Recent Salinity and Selenium Science and Modeling for the Bay Delta Estuary

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Summary

1. Salinity
   - South Delta salinity and the Central Valley Project
   - Interior South Delta Salinity Objectives
2. Selenium
   - The “Selenium Reservoir”
   - Selenium in Different Aquatic Environments
3. Recommendations for Bay-Delta Water Quality Control Plan (WQCP).

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Salinity and the Central Valley Project

- Saline discharges to the San Joaquin river come principally from irrigated agriculture. (State Board, D-1641, 2000: 83)
- Low flows in the river due to upstream water development reduce the River's assimilative capacity.
- State Water Board made USBR "responsible for significant deterioration of water quality in the South Delta" as well.
  - Delta Mendota Canal imports ***900,000 to 1 million tons of salts*** annually.
  - 1/4 of flows reaching Vernalis originate 2/3 of salt load in San Joaquin River: Northwest Side and Grassland areas major sources.

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Salt Loads Increased with Central Valley Project Operations

Decadal changes in salinity conditions for the San Joaquin River as measured at Vernalis, 1930s through 1960s. Source: US Water and Power Resources Service and South Delta Water Agency, 1980.

- 1930s average TDS = 228 mg/L
- 1960s average TDS = 427 mg/L

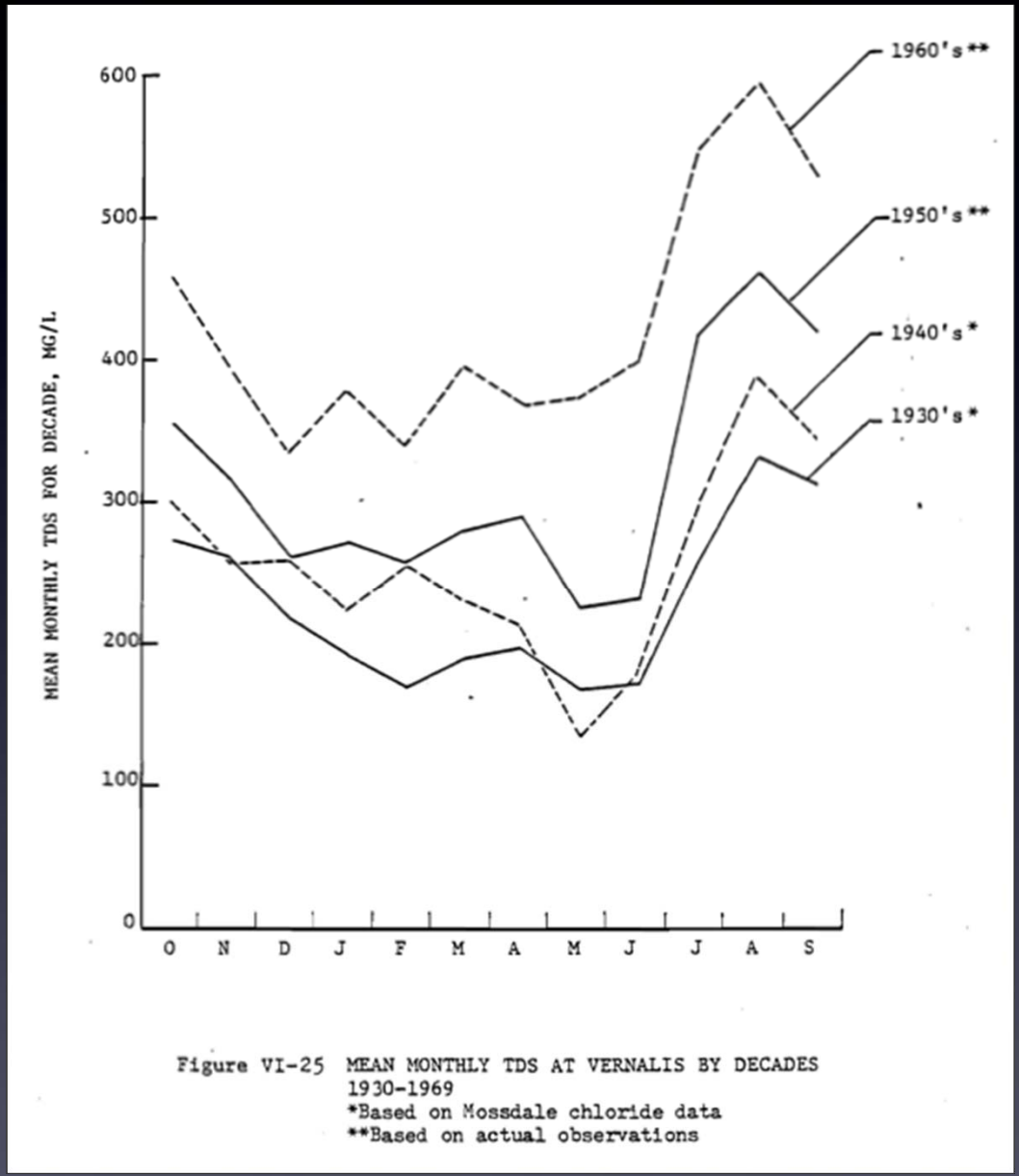

Figure VI-25 MEAN MONTHLY TDS AT VERNALIS BY DECADES 1930-1969
*Based on Mossdale chloride data
**Based on actual observations

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South Delta Agricultural Salinity Objectives

- USBR & DWR made responsible for compliance starting in 2005 under D-1641.
- Interior Monitoring Sites: SJR at Brandt Bridge, Old River at Union Island, and Old River at Tracy Blvd:
- April 1 through August 31 = 0.7 EC
- September 1 through March 31 = 1.0 EC
- Exceedances began immediately in 2005 by DWR and Bureau

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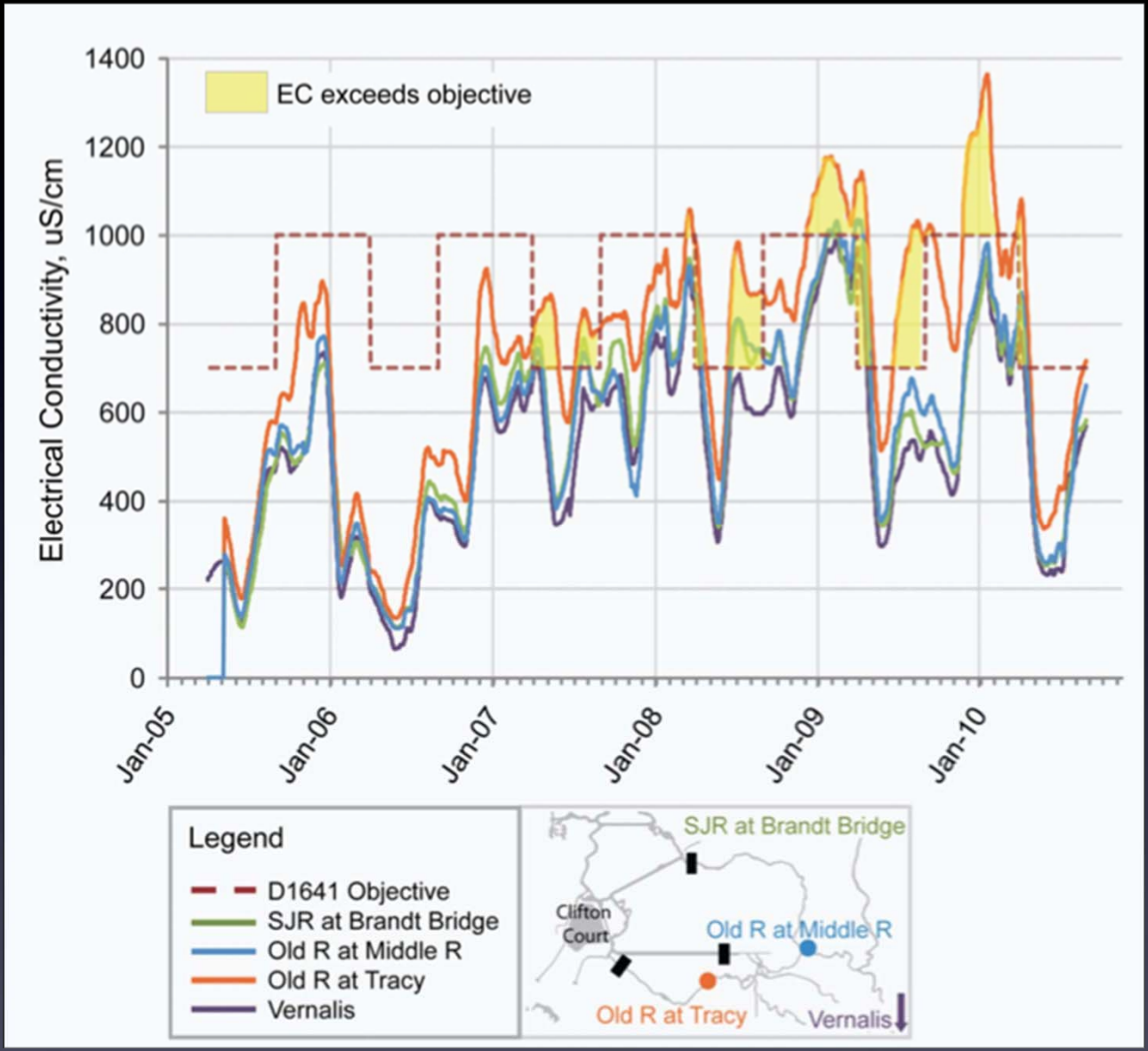
Recurring Exceedances



