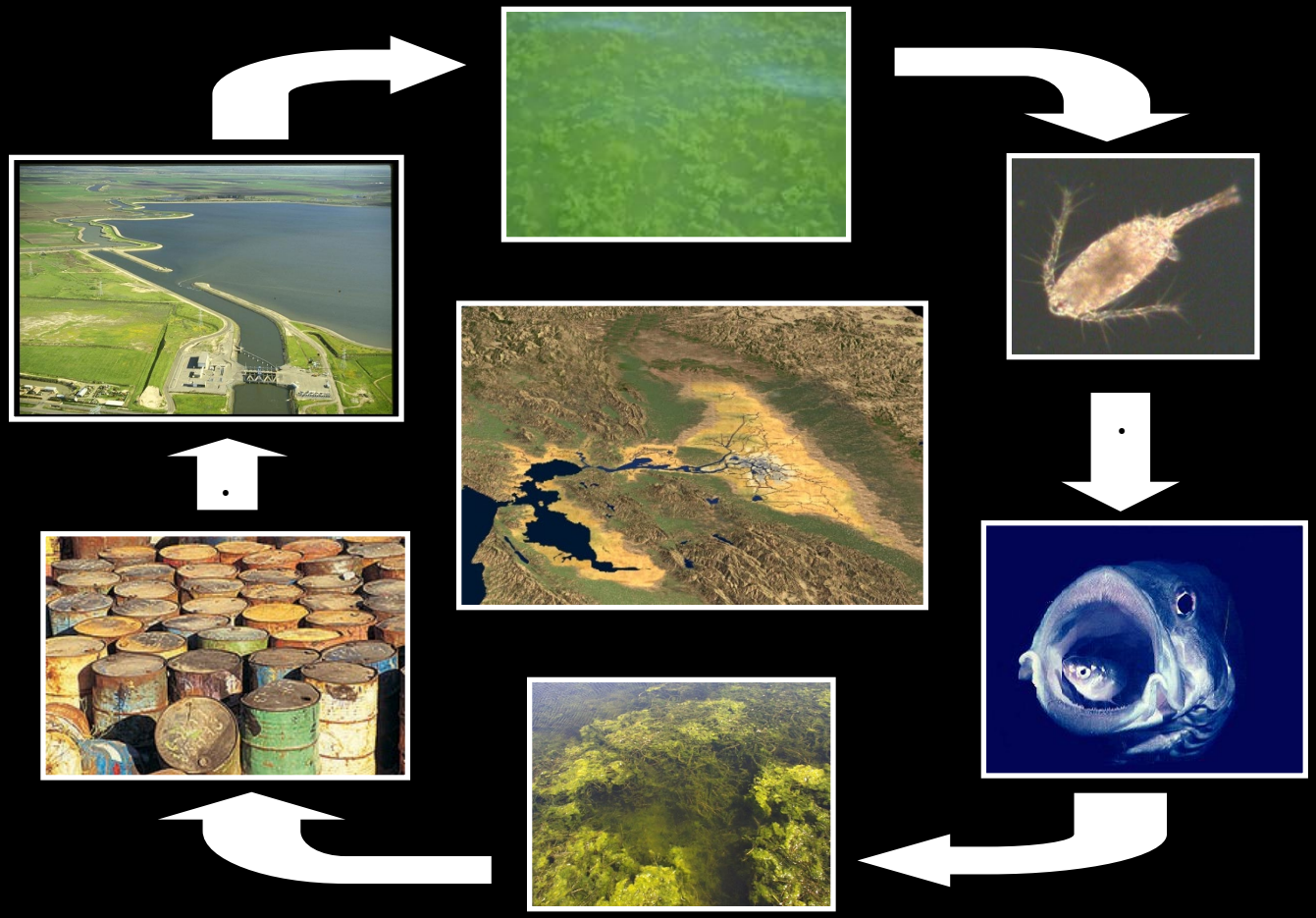
Bay-Delta Hydrology



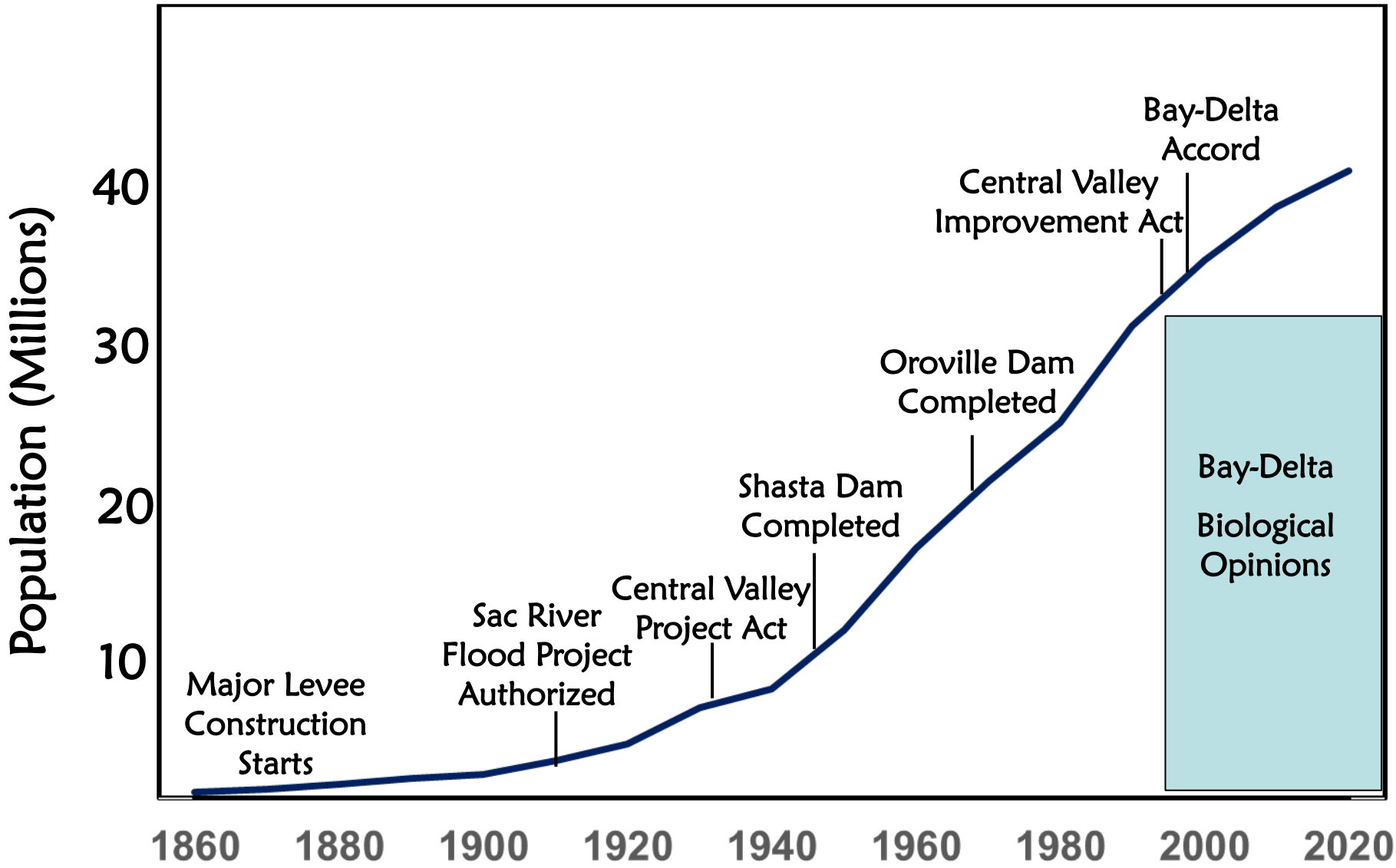
Ted Sommer

Public Policy Inst of California (Research Fellow)

