Recent Research Confirms Link Between Ocean Beach Erosion and Sand Removal in the Bay

Research Summary by Ian Wren, Baykeeper Staff Scientist

A recent issue of the scientific journal *Marine Geology* included over 20 papers focused on sediment transport research in the San Francisco Bay Coastal System, including the synthesis of a series of studies conducted over the last decade. This special issue is considered a culmination of nearly 100 years of research on many topics, ranging from tidal marsh sustainability, suspended sediment transport, bedform migration and evolution, behavior of the open coast littoral system, and fluvial impacts (Barnard, et al., 2013).

This research was driven by the need for a definitive understanding of sediment sources, sinks, and pathways in this highly urbanized estuary. An understanding of how activities within the estuary affect the coast is essential for assessing current and future effects of sediment-impacting activities, such as dredging operations, aggregate mining, shoreline armoring, and watershed modifications. More informed management of sediment resources can promote the sustainability of tidal wetlands and beaches, the first line of defense against sea level rise and potentially larger storms. Erosion of beaches and wetlands increases the vulnerability of coastal environments and communities, enhancing threats to public safety, vital infrastructure, and ecosystems (Barnard, et al., 2013).

Several papers were the output of a multi-faceted, multi-disciplinary study designed to establish the primary sources, sinks, and transport pathways of sand in the region. This research established links between anthropogenic activities and geomorphic change through extensive sampling and analysis of sediment from the seabed, Bay floor, beaches, representative rocks, and all major and some minor rivers and creeks (Hein, et al., 2013). Anthropogenic activities, including sand mining and dredging, were definitively identified as directly limiting the supply of beach-sized sand grains to the southern outer coast, most notably from the vicinity of Ocean Beach at Noriega Street, in San Francisco, and extending south to Pacifica (Barnard, et al., 2013).

Specific findings:

- Based on multiple techniques for assessing the geologic origin (or provenance) of sand in the region, the Sierra Nevada Range is the dominant source of beach-sized sand to the San Francisco Bay Coastal System, including Ocean Beach. This sand is actively transported into and through the Bay to the mouth of San Francisco Bay, and along the southern open coast. This dominant pathway for beach-sized sand material destined for the open coast directly intersects the two major active aggregate mining regions in San Francisco Bay, Suisun Bay and Central Bay (Barnard, et al., 2013).
- From 1997 to 2008, approximately 2.3 million (cubic meters) of sand was lost from aggregate mining lease sites on Presidio Shoals in southern Central Bay. Most of this was attributed to sand and gravel removed by aggregate mining (Barnard & Kvitek, 2010). Researchers found that mining activities have significantly reduced the sediment available for transport to the mouth of San Francisco Bay and adjacent beaches (Barnard, et al., 2013).

- Based on USGS analysis and review of dredging and mining records within the 20th century, over 200 million cubic meters of sediment was removed from the San Francisco Bay Coastal System through dredging, aggregate mining, and borrow pit mining, including at least 54 million cubic meters of sand-sized or coarser sediment from Central Bay alone (Dallas & Barnard, 2009; Dallas & Barnard, 2011).
- Within the last century, rates of coastal erosion along the outer coast south of the Golden Gate are the highest for the entire coast of California (Hapke, et al., 2006; Hapke, et al., 2009) and have accelerated by 50% between Ocean Beach and Pt. San Pedro since the 1980s (Dallas & Barnard, 2011).
- Aggregate mining removes approximately 900,000 cubic meters per year of sand and gravel-sized sediment in Central Bay and Suisun Bay (Hanson, et al., 2004), while dredging removes about 3 million cubic meters of sediment per year, with the majority of this material permanently removed from the San Francisco Bay Coastal System (Dredged Material Management Office, 2008; San Francisco Estuary Institute, 2009). Together, these losses exceed the present annual sediment supply from the Sierras and local watersheds combined (Schoellhamer, et al., 2005).
- Dredging and aggregate mining in the Bay, as well as watershed modifications, are correlated to approximately 150 million cubic meters of erosion from the floor of San Francisco Bay over the last half of the 20th century (Barnard & Kvitek, 2010). At the same time, the San Francisco Bar, an ebb-tide delta at the mouth of San Francisco Bay (Hanes & Barnard, 2007; Dallas & Barnard, 2009) has eroded significantly, as have adjacent, open-coast beaches (Hapke, et al., 2006; Dallas & Barnard, 2011; Barnard, et al., 2012).
- Erosion of the San Francisco Bar, which extends seaward from the coastline just north and south of the Golden Gate, has caused it to contract and close in toward the Golden Gate over several decades. This migration has modified sediment transport patterns along Ocean Beach, effectively causes more sediment to build up at the northern end of Ocean Beach,
- As the northern shoreline has continued to extend seaward, increasingly higher volumes of northward-moving sand are no longer trapped at Pt. Lobos at the north end of Ocean Beach, instead moving toward Baker Beach and eventually into Central Bay at Crissy Field. Over the last decade, sedimentation within the Bay forced the relocation of a tide gauge and caused shoaling within the adjacent yacht harbor. These trends and correlative impacts are expected to continue as higher sea levels and further reductions in sediment supply drive further contraction of the ebb-tidal delta. (Barnard, et al., 2013)
- While sediment is building up at the north end of Ocean Beach, the southern end of the beach is eroding at a similar rate. Modeling supports observed changes over this time, including a three-fold increase in the rates of shoreline accretion at the north end of Ocean Beach and similarly higher rates of erosion at southern Ocean Beach, leading to significant infrastructure damage to existing roadways and posing eminent threat to adjacent sewer mains (Barnard, et al., 2013).
- The dominant regional direction of sediment transport is from the Bay seaward toward the ebb-tidal delta, and then primarily to the south (Barnard, et al., 2013). This link defines a critical pathway because large volumes of sediment have been removed from the Bay over the last

century via channel dredging, aggregate mining, and borrow pit mining. During this same period, comparable volumes of erosion from the San Francisco Bar over the same period have been observed, in addition to high rates of shoreline retreat along the adjacent, open-coast beaches. (Hein, et al., 2013)

- This work highlights the need to more efficiently manage existing in-Bay sediment resources, as active aggregate mining and dredging occurs along well-defined sand transport pathways that carry sediment toward outer coast beaches, at removal rates that exceed the present-day sediment supply rates from all San Francisco watersheds (Barnard, et al., 2013) (Schoellhamer, et al., 2005).
- Researchers agree that the reduction in sediment originating from the Sierras is driving massive erosion of the Bay floor, ebb-tidal delta, and the highest regional shoreline retreat rates in California along the adjacent outer coast (Barnard, et al., 2013).

References

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