Board's Cease and Desist Order (CDO)

- In 2006, SWRCB prosecuted a CDO to "obviate the threat of non-compliance" with interior South Delta salinity objectives.
    - Compliance required by July 1, 2009.
- In 2010, SWRCB extended compliance deadline with interior South Delta salinity objectives to 2014.
- The Board required two new studies by DWR & USBR of salinity conditions and options for achieving compliance.

DWR Low-Head Pumping Study (2011)

- Modeled use of low-head pumps to shunt higher quality Sacramento River water upstream of temporary South Delta barriers.
- DWR found:
  - Low-head pumping yielded only small effects on salinity even at 500 to 1,000 cfs pumping rates.
  - Various combinations of monitoring site pumping resulted in only a "minimal" number of reductions in salinity violations.
  - 83 to 93 percent of all salty water reaching South Delta interior sites is from the San Joaquin River.

USBR Dilution Flow Study

- Examined reservoir release volumes needed to "obviate threat of non-compliance."
- Assumed dilution flow salinity of 60 micromhos (~38 mg/L TDS)—high-quality water from High Sierras.
- Bureau modeled "surrogate" objectives observable at Vernalis that would result in downstream compliance.
- Using unnamed "eastside reservoir" sources, the Bureau found:
  - Additional 100,000 to 200,000 acre-feet with most lenient water quality surrogates.
  - Need additional 1.4 million acre-feet with most stringent surrogates during driest years.