Some Key Points

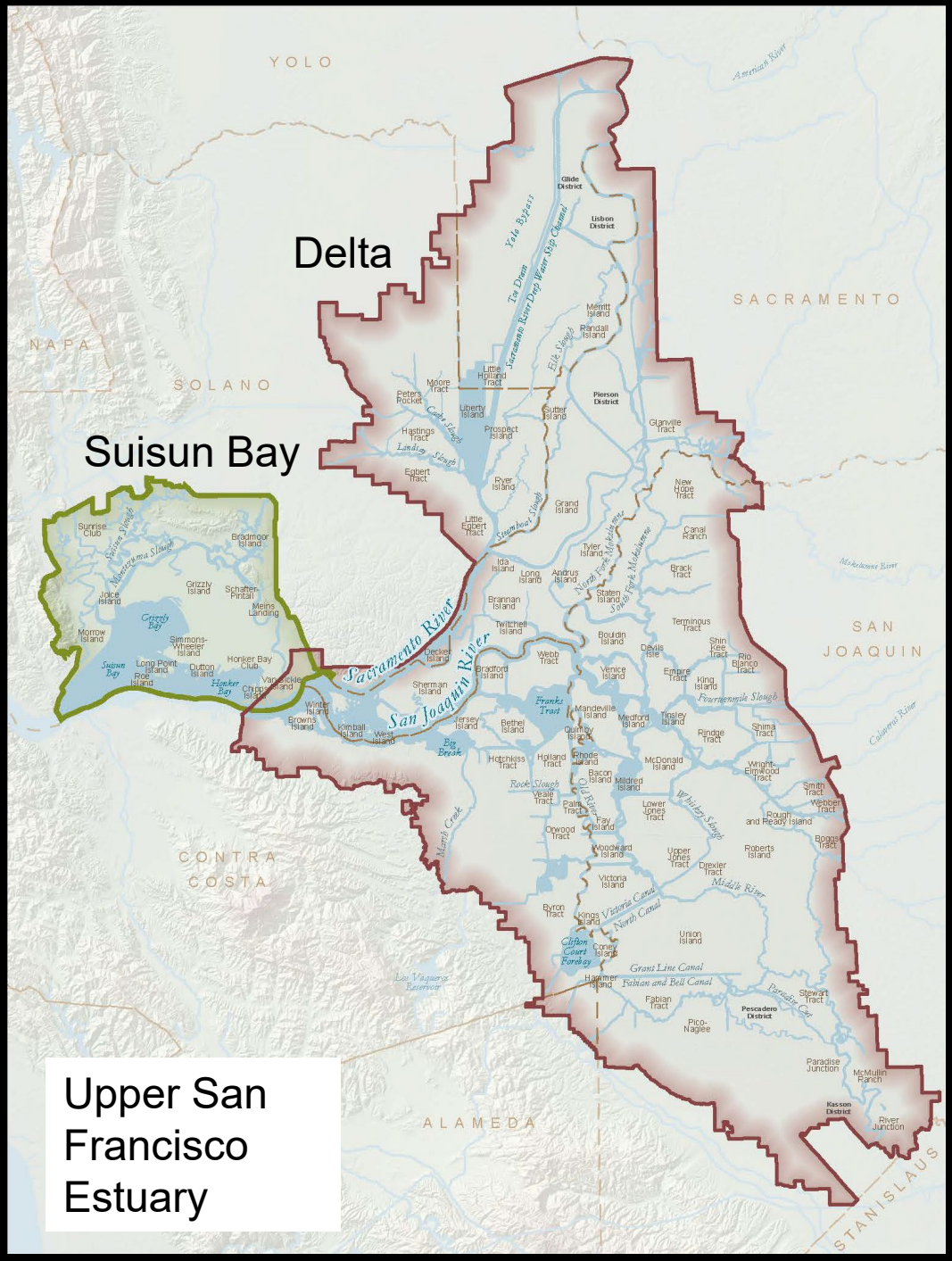
- The estuary is NOT a river!
- The estuary isn't a regular estuary either…..
- No such thing as a free lunch
- Nothing lasts forever

California Water Development Milestones



Sources: Water Education Foundation (Milestones); Wikipedia (Population)

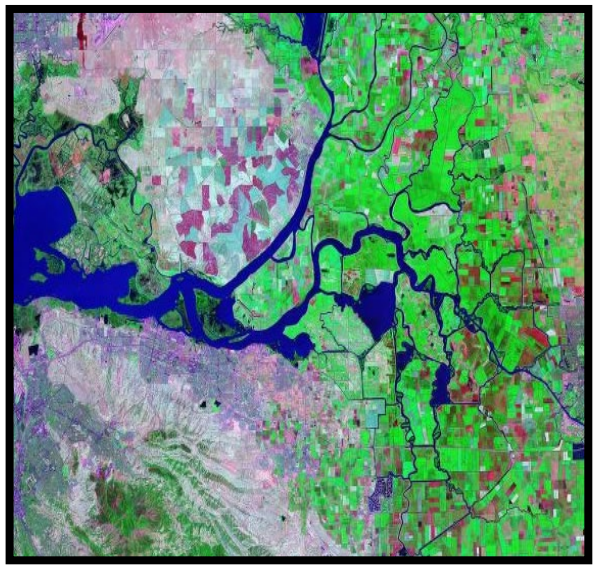
Basic Geography



California Bay-Delta

Your Basic Delta

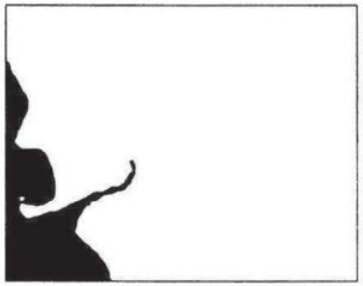
Ocean ⟵ Inland



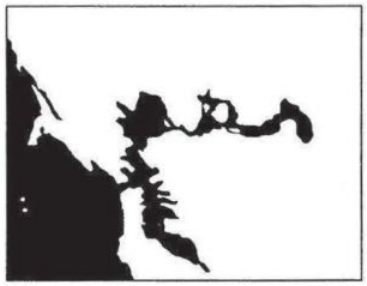
Our **Freaky** Delta

Formation of the SF Estuary

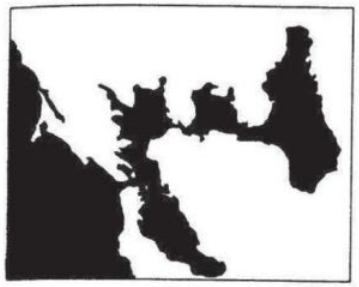
15,000 Years Ago
(End of last Ice Age -- sea level approximately 400 feet below present level; rivers not shown)



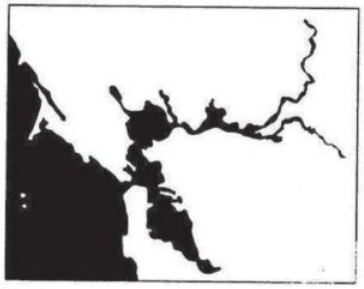
10,000 Years Ago
(Formation of Farallon Islands and intrusion into the "Golden Gate")



5,000 Years Ago
(Formation of Bay and Delta Basins)



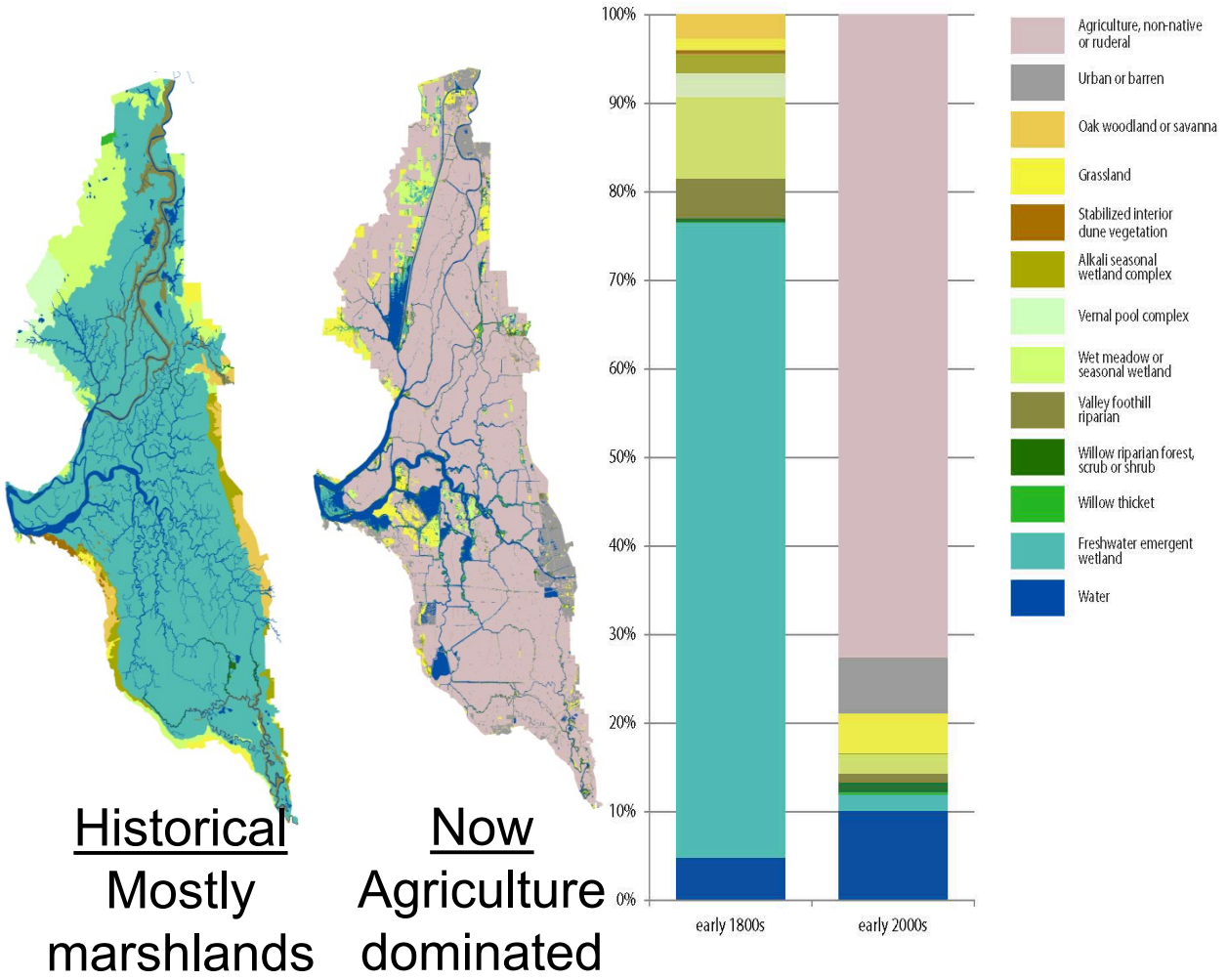
125 Years Ago
(Landward edge of undiked tidal marsh)



