Mercury in the San Francisco Estuary

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I Introduction

A Purpose and Scope

Ever since the recognition of mercury as an environmental problem, San Francisco Estuary has been an active area of mercury research. It is little wonder that this is so: the estuary is in the middle of a region of mercury mineralization and historic mercury mining, and it is downstream of an area of historic gold mining where millions...
of kilograms of mercury were used. It is also a heavily urbanized area that once featured chloralkali facilities and numerous shipyards potentially contaminated with mercury-based paints. In addition, it is a drainage area for rich agricultural regions that may have seen substantial environmental applications of mercury insecticides and fungicides. In this review, we present a survey of literature on mercury contamination and biogeochemistry focusing on San Francisco Estuary. Our intent is to stimulate scientific questions addressing mercury contamination in this and other estuarine systems, as well as to describe the restoration and management efforts that accompany mercury-contaminated sites.

B Overview of the Problem

Before presenting work specific to mercury contamination in San Francisco Estuary, an overview of the environmental mercury problem and mercury chemistry is appropriate. There are many valuable reviews on this wider topic, with focuses on toxicological (Clarkson and Magos 2006), biogeochemical (Benoit et al. 2003; Fitzgerald and Lamborg 2003; Fitzgerald et al. 2007; Ravichandran 2004; Ullrich et al. 2001), ecological (Wiener et al. 2003), and microbiological aspects (Barkay et al. 2003).

Mercury is an environmental and human health concern largely because of the formation of methylmercury, particularly monomethylmercury (MMHg), which is bioaccumulated and biomagnified to toxic concentrations in higher trophic level organisms, including birds (Schwarzbach et al. 2006) and mammals (Wiener et al. 2003). It is a neurotoxin for humans, and effects have been noted in populations consuming fish (Clarkson and Magos 2006). In estuarine systems, sediments are a primary area of MMHg production (Mason et al. 2006). Sulfate-reducing bacteria are thought to be the principal methylators of mercury in anoxic estuarine sediment (Compeau and Bartha 1985), although iron-reducing bacteria have recently also begun receiving scrutiny (Kerin et al. 2006). The production of MMHg is, therefore, controlled by factors influencing the distribution of mercury between abiotic and biotic compartments, such as sulfur chemistry and organic matter, and by factors that control microbial activity, such as temperature and the availability of suitable organic matter for cellular respiration (Gilmour and Henry 1991; Hammerschmidt and Fitzgerald 2004; Heyes et al. 2006; King et al. 2001). Methylmercury produced in sediment that is exported to the water column can be bioaccumulated by phytoplankton or other organisms (Pickhardt and Fisher 2007) and biomagnified to higher trophic levels (Lawson and Mason 1998).

C Environmental Setting of San Francisco Estuary

An understanding of the setting of San Francisco Estuary is essential as a backdrop for this review. The monograph San Francisco Bay: The Urbanized Estuary is an older, but excellent description (Conomos 1979), as is the more recent San Francisco