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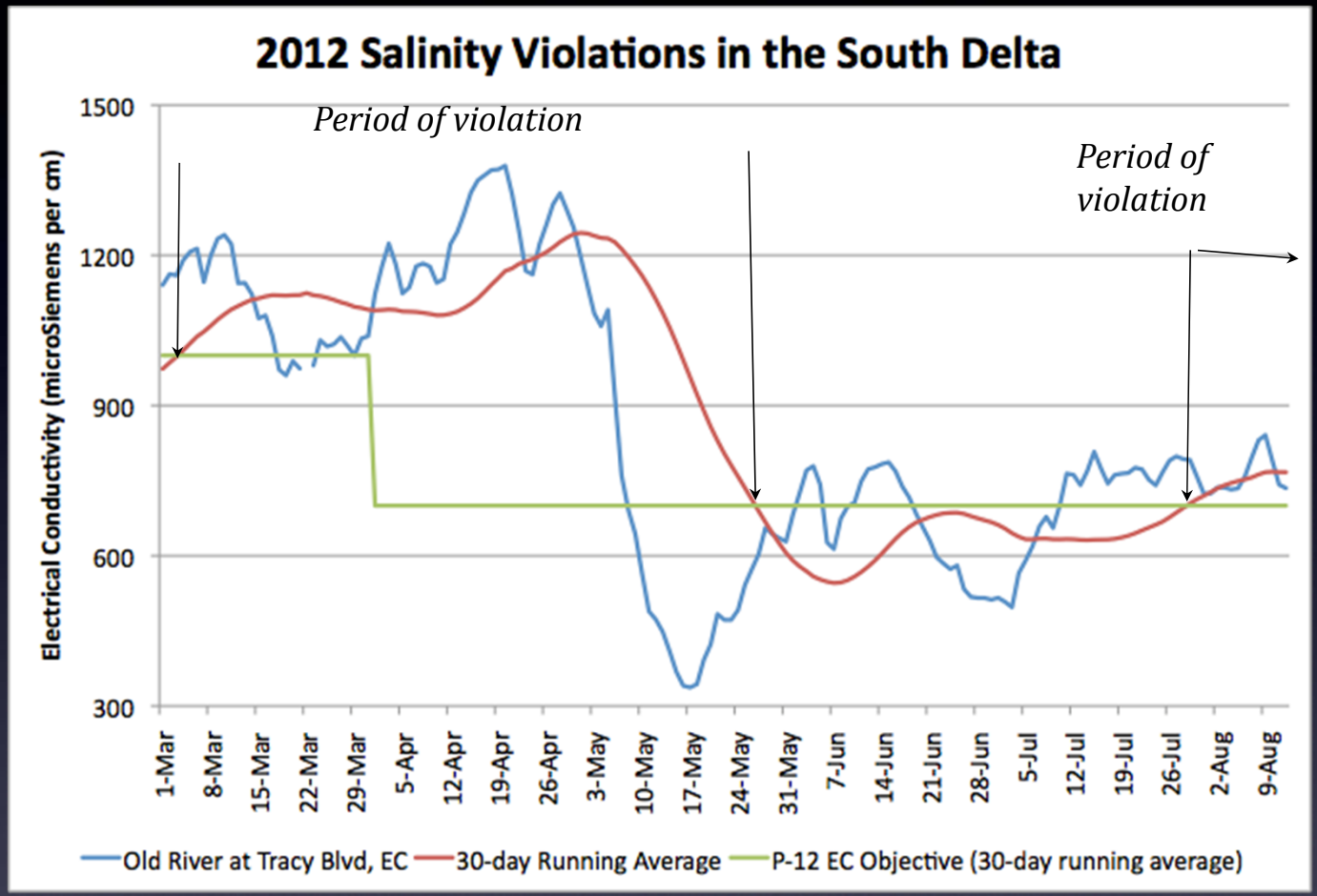
USBR Dilution Flow Study

- Bureau's study assumed the existing salinity discharges that now reach the San Joaquin River—that is, the Bureau assumes no change to salty irrigation imports via the Delta Mendota Canal.

Interior South Delta salinity violations by DWR and USBR continue in 2012

- Exceedances 84 consecutive days from March 4 thru May 26.
- Additional summer season exceedances from July 29 thru August 12 (last data CDEC collected).
- Winter = 27 days, Summer = 71 days.



Salinity violations in the South Delta between March 1 and August 12, 2012. Source: California Data Exchange Center, California Water Impact Network. See Appendix E for supporting data.

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State Water Board 2012 Proposal

- Relax Interior South Delta objectives to:
  - April 1 thru August 31 = 1.0 EC
  - September 1 thru March 31 = 1.4 EC

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Salinity Recommendations

- C-WIN urges:
  - Bay-Delta Plan should incorporate:
    - Salt recirculation, reduced assimilative capacity, and exports of high quality water.
    - Recent modeling results (if not agency conclusions) from DWR Low-Head Pumping and USBR Dilution Flow studies.
    - Effects of Board's interior South Delta proposal under Clean Water Act Anti-Degradation Policy and interior Delta water rights.
    - Research on Old River salinity problems.

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San Joaquin Valley's Selenium "Reservoir"

- Darkest areas have highest Se concentrations in uppermost 12 inches of soil horizon.
- Major source areas of Se in San Joaquin Valley:
- Panoche Creek Alluvial Fan
- Lost Hills region
- Buena Vista Lake Bed
- Panoche Creek fan nearest to San Joaquin River and Bay-Delta Estuary.