Today
(Includes changes due to hydraulic mining sediment deposition, land reclamation, and filling of wetland areas)

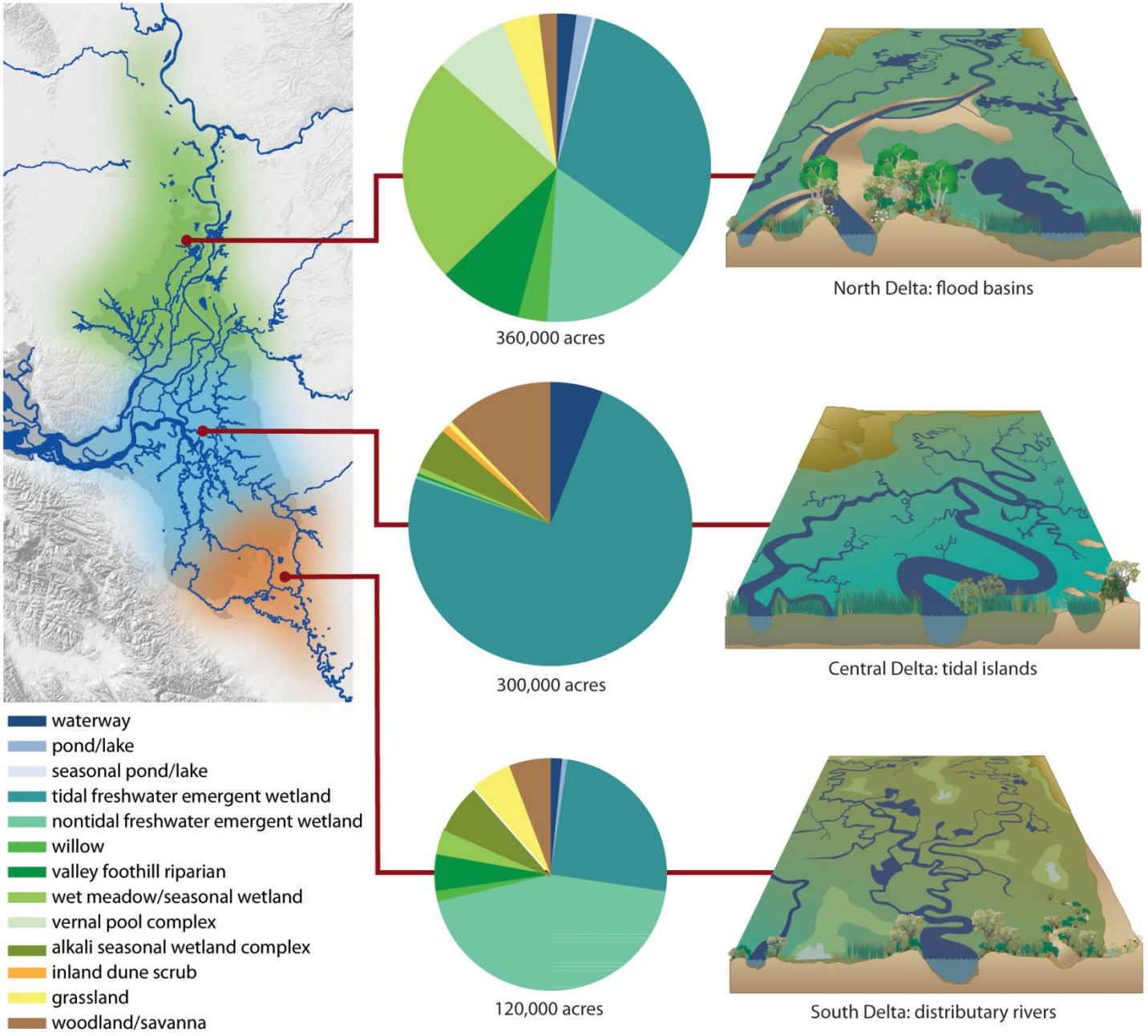
Figure 1.4. The invading estuary. Holocene transgression of the San Francisco Estuary and current extent of tidal waters as influenced by modern land use. (adapted by San Francisco Estuary Project from Atwater 1979 and Atwater et al. 1979, reprinted in TBI 1998)

A Delta Transformed

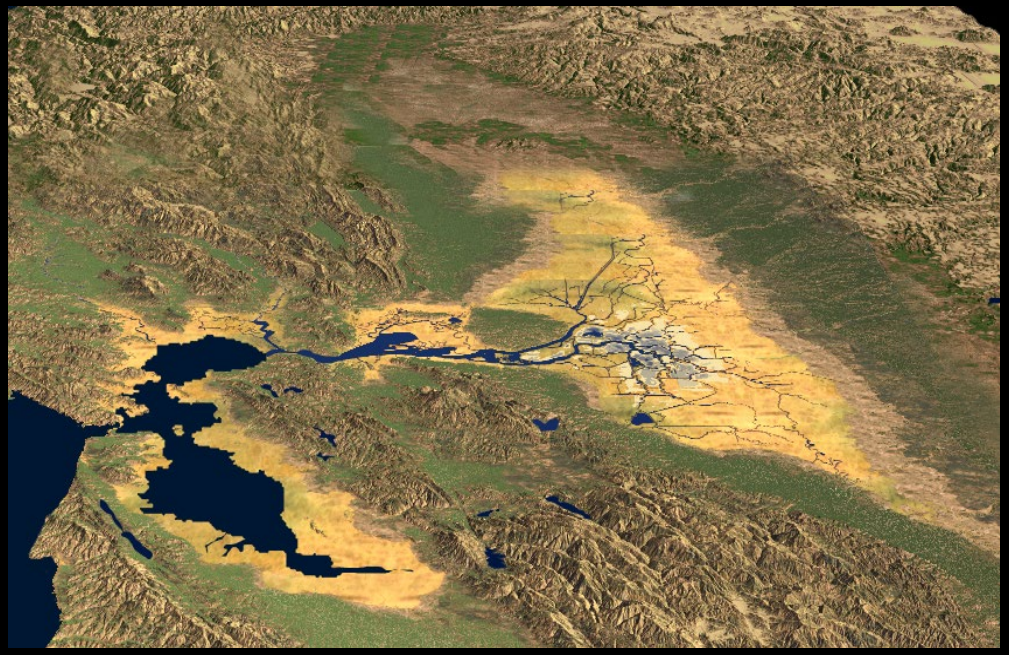


Source: Whipple et al. (2012)

Reconstruction of the Historical Delta: SFEI (2012)



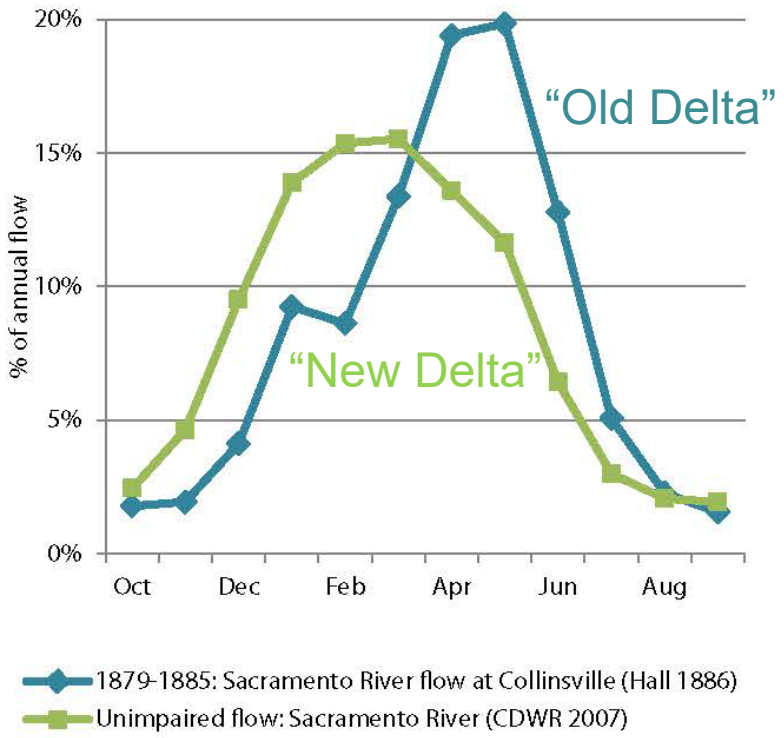
The Modern Estuary:
A Highly Variable and Altered System!



