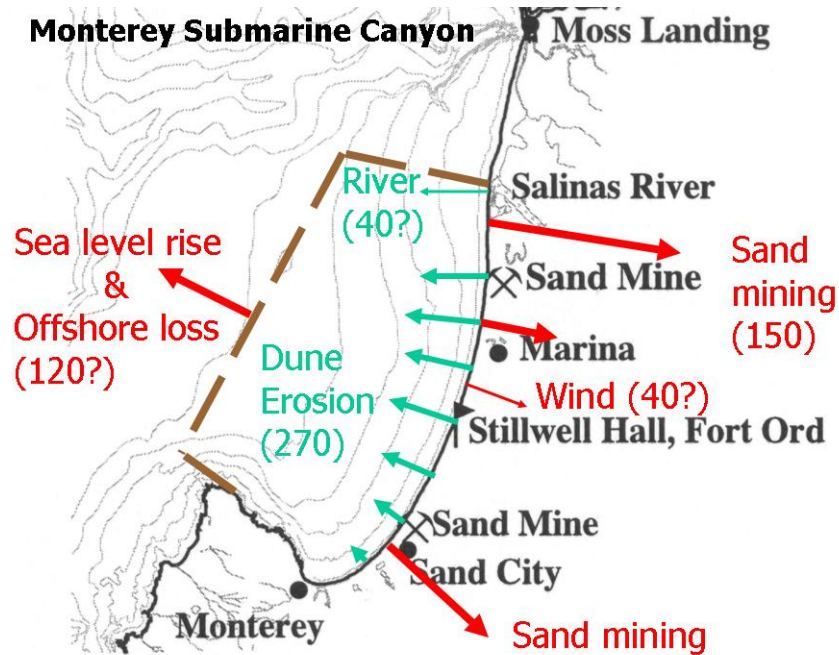


Figure 2. Sediment Budget schematic for southern Monterey Bay, California for years 1940 to the present indicating input and loss contributions ($\times 10^3 \text{ m}^3/\text{year}$). The inputs that are not well estimated are indicated by (?).

LITERATURE CITED

Hapke, C. and D. Reid, 2006, The National Assessment of Shoreline Change: A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the Sandy Shorelines of the California Coast, U.S. Geological Survey Open-File Report 2006-1251.

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