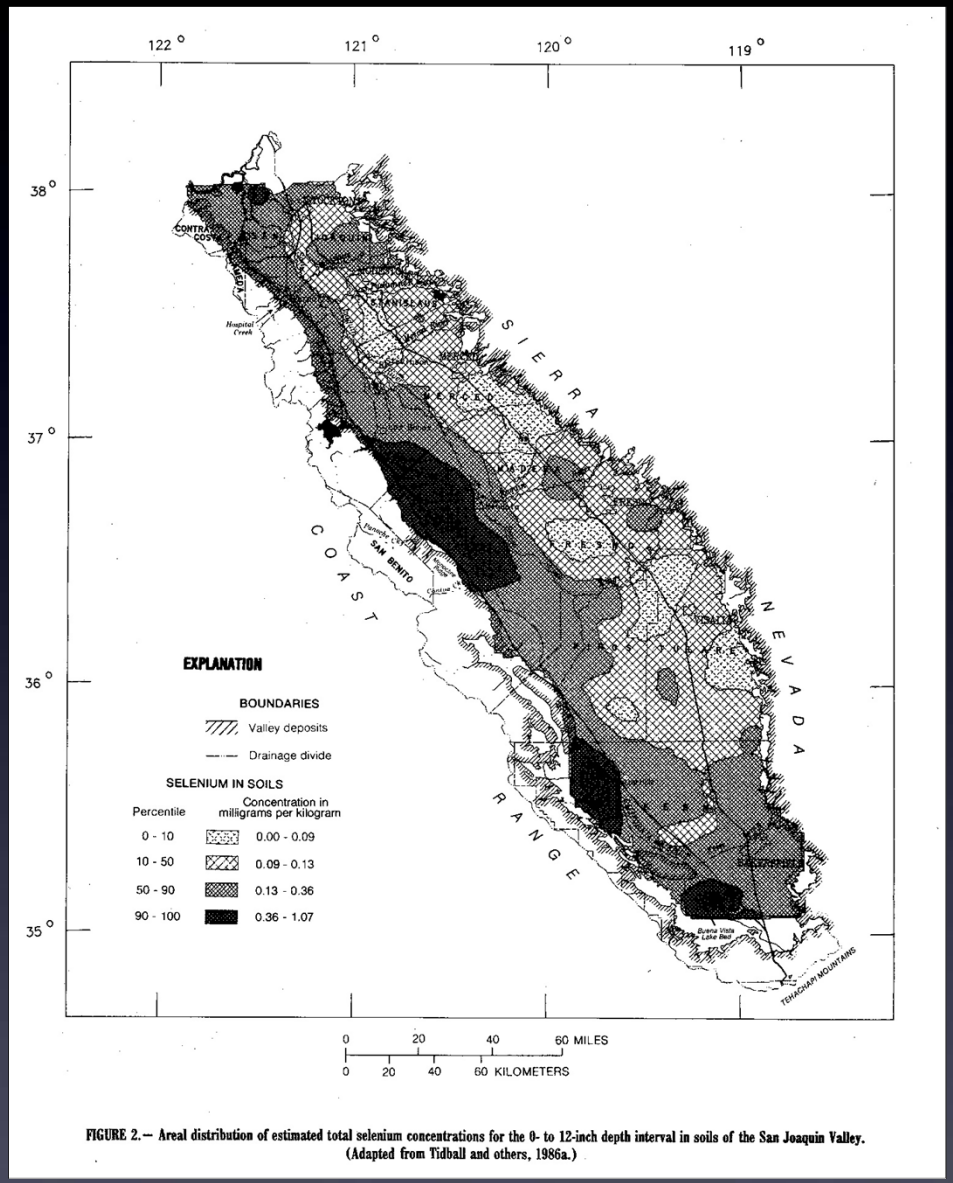

FIGURE 2.— Areal distribution of estimated total selenium concentrations for the 0- to 12-inch depth interval in soils of the San Joaquin Valley. (Adapted from Tidball and others, 1986a.)