- **Inflow: Seasonal and Annual**
- **Anthropogenic changes**
- **Tidal cycles**
- **Geographic bottlenecks**

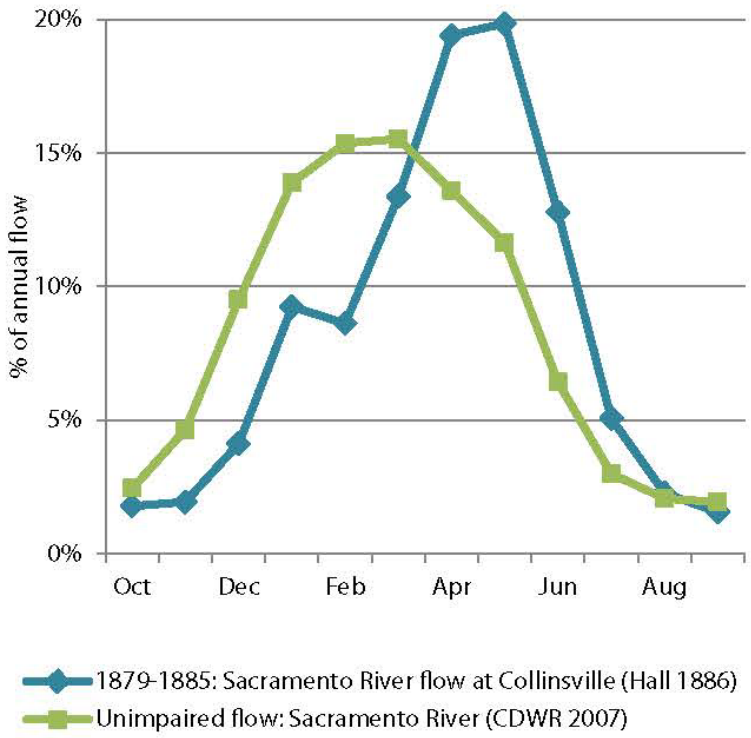
Hydrograph

14 “Buffering” By Historical Landscape?

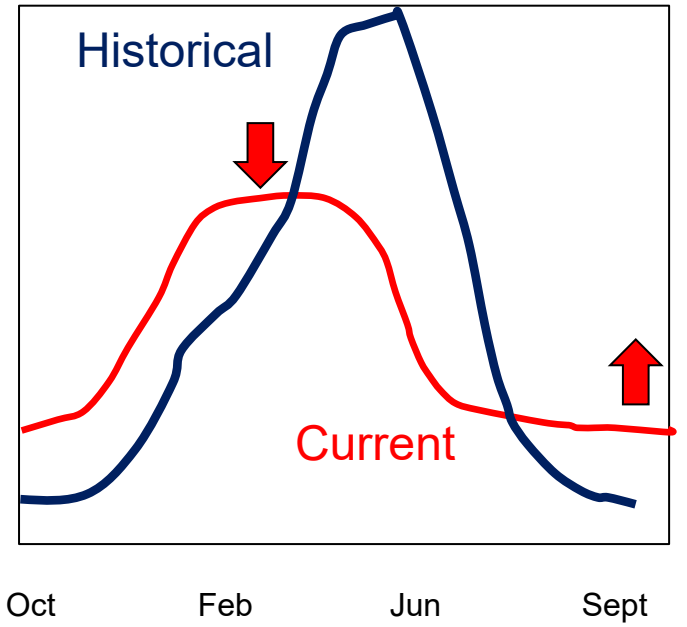


Hydrograph

"Buffering" By Historical Landscape?

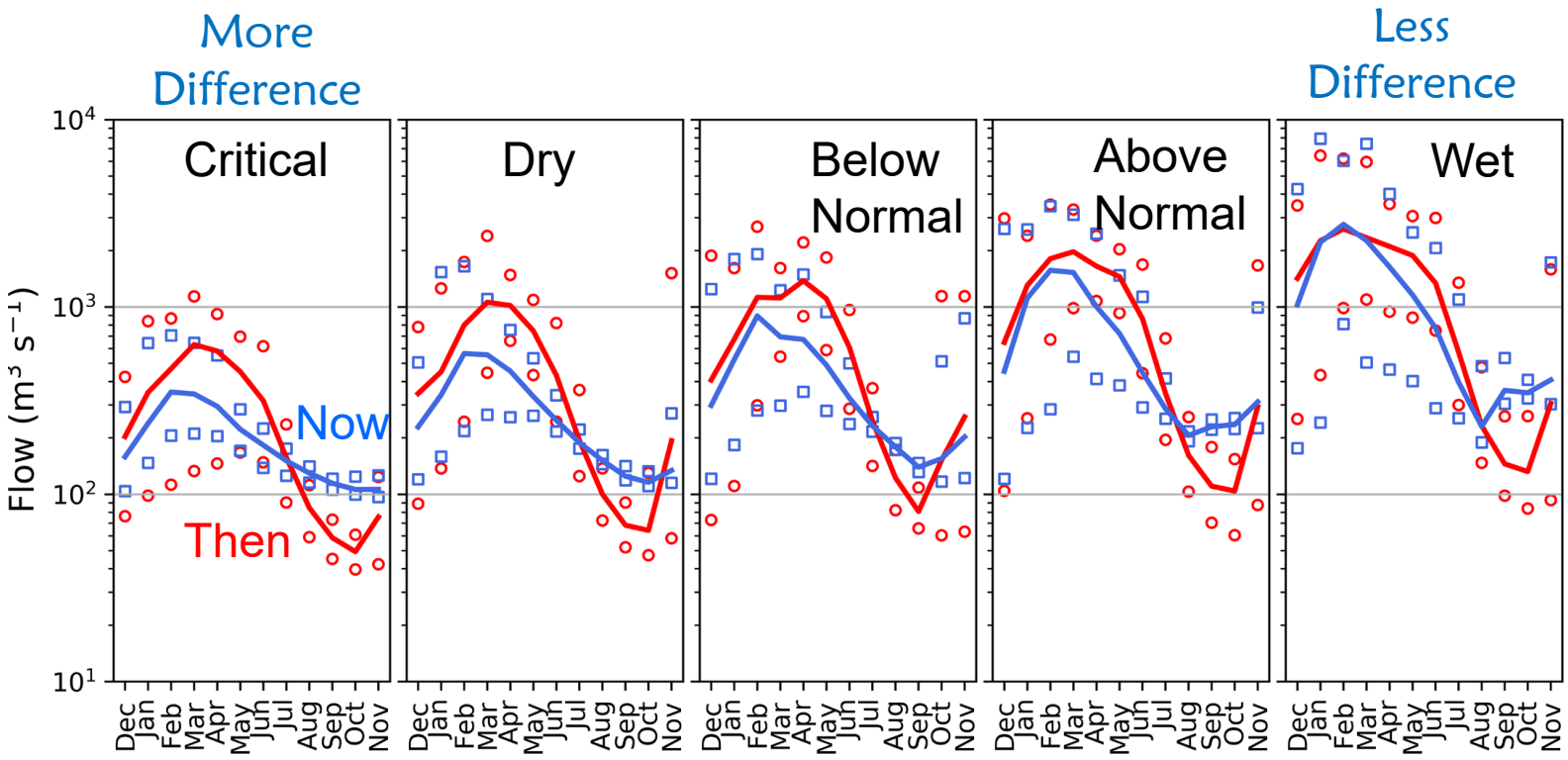


Effect of Reservoirs



Changes Vary Depending on Water Year Type

Modeled Net Effect On Delta Outflow



OCTOBER 2018
SAN FRANCISCO ESTUARY & WATERSHED SCIENCE
RESEARCH

A Comparison of Outflow and Salt Intrusion in the Pre-Development and Contemporary San Francisco Estuary

Edward S. Gross,*[1] Paul H. Hutton,[2] Andrew J. Draper[3]

