## **Delta Mercury Model DSM2-Hg**

#### Reed Harris and Jamie Anderson, Delta Tributaries Mercury Council Sept. 28, 2021



### Study Team



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#### Part of a broader overall effort...

#### The Open Water Mercury Technical and Modeling Workgroup











# **Delta Mercury TMDL**

- Delta Mercury Control Program established Total Maximum Daily Loads (TMDL) for methylmercury
- Goal: Reduce open water methylmercury load
- Phased adaptive management approach included developing and applying mechanistic mercury models for the Delta and Yolo Bypass
  - Model analysis was completed in Phase I and a final report was submitted to the Central Valley Water Quality Control Board in 2020
  - Phase II of the Delta Mercury Control Program ~2022

#### Areas that require load reductions



## Delta Mercury Model Development

Extend existing Delta flow and water quality model to include mercury cycling



Replicate conditions from 1999 -2006 and compare to field data

Explore model results for insights into key sources and processes

# **Delta Mercury Model**

- Extended the existing Delta Simulation Model version 2 (DSM2)
- Additions to DSM2
  - Suspended sediment & sediment bed
  - Methylmercury, MeHg\*
  - Inorganic mercury Hg(II)\*
  - Elemental mercury Hg(0)\*
- Analysis did not include food web
- Model Calibration
  - October 1999 to July 2006
  - Regression equations used to create mercury boundary conditions
  - Used data from several previous studies

\* In water column and surface sediment bed



### Mercury Cycle in Delta Model

- Includes key physical, chemical and biological processes
- Simulates fate and transport
  - Inorganic and methylmercury
  - Water column including on sediment particles
  - Sediment bed



### **Data Challenges**

- Field data availability was variable, often limited
- Best data for suspended sediment and mercury were from different places and times
- Approach: calibrated mercury and suspended sediments for different time periods
  - Suspended sediment calibration Oct 2010-Sept 2013
  - Mercury calibration Oct 1999 to July 2006



#### **Top: Suspended sediment stations**

#### Bottom: Hg(II) & MeHg Stations



#### Observed and simulated suspended sediment concentrations Oct 2010-Sept 2013





### Observed and simulated methylmercury concentrations Jan 2000 to July 2006





### **Delta Modeling Results**

Model results found the Delta to be a:

- Net sink for:
  - Suspended sediment
  - uHg
  - uMeHg

#### Inflows are the major source of SSC, Hg and MeHg

- Sacramento River is major MeHg source
- Importance of MeHg sources varies from year to year with hydrology
- Yolo Bypass is typically the 2nd major source of MeHg but varies between <5 to 50%</li>



#### Simulated Annual MeHg Tributary Loads into the Delta



Month

## Spatial Patterns

Snapshots during high, median and low flows

Concentrations are tributary driven

At high flows, SSC and Hg(II) have lower concentrations in Central Delta similar to observed fish tissue patterns

Field data are limited



## Methylmercury animation

- Model results from Dec 17, 2005 to March 15, 2006
- Large New Year's eve storm with Yolo Bypass flood flows
- Feb and March storms result in pulses of MeHg from Yolo bypass and Cosumnes & Mokelumne Rivers



**Martinez** 



#### Yolo Bypass

Cosumnes &



# Some Key Findings

- Developed mechanistic model framework for Hg in Delta waters and surface sediments.
- Model reasonably reflects existing data for THg and MeHg.
- Tributaries are major MeHg source, including Yolo Bypass when flooded. Can upstream sources be addressed?
- Delta is a net sink for solids, inorganic Hg and MeHg.
- System is highly dynamic. Concentrations and fluxes can vary quickly and spatially. This has implications for characterizing system, quantifying sources, and monitoring benefits of remediation.

## **Model Uncertainty**

- Model analysis provided meaningful estimates and rankings of sources of Hg and MeHg, but was not-tightly constrained.
  - The Delta is large, dynamic and heterogeneous with many human influences (*i.e.* data-demanding): Data limitations were an issue.
  - Some knowledge gaps also exist (e.g. effects of vegetation on methylmercury production)
- Parameter estimation technique applied to Yolo Bypass (PEST) could be used for Delta to help calibrate model, quantify uncertainty and examine sensitivity

### **Potential Future Directions**

- Model could be used for scenario testing.
- Improved characterization of system and boundary loads would improve model confidence and utility.
- Delta-wide coordinated effort designed to help address TMDL questions would help (monitoring, process understanding, analysis). Framework could be extended to include food web
- Enhance uncertainty analysis •
- Extend geographic scope (Schism) •



Zip File

Executables

Input files, data sets, instructions

Documentation folder includes technical appendices that are not posted online

### **Delta Mercury Model public release** https://data.cnra.ca.gov/dataset/dsm2

data.cnra.ca.gov/dataset/dsm2/resource/ea7b1b18-26a4-4583-bca4-7cddf8af78b3



**Open Data Organizations Topics Training** 

ORGANIZATIONS / CALIFORNIA DEPARTMENT OF ... / DSM2 / DSM2-HG / OPEN WATER ....

#### **DSM2-Hg / Open Water Mercury Program inputs**

URL: https://data.cnra.ca.gov/dataset/039928f9-5b4c-47e9-9953-69.

A zip file containing the DSM2-Hg model, and inputs for the Open Water Mercury Program.

There are no views created for this resource yet.

#### **Additional Information** Resources DSM2-Hg / Open Water ... FIELD DSM2 v8.2.1 LAST UPDATED DSM2 v8.2.0 CREATED DSM2 8.2.0 beta1 FORMAT

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Ownload

VALUE	
September 9, 2021	
September 9, 2021	
ZIP	

## **Open Water Mercury Final Report** Submitted to Central Valley Water Quality Control Board

- Delta Stewardship Council website: https://deltacouncil.ca.gov/delta-science-program/independent-sciencereview-of-the-delta-mercury-control-program Posted as individual chapters, CH 5 Delta Hg Model
- DWR website: https://water.ca.gov/Programs/Environmental-Services/Applied-Research select the mercury tab, entire main report is a single PDF
- Technical appendices available upon request

# Thank You!

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# **Extra Slides**



# **Estimated Delta MeHg Fluxes**

Modeled and fieldestimated fluxes matched reasonably

Tributaries are major source of uMeHg

Small sediment fluxes

Delta is a net sink for uMeHg



Field estimates from Foe and others 2008

uMeHg=unfiltered methyl mercury SWP=State Water Project uHg(II)=unfiltered inorganic mercury CVP=Central Valley Project



#### Modeled Mercury Inflows and Outflows Oct 1999 to June 2006



uHg(II) = unfiltered inorganic mercury uMeHg=unfiltered methyl mercury

- Sacramento River is major source
- Yolo Bypass is an important source for MeHg
- Most Hg leaves the Delta at Chipps Island and flows into SF Bay

		uHg(II)	uMeHg
	Sacramento	71%	52%
11	San Joaquin	8%	11%
	Yolo Bypass	18%	34%
1	Cosumnes	<1%	3%
	Mokelumne	<1%	<1%
-	Calaveras	<1%	<1%

		uHg(II)	uMeHg
111	CVP	5%	7%
	SWP	6%	8%
11	Chipps Is.	89%	85%

CVP = Central Valley Project SWP = State Water Project