Selenium "Reservoir"

- Management approaches:
  - San Joaquin Valley Master Drain, completed only to Kesterson Reservoir.
  - On-farm management.
  - Reuse and treatment options: Grassland Bypass Project
  - Court mandates and State Water Board efforts urging the Bureau to provide drainage service to Valley.
- Nowhere to put the saline and seleniferous waste from irrigation use that doesn't redistribute effects of the problem.

Selenium "Reservoir"

- State Water Board seems to prefer "regional drainage management":
  - D-1641 approvingly described Central Valley Regional Board staff testimony supporting a drain to the Delta.
  - A valley-wide drain exporting salts and selenium would be the only feasible long-term solution to drainage problems.

Selenium "Reservoir"

- "...there are, for all practical purposes, unlimited reservoirs of selenium and salt stored within the aquifers and soils of the valley and upslope in the Coast Ranges." (Presser and Schwarzbach, 2008: 2)
- Se Reservoir characterized by:
  - Aggregate load of Se in San Joaquin region source rocks and soils.
  - Assumed discharge rates (i.e., reservoir drawdown)
  - Duration as a societal resource management problem: Presser & Luoma (2006: 108) concluded it would take ***63 to 180 years*** to eliminate Se from the western San Joaquin Valley region ***with conveyance***.

Se in Different Aquatic Environments

- Current Se toxicity criteria are set with respect to concentrations in water column.
- However, new research strongly suggests such existing criteria are not protective enough.
- What matters with Se toxicity is how it accumulates in predator tissues (including reproductive systems).
- Pathway to predator tissues requires understanding hydrological (flow energetics) and ecological (food web) routes Se travels.

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Se in Different Aquatic Environments

- K_d signifies the rate at which Se leaves solution for particulate binding, deposition, and bio-availability.
- High values of K_d associated with low-energy aquatic environments (estuaries, ponds, reservoirs).
- Low K_d values associated with high energy aquatic environments.

Table 7
Examples of Ecosystem and Hydrologic Environment-Specific Selenium Criteria in Tissue and in Water Column

Hydrologic Environment	Selenium Partitioning Factor (K_d)	Target Selenium Concentration in Tissue (µg/g, dry wt)	Hypothetical Selenium Concentration in Water Column (µg/L)	Protected Fish or Birds in Hydrologic Environment
Mainstream River	150	5 (fish tissue)	10.8 to 34	Bluegill; Trout
Backwater	350	5 (fish tissue)	4.6 to 14.4	Bluegill; Trout; Bass
Reservoir	1,800	5 (fish tissue)	0.89 to 1.7	Blackfish; Redear
Estuary	3,000	5 (fish tissue)	0.24 to 1.2	Starry Flounder; White Sturgeon
Estuary	3,000	8 (bird tissue)	0.24	Scaup
Wetland	900	8 (bird tissue)	1.8	Grebe
Stream	350	8 (bird tissue)	4.5	Dipper
Saline Lake or Pond	1,500	8 (bird tissue)	0.70 to 1.8	Blacknecked Stilt

Source: Presser and Luoma (2010a: Figure 6, 703); California Water Impact Network.

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Se in *Corbula*, the invasive Asian Clam

- C-WIN put together case study in Delta to test findings about hydrologic factor's role in Se bioavailability.
- Kleckner et al (2010) published data on Se tissue concentrations in *Corbula* at several sites from San Pablo Bay to Chipps Island.
  - Best data in a time series from early 2002 to early 2010.
  - Covered a range of water year types, wet and dry.
- C-WIN devised simple comparisons of Se tissue concentration changes in *Corbula* with isohaline (X2) trends from Interagency Ecological Program's Dayflow dataset.