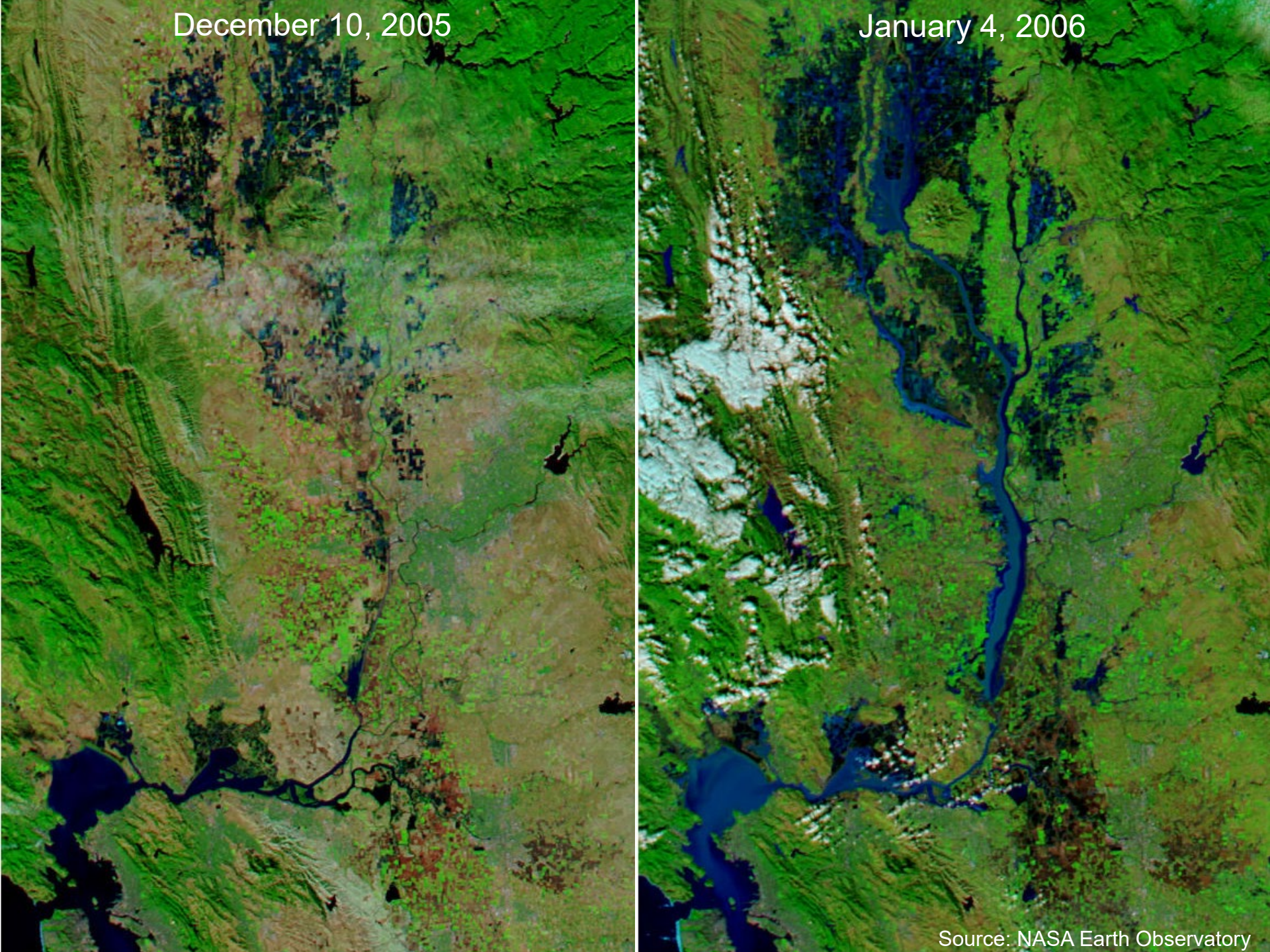
Channelization

THEN

- Highly dendritic
- Lots of microhabitats

NOW

- Designed to convey floods
- Designed to keep Delta fresh
- Great for navigation

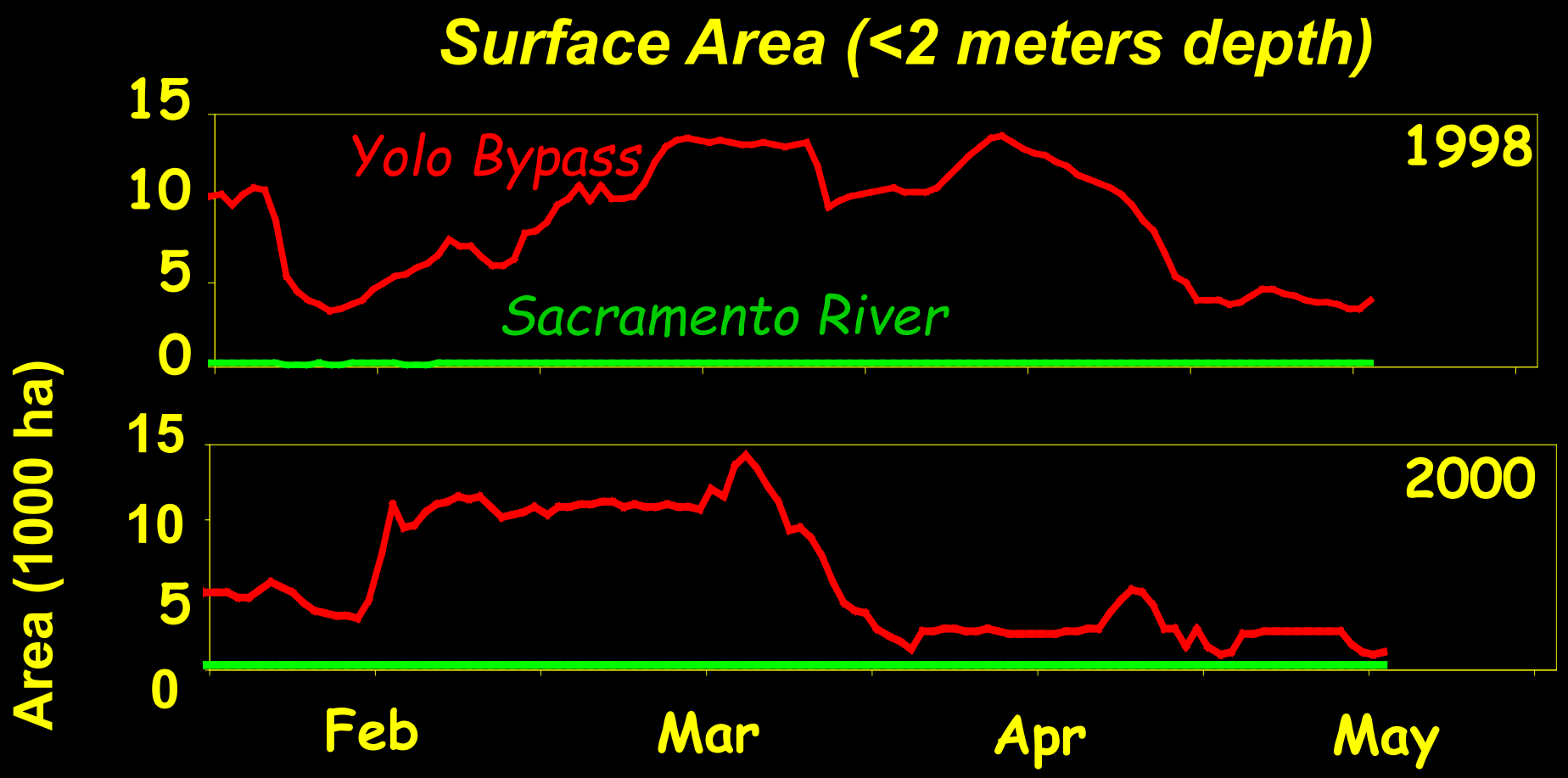

December 10, 2005
January 4, 2006
Source: NASA Earth Observatory

Fremont Weir

Sacramento Weir

Yolo Bypass Hydrologic Inputs


Putah Creek
Cache Creek
Knight's Landing Ridge Cut
Sacramento River



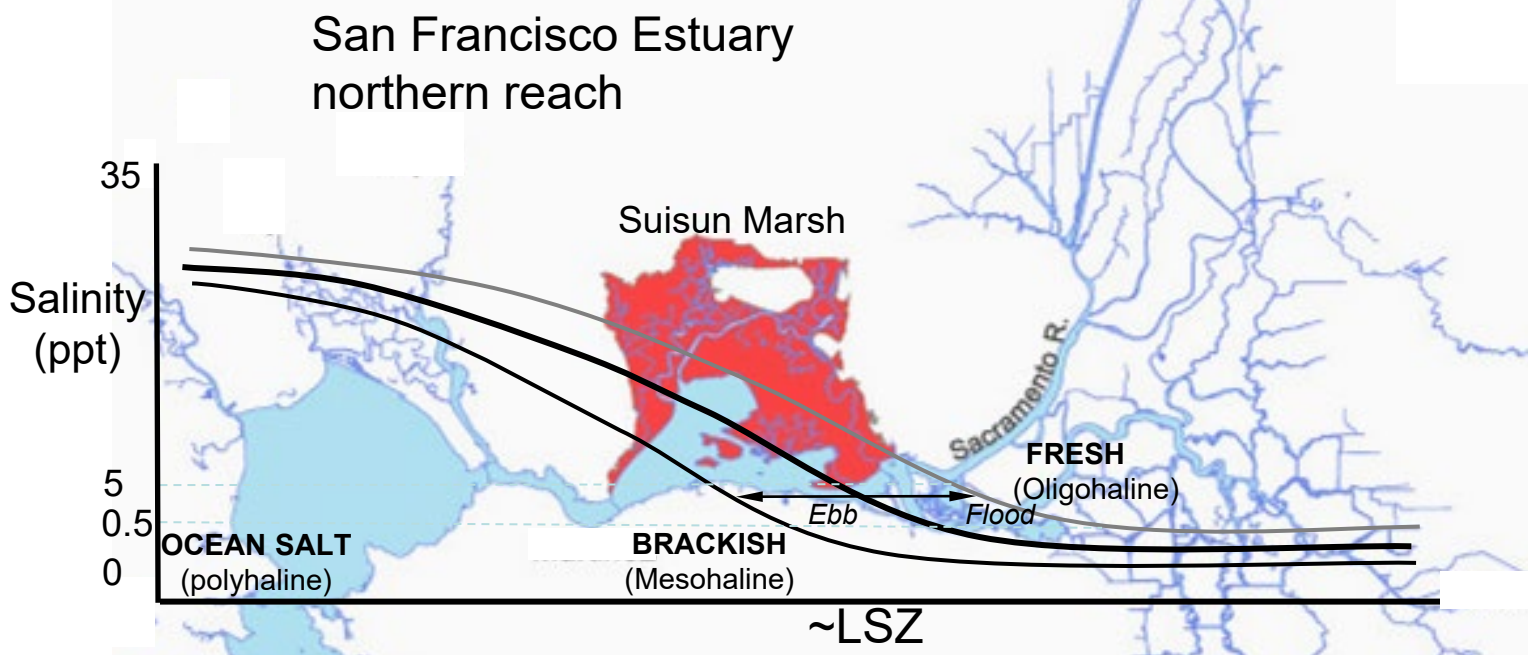
Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA

