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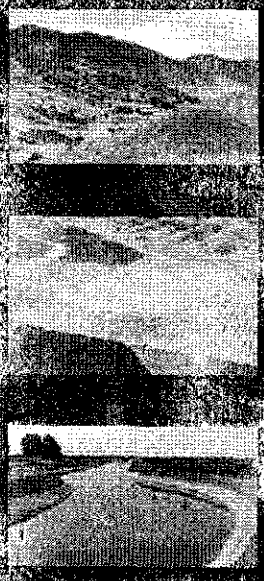
Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension



Sources

Environment

Physiology

Bioaccumulation

Effects

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Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension

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Abstract

Selenium discharges to the San Francisco Bay-Delta Estuary (Bay-Delta) could change significantly if federal and state agencies (1) approve an extension of the San Luis Drain to convey agricultural drainage from the western San Joaquin Valley to the North Bay (Suisun Bay, Carquinez Strait, and San Pablo Bay); (2) allow changes in flow patterns of the lower San Joaquin River and Bay-Delta while using an existing portion of the San Luis Drain to convey agricultural drainage to a tributary of the San Joaquin River; or (3) revise selenium criteria for the protection of aquatic life or issue criteria for the protection of wildlife.

Understanding the biotransfer of selenium is essential to evaluating effects of selenium on Bay-Delta ecosystems. Confusion about selenium threats to fish and wildlife stem from (1) monitoring programs that do not address specific protocols necessary for an element that bioaccumulates; and (2) failure to consider the full complexity of the processes that result in selenium toxicity. Past studies show that predators are more at risk from selenium contamination than their prey, making it difficult to use traditional methods to predict risk from environmental concentrations alone. This report presents an approach to conceptualize and model the fate and effects of selenium under various load scenarios from the San Joaquin Valley. For each potential load, progressive forecasts show resulting (1) water-column concentration; (2) speciation; (3) transformation to particulate form; (4) particulate concentration; (5) bioaccumulation by invertebrates; (6) trophic transfer to predators; and (7) effects on those predators. Enough is known to establish a first-order understanding of relevant conditions, biological response, and ecological risks should selenium be discharged directly into the North Bay through a conveyance such as a proposed extension of the San Luis Drain.

The approach presented here, the Bay-Delta selenium model, determines the mass, fate, and effects of selenium released to the Bay-Delta through use of (1) historical land-use, drainage, alluvial-fill, and runoff databases; (2) existing knowledge concerning biogeochemical reactions and physiological parameters of selenium (e.g., speciation, partitioning between dissolved and particulate forms, and bivalve assimilation efficiency); and (3) site-specific data mainly from 1986 to 1996 for clams and bottom-feeding fish and birds. Selenium load scenarios consider effluents from North Bay oil refineries and discharges of agricultural drainage from the San Joaquin Valley to enable calculation of (a) a composite freshwater endmember selenium concentration at the head of the estuary; and (b) a selenium concentration at a selected seawater location (Carquinez Strait) as a foundation for modeling. Analysis of selenium effects also takes into account the mode of conveyance for agricultural drainage (i.e., the San Luis Drain or San Joaquin River); and flows of the Sacramento River and San Joaquin River on a seasonal or monthly basis.

Load scenarios for San Joaquin Valley mirror predictions made since 1955 of a worsening salt (and by inference, selenium) build-up exacerbated by an arid climate and massive irrigation. The reservoir of selenium in the San Joaquin Valley is sufficient to provide loading at an annual rate of approximately 42,500 pounds of selenium to a Bay-Delta disposal point for 63 to 304 years at the lower range of projections presented here, even if influx of selenium from the California Coast Ranges could be curtailed. Disposal of wastewaters on an annual basis outside of the San Joaquin Valley may slow the degradation of valley resources, but drainage alone cannot alleviate the salt and selenium build-up in the San Joaquin Valley, at least within a century.

Load scenarios also show the different proportions of selenium loading to the Bay-Delta. Oil refinery loads from 1986 to 1992 ranged from 8.5 to 20 pounds of selenium per day; with treatment and cleanup, loads decreased to 3.0 pounds of selenium per day in 1999. In contrast, San Joaquin Valley agricultural drainage loads disposed of in a San Luis Drain extension could range from 45 to 117 pounds of selenium per day across a set of historical and future conditions. Components of this valley-wide load include five source subareas (i.e., Grassland, Westlands, Tulare, Kern, and Northern) defined by water and drainage management. Loads