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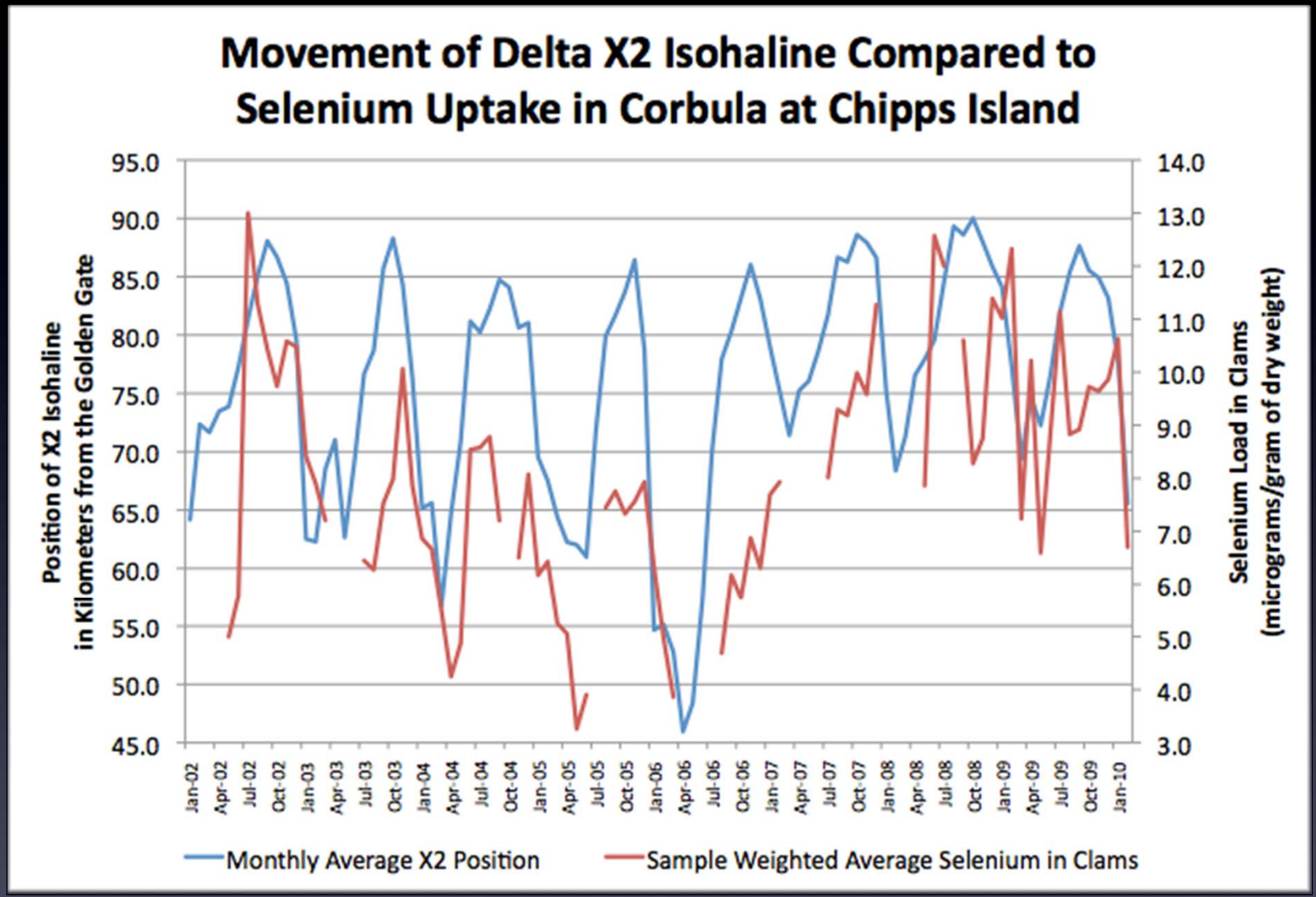
Se in *Corbula* compared with X2



C-WIN Recommends for Bay-Delta WQCP

- Lower the water column Se objective.
  - Presser & Luoma 2010b research: water-column Se criterion should be reduced from 2 ppb to 0.2 ppb in estuaries (see 2010b: 703, Figure 6D).
- Keep water moving through the Delta estuary.
  - Actions to lengthen residence time and reduce flows appear likely to increase Se bioaccumulation in highly receptive species at base of Bay-Delta Estuary food webs, such as *Corbula*.
- Stop pouring imported water on the problem!
  - Adopt a land retirement strategy to go with new flow objectives.

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