TED R. SOMMER[a,*], WILLIAM C. HARRELL[a], ANKE MUELLER SOLGER[a], BRAD TOM[a] and WIM KIMMERER[b]

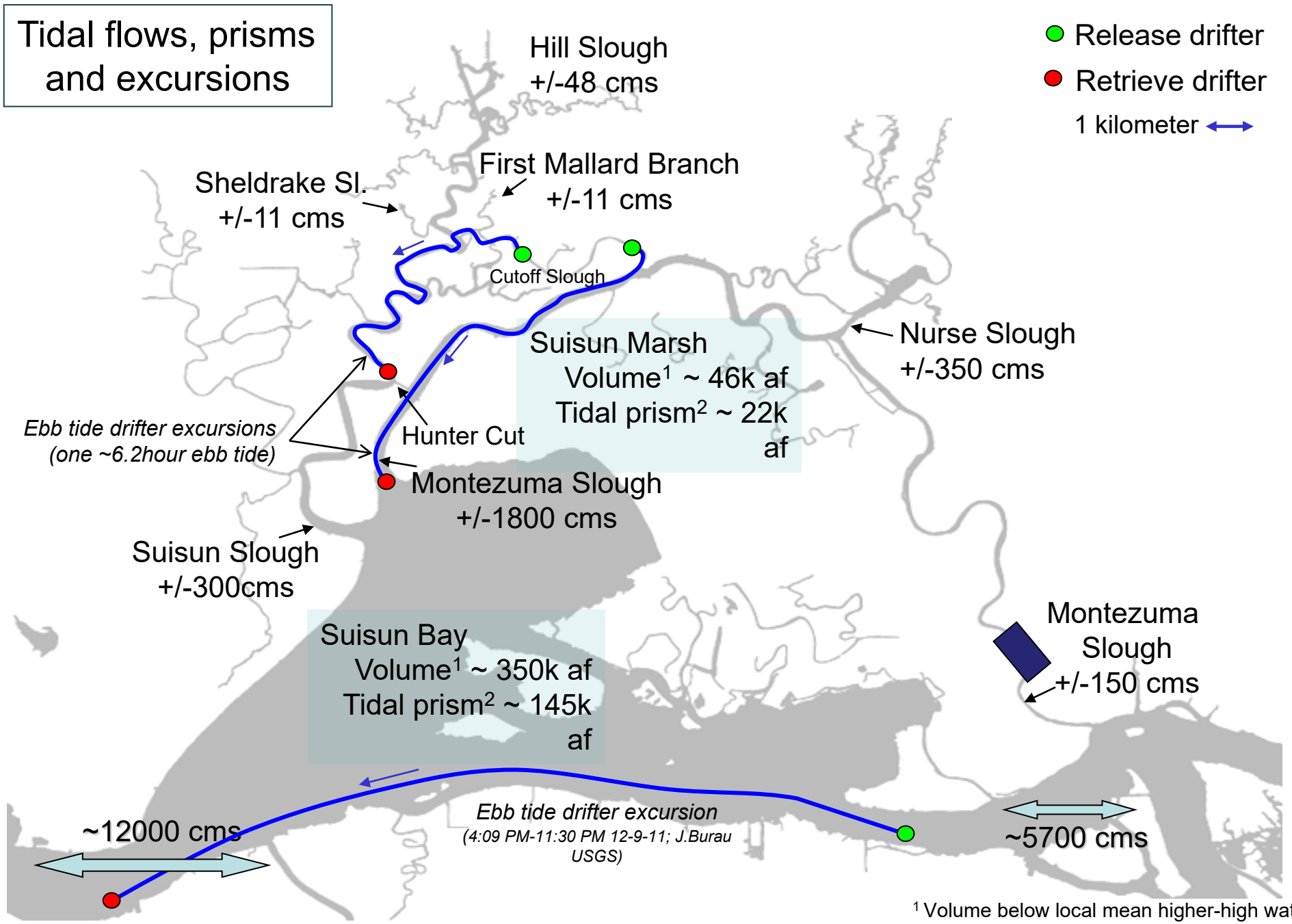
[a] *California Department of Water Resources, Sacramento, CA 95816, U.S.A.*

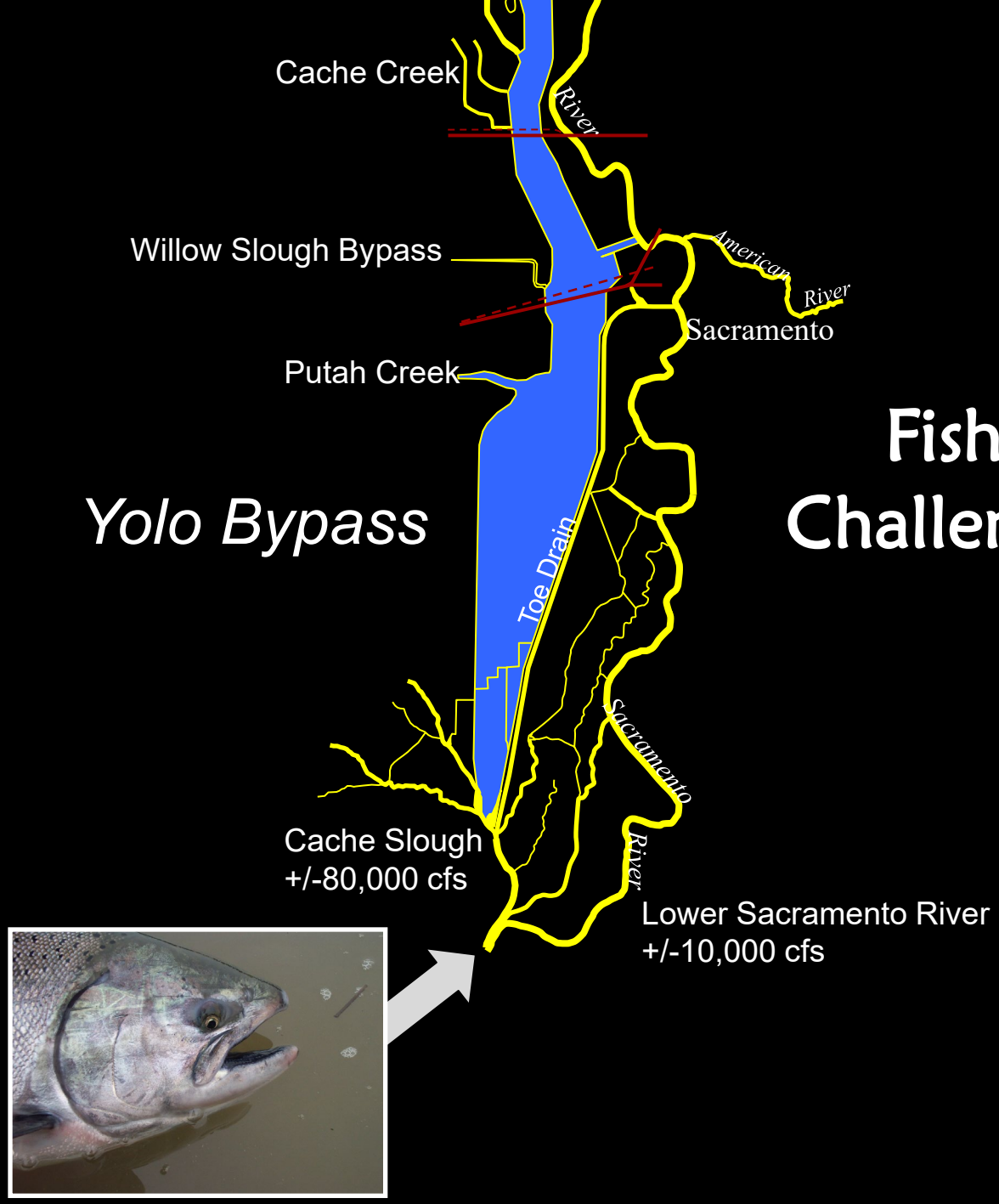
[b] *Romberg Tiburon Center, San Francisco State University, Tiburon CA 94920, U.S.A.*

