STATE OF CALIFORNIA
REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

STAFF SUMMARY REPORT: Barbara Baginska, PhD
MEETING DATE: November 13, 2024

ITEM: **7**

Selenium Impairment in North San Francisco Bay – Total Maximum Daily Load (TMDL) Update

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Discussion

This item provides an update on the implementation and the basis for the Selenium Total Maximum Daily Load (TMDL) for North San Francisco Bay adopted by the Board in 2015. Our TMDL development paralleled an interagency effort, led by U.S. EPA, to develop site-specific criteria for selenium in San Francisco Bay and our TMDL incorporates elements of the U.S. EPA criteria. North San Francisco Bay was attaining the numeric targets set in the TMDL at the time of its adoption; therefore, load and wasteload allocations were based on existing loads and load reductions were not required. To ensure continued protection of beneficial uses in the Bay: 1) the load and wasteload allocations in the TMDL set a cap on selenium loads; 2) require effluent limits in National Pollutant Discharge Elimination System permits for petroleum refineries consistent with the TMDL; and 3) the Regional Monitoring Program continues to measure selenium concentration in fish, clams, and water column.

Background

North San Francisco Bay (from the Bay Bridge to the Delta) has been on the 303(d) list of impaired water bodies since 1998 due to concerns about selenium. Selenium occurs naturally in the environment and is an essential micronutrient at low concentrations. It is also highly bioaccumulative and is known to cause reproductive impacts in fish and wildlife. However, selenium bioaccumulation is site-specific and highly dependent on selenium speciation, environmental conditions, the type of organisms present and their food preferences. The highest bioaccumulation takes place at the base of the food web while the subsequent transfers to higher trophic levels (such as fish) tend to be much smaller.

In addition, some types of food webs bioaccumulate selenium more efficiently than others. In the North San Francisco Bay adverse impacts of selenium bioaccumulation have been detected only in the benthic food web and are particularly evident in the dominant invasive clam *Potamocorbula amurensis.* Studies have found that this clam displayed a 10-times slower rate for selenium loss compared to native clams leading to high tissue concentrations in *Potamocorbula amurensis* ranging from 4 to over 15 micrograms per gram (µg/g) dry weight. This clam's spread and its efficient selenium uptake is largely responsible for the accelerated bioaccumulation of selenium in fish that feed on clams, such as white sturgeon, which is particularly susceptible to selenium.

The TMDL numeric target is based on EPA's chronic criteria and is established to protect sturgeon. We used a numerical estuary model and the United States Geological Survey (USGS) bioaccumulation model to simulate transformations and biological uptake of selenium in the Bay under different loading scenarios and to calculate allowable water column concentrations from the fish tissue target. The water column target derived from the fish tissue is an order of magnitude more stringent than the current Basin Plan water quality objective of 5 micrograms per liter (µg/L).

Numeric targets to protect sturgeon in North San Francisco Bay

Fish Tissue Targets	Water Column Target
8.0 µg/g whole-body dry weight **11.3** µg/g muscle tissue dry weight	**0.5** µg/L (dissolved total selenium)

Selenium concentrations in white sturgeon have significantly declined since the 1990s and fish tissue numeric targets are attained. Water column concentrations have been consistently below the water column target of 0.5 µg/L which suggests that substantial assimilative capacity exists in the Bay. For this reason, the TMDL caps selenium loads at then-current levels and does not call for load reductions.

Selenium Sources and Implementation

The largest source of selenium loading, in excess of 4,000 kilograms per year (kg/yr), is from the Sacramento and San Joaquin Rivers (Central Valley watershed). This source is mostly uncontrollable and related to selenium occurring naturally in soils and sediments. There are also legacy agricultural sources that are addressed by TMDLs adopted by the Central Valley Water Board. Changes in Delta outflows from the Central Valley watershed may impact selenium loading to the North San Francisco Bay, especially if the increased flows originate in the San Joaquin River where there are legacy agricultural sources. The Selenium TMDL for the North San Francisco Bay sets a load allocation for the Central Valley watershed and requires monitoring to inform the need for adaptive implementation.

Five petroleum refineries discharge approximately 570 kg per year and remain the largest controllable source of selenium. To ensure that the waste load allocations are met, NPDES permits for refineries impose numeric water quality-based effluent limits for selenium consistent with the TMDL. Compliance with the limits is assessed on a monthly and an annual basis.

The TMDL and its implementation plan requires that the then-current selenium load be maintained into the future with ongoing monitoring of selenium levels in fish, especially sturgeon. To ensure compliance with the TMDL requirements, we developed a comprehensive water and clam monitoring strategy, along with non-lethal monitoring of muscle plugs from sturgeon. This strategy emphasizes detection of changes to enable prompt and effective preventive management actions.

Water quality improvements to date include:

- Selenium loads from petroleum refineries into North Bay were reduced from almost 2,500 kg/yr to 570 kg/yr (beginning in the 1990s)
- Selenium concentrations in sturgeon remain largely below the TMDL target of 11.3 µg/g dry weight
- Water column concentrations do not exceed 0.2 µg/L and are well below the TMDL target of 0.5 µg/L
- Loads from the San Joaquin River continue to decrease due to long-term efforts to divert and recycle selenium from agricultural drainage in the Central Valley. Concentrations of selenium in the San Joaquin River (measured near Vernalis) have also declined to less than 0.5 µg/L