

Annual sediment flux estimates in a tidal strait using surrogate measurements

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Received 9 November 2005; accepted 9 April 2006

Available online 6 June 2006

Abstract

Annual suspended-sediment flux estimates through Carquinez Strait (the seaward boundary of Suisun Bay, California) are provided based on surrogate measurements for advective, dispersive, and Stokes drift flux. The surrogates are landward watershed discharge, suspended-sediment concentration at one location in the Strait, and the longitudinal salinity gradient. The first two surrogates substitute for tidally averaged discharge and velocity-weighted suspended-sediment concentration in the Strait, thereby providing advective flux estimates, while Stokes drift is estimated with suspended-sediment concentration alone. Dispersive flux is estimated using the product of longitudinal salinity gradient and the root-mean-square value of velocity-weighted suspended-sediment concentration as an added surrogate variable. Cross-sectional measurements validated the use of surrogates during the monitoring period. During high freshwater flow advective and dispersive flux were in the seaward direction, while landward dispersive flux dominated and advective flux approached zero during low freshwater flow. Stokes drift flux was consistently in the landward direction. Wetter than average years led to net export from Suisun Bay, while dry years led to net sediment import. Relatively low watershed sediment fluxes to Suisun Bay contribute to net export during the wet season, while gravitational circulation in Carquinez Strait and higher suspended-sediment concentrations in San Pablo Bay (seaward end of Carquinez Strait) are responsible for the net import of sediment during the dry season. Annual predictions of suspended-sediment fluxes, using these methods, will allow for a sediment budget for Suisun Bay, which has implications for marsh restoration and nutrient/contaminant transport. These methods also provide a general framework for estimating sediment fluxes in estuarine environments, where temporal and spatial variability of transport are large.

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Keywords: sediment flux; sediment budgets; estuaries; San Francisco Bay

1. Introduction

Sediment supply to a subembayment of an estuary is determined by watershed sediment input and the sediment exchange with adjacent embayments. Sediment supply is a critical variable for investigations of habitat stability, restoration potential, and contaminant fate/transport. Suspended-sediment is needed to create and sustain valuable estuarine habitats such as tidal wetlands (Zedler and Callaway, 2001;

Pont et al., 2002; Reed, 2002; Temmerman et al., 2003), though sediment-associated contaminants can also accumulate wherever sediment preferentially deposits (Hornberger et al., 1999; Arzayus et al., 2002; Taylor et al., 2004). In addition, nutrients and biota accumulate near estuarine turbidity maxima (ETM), where high suspended-sediment and contaminant concentrations are found (Peterson et al., 1975; Jassby and Powell, 1994). Enhanced biological activity in these areas may increase contaminant uptake by the food web (Kimmerer et al., 1998).

These issues converge in Suisun Bay, California (Figs. 1 and 2). Over 90% of marsh area has been lost in San Francisco Bay since the 19th century, and current management goals in Suisun Bay include marsh restoration. Deposited sediment