Tidal Variation in the Estuary



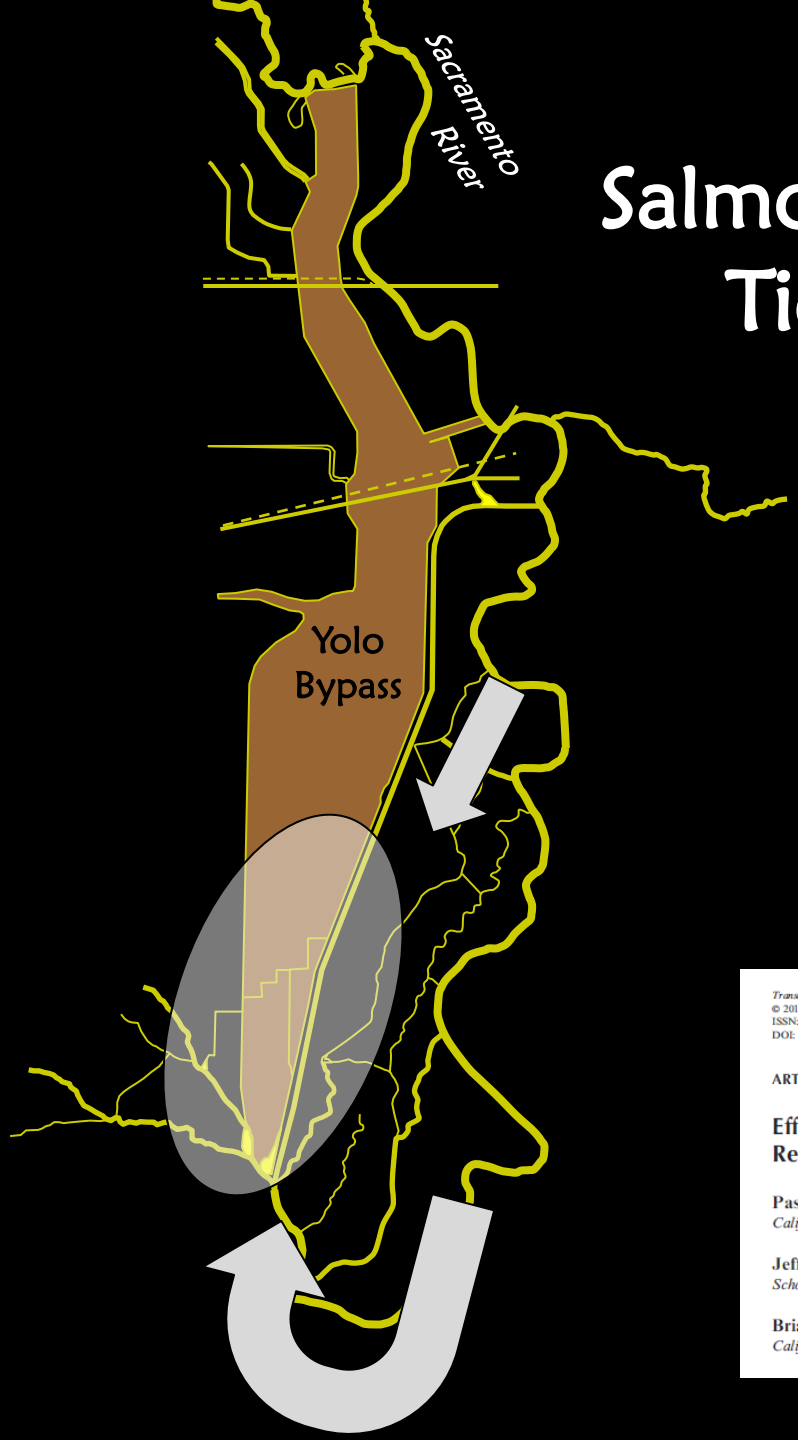
Source: Chris Enright


Tidal flows, prisms and excursions
Release drifter
Retrieve drifter
1 kilometer
Hill Slough
+/-48 cms
First Mallard Branch
+/-11 cms
Sheldrake Sl.
+/-11 cms
Cutoff Slough
Nurse Slough
+/-350 cms
Suisun Marsh
Volume[1] ~ 46k af
Tidal prism[2] ~ 22k af
Ebb tide drifter excursions
(one ~6.2hour ebb tide)
Hunter Cut
Montezuma Slough
+/-1800 cms
Suisun Slough
+/-300cms
Suisun Bay
Volume[1] ~ 350k af
Tidal prism[2] ~ 145k af
Montezuma Slough
+/-150 cms
Ebb tide drifter excursion
(4:09 PM-11:30 PM 12-9-11; J.Burau USGS)
~12000 cms
~5700 cms
[1] Volume below local mean higher-high wate
[2] Tidal prism between MLLW and MHHW



Fish Migration Challenges in a Tidal System

Salmon Use of North Delta Tidal Slough Habitat



Transactions of the American Fisheries Society

ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1002/tafs.10028

ARTICLE

Effects of Extreme Hydrologic Regimes on Juvenile Chinook Salmon Prey Resources and Diet Composition in a Large River Floodplain

Pascale Goertler* and Kristopher Jones
California Department of Water Resources, West Sacramento, California 95691, USA

Jeffery Cordell
School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington 98195, USA

Brian Schreier and Ted Sommer
California Department of Water Resources, West Sacramento, California 95691, USA


X-men


X Files


X-ray


X²

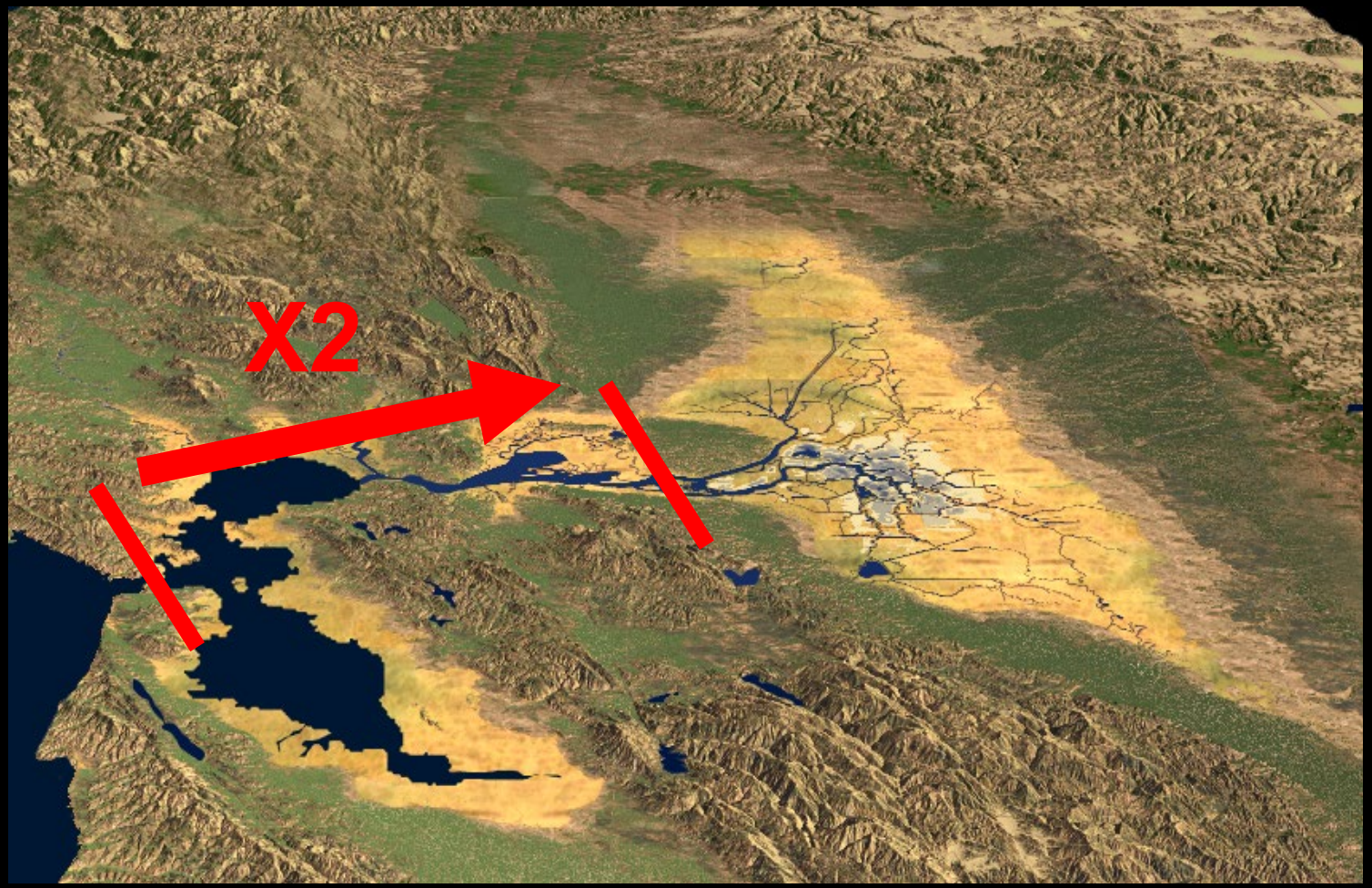

X2?


