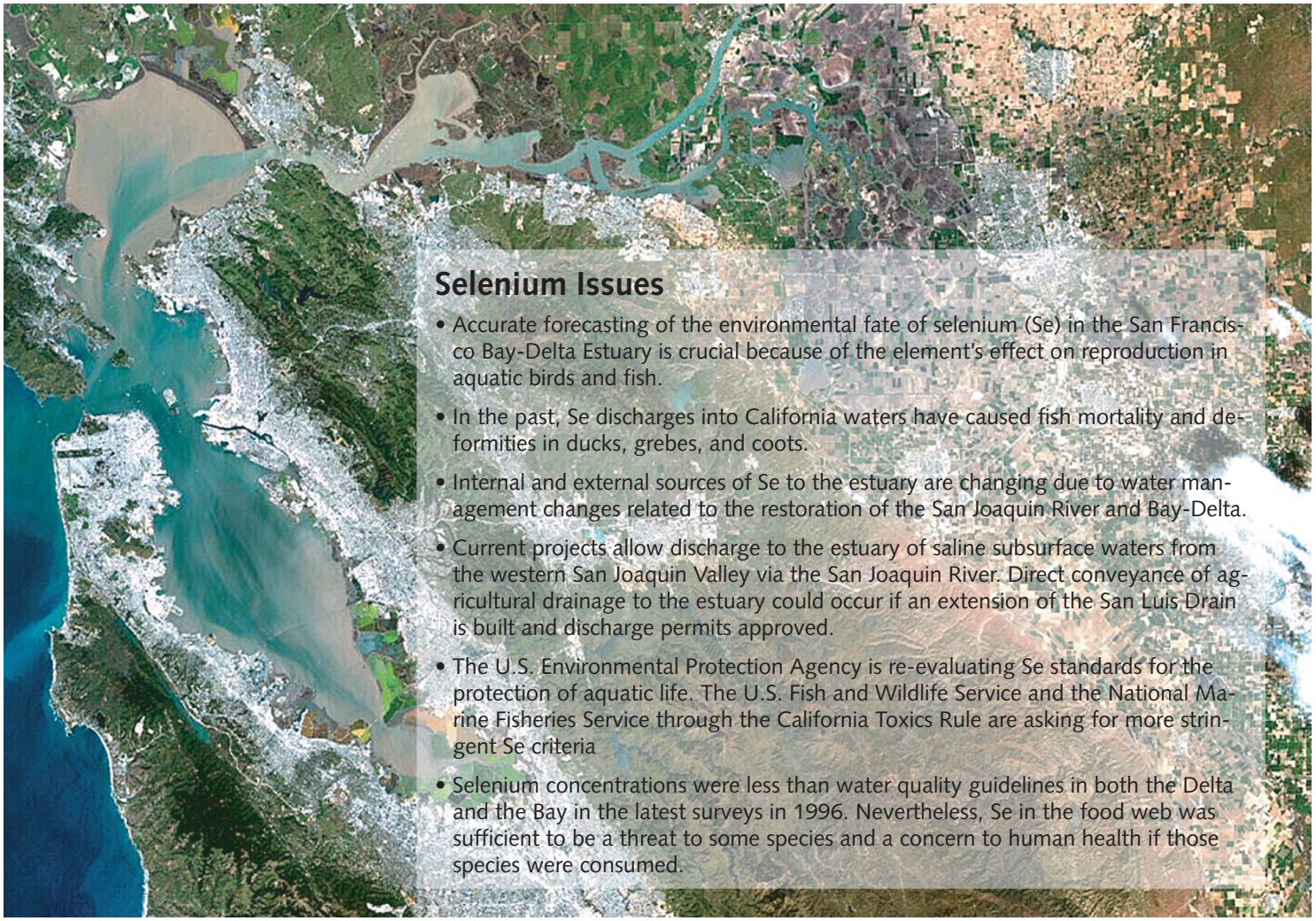
USGS

The Bay-Delta Selenium Model

A new tool to predict ecological effects based on the major processes leading from loading through consumer organisms to predators



Selenium Issues

- Accurate forecasting of the environmental fate of selenium (Se) in the San Francisco Bay-Delta Estuary is crucial because of the element's effect on reproduction in aquatic birds and fish.
- In the past, Se discharges into California waters have caused fish mortality and deformities in ducks, grebes, and coots.
- Internal and external sources of Se to the estuary are changing due to water management changes related to the restoration of the San Joaquin River and Bay-Delta.
- Current projects allow discharge to the estuary of saline subsurface waters from the western San Joaquin Valley via the San Joaquin River. Direct conveyance of agricultural drainage to the estuary could occur if an extension of the San Luis Drain is built and discharge permits approved.
- The U.S. Environmental Protection Agency is re-evaluating Se standards for the protection of aquatic life. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service through the California Toxics Rule are asking for more stringent Se criteria
- Selenium concentrations were less than water quality guidelines in both the Delta and the Bay in the latest surveys in 1996. Nevertheless, Se in the food web was sufficient to be a threat to some species and a concern to human health if those species were consumed.

Forecasts obtained from the Bay-Delta Selenium Model consider (1) loads, (2) water column concentrations, (3) speciation, (4) transformation to particulate forms, (5) particulate concentrations, (6) bioaccumulation, and (7) trophic transfer to predators in addition to traditional considerations of water supply and drainage demand. Data gathered during the years prior to refinery cleanup helped check the model and provide a baseline for determining site-specific effects.

Historical analyses of drainage needs were used to identify the most likely Se loads that would be carried outside the San Joaquin Valley via a conveyance discharging a constant load and conveyance via the San Joaquin River. Selenium concentrations and forms in the Bay-Delta were forecast, then those concentrations were used to model bioaccumulation in invertebrates, like clams. Transfer from clams to predators was estimated from field data, and Se effects on the predators were then forecast from data in the existing literature.

The model allows consideration of many different drainage options. Most options that meet existing demand for drainage appear to pose strong risks to the reproduction and survival of sensitive birds and fish. Threats to reproduction and survival of birds and fish are particularly severe during periods of low river flow. Vulnerable species include diving ducks, white sturgeon and Sacramento splittail.

The Bay-Delta is probably best suited for site-specific Se guidelines and the aforesaid model could provide a framework for developing new protective criteria. If water quality criteria are to be employed in managing Se inputs, then consideration should be given to the elevated Se concentrations currently occurring in clams and fish of the Bay-Delta even though waterborne Se concentrations in the Bay-Delta are less than recommended criteria.

Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of A Proposed San Luis Drain Extension, by Samuel N. Luoma and Theresa S. Presser, U.S. Geological Survey Open-File Report 00-416, is available at USGS libraries and from USGS Branch of Information Services, Box 25286, Federal Center, Denver, CO 80225 (phone 303-202-4200). Federal and local agencies funding the USGS study include the U.S. Environmental Protection Agency, the Contra Costa Water District, and the Contra Costa County.