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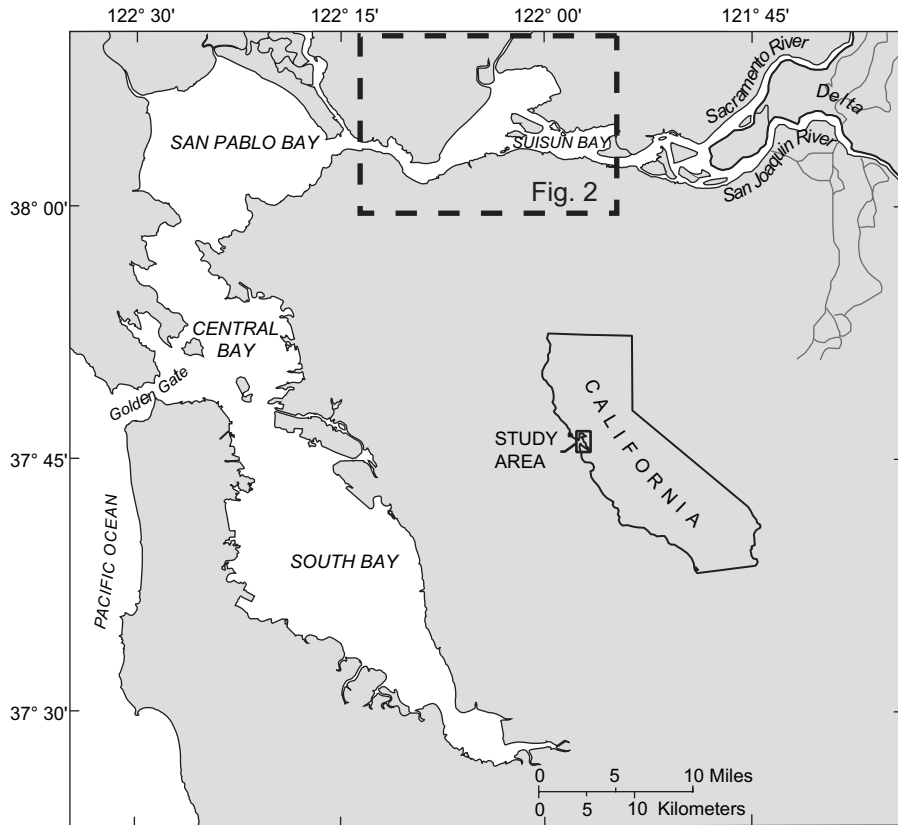


Fig. 1. San Francisco Bay and Sacramento/San Joaquin River Delta. Suisun Bay is the landward-most subembayment of the estuarine system, and receives the majority of its water from the Delta.

in Suisun Bay is thought to be high in mercury concentrations due to 19th century gold mining in the watershed (Hornberger et al., 1999), leading to concerns about resuspension of these deposits over long timescales (>10 yr). Cappiella et al. (1999) show net erosion in Suisun Bay since the first

bathymetric surveys in the 19th century. The net sediment budget of Suisun Bay in the current era may shed light on the viability of habitat restoration as well as the magnitude of mercury introduction to the water column. In order to quantify this sediment budget, sediment flux at the landward

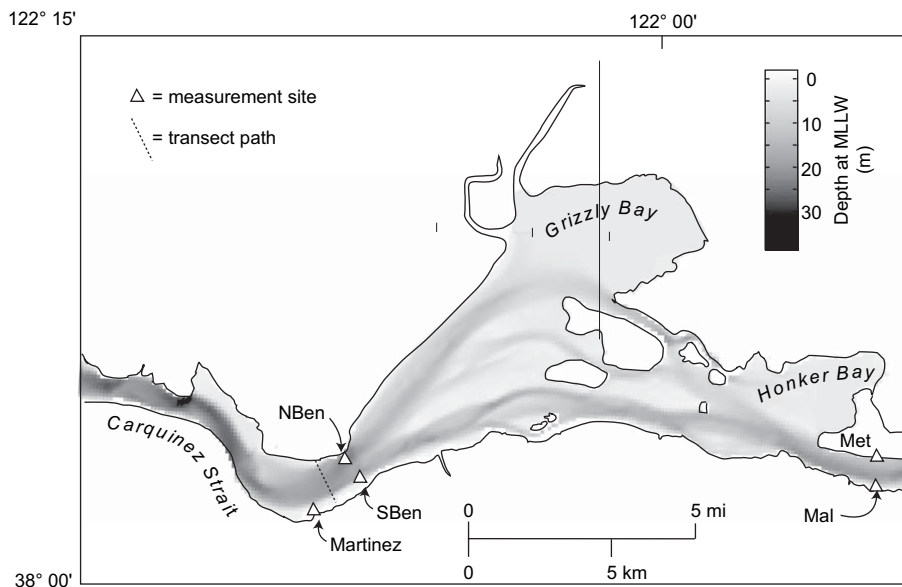


Fig. 2. Suisun Bay outline and bathymetry. Sites Mal and Met are situated at the confluence of the Delta and Suisun Bay. Sites NBen and SBen occupy piers of the Benicia Bridge, landward of Carquinez Strait, which then leads to the expanse of San Pablo Bay.

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