XMAS

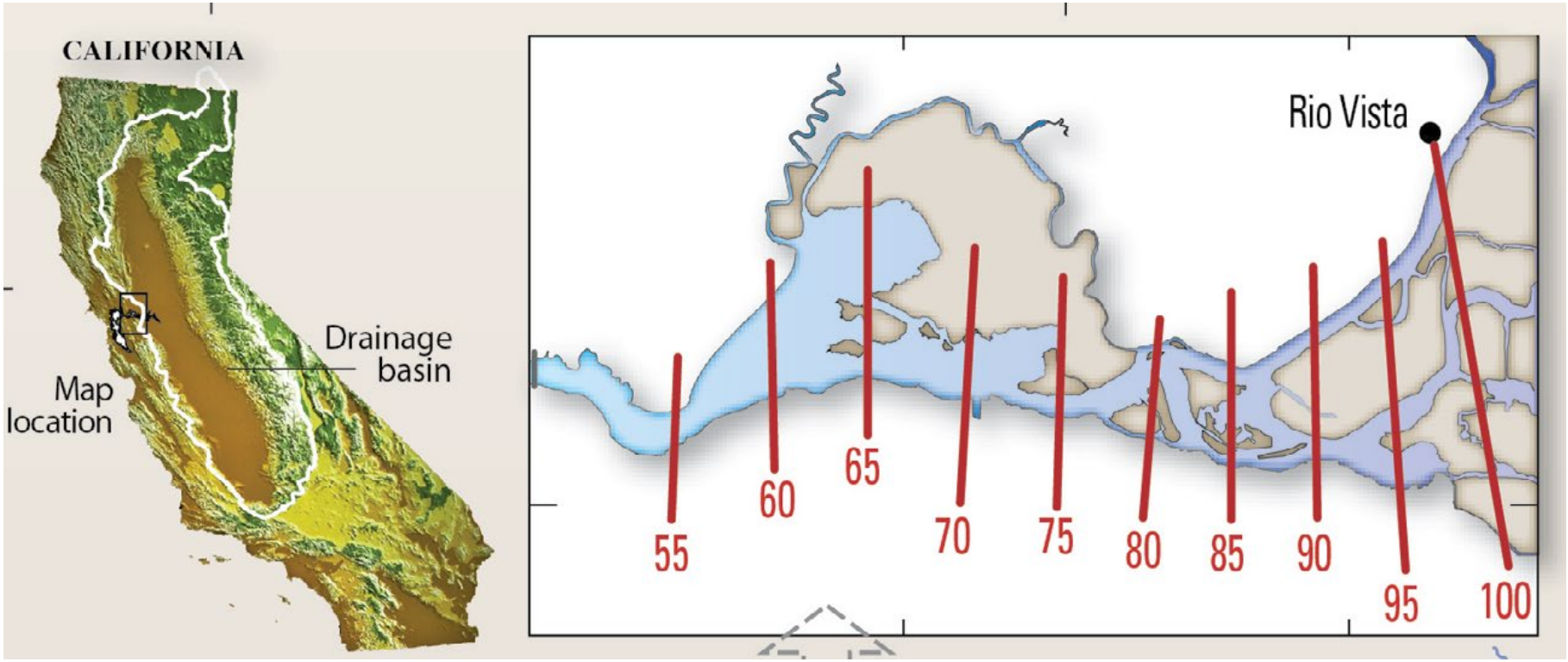
X-WIFE


X-rated

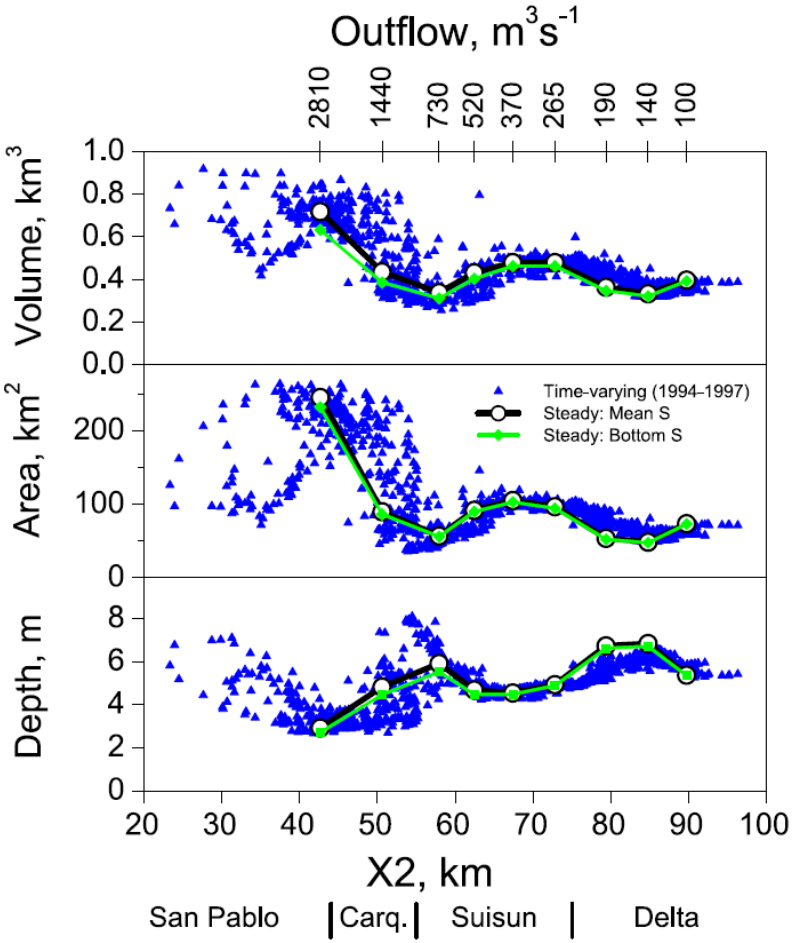
X2 = Distance of 2 ppt salinity from Golden Gate Bridge



Example X2 Values



X2 Affects Habitat Area and Volume



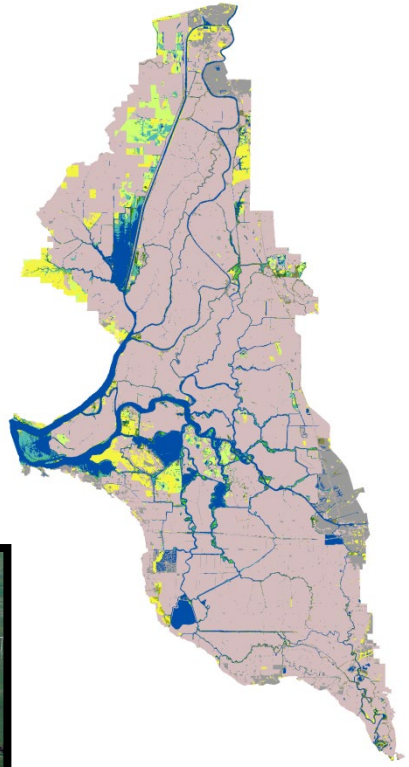
DECEMBER 2013

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Variation of Fish Habitat and Extent of the Low-Salinity Zone with Freshwater Flow in the San Francisco Estuary

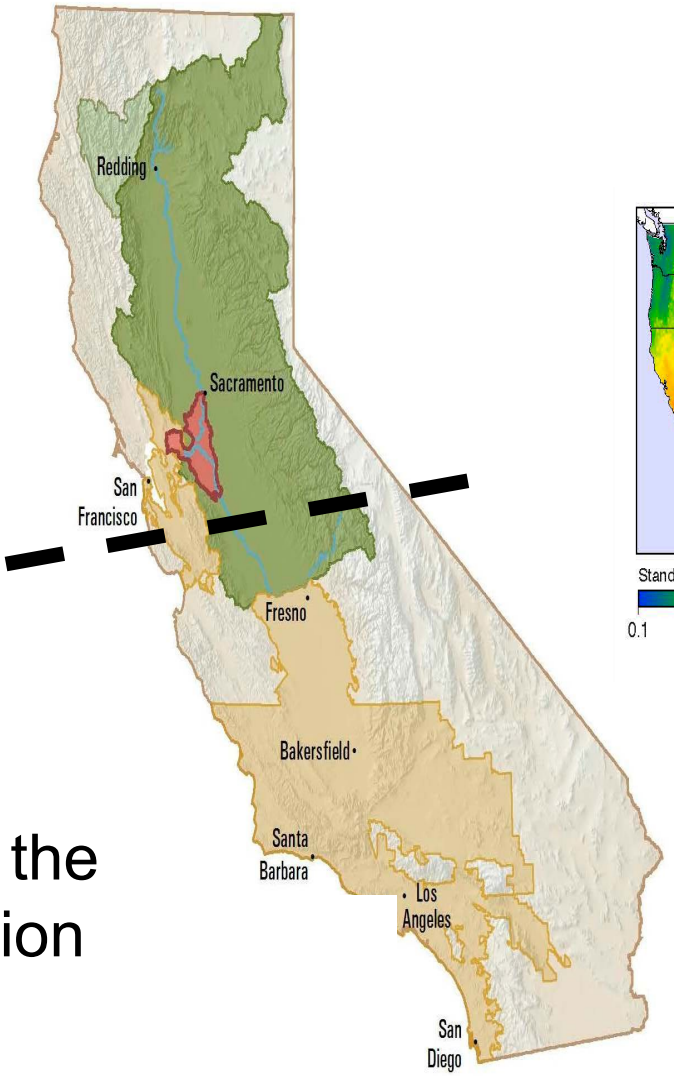
Wim J. Kimmerer*, Michael L. MacWilliams[1], and Edward S. Gross[2]

Water Distribution System: Components and Effects



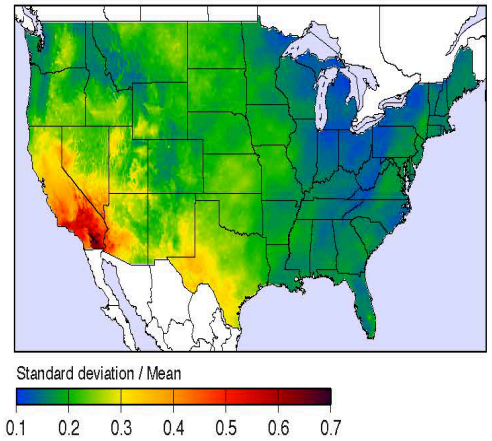
The Big Issue: Water Supply

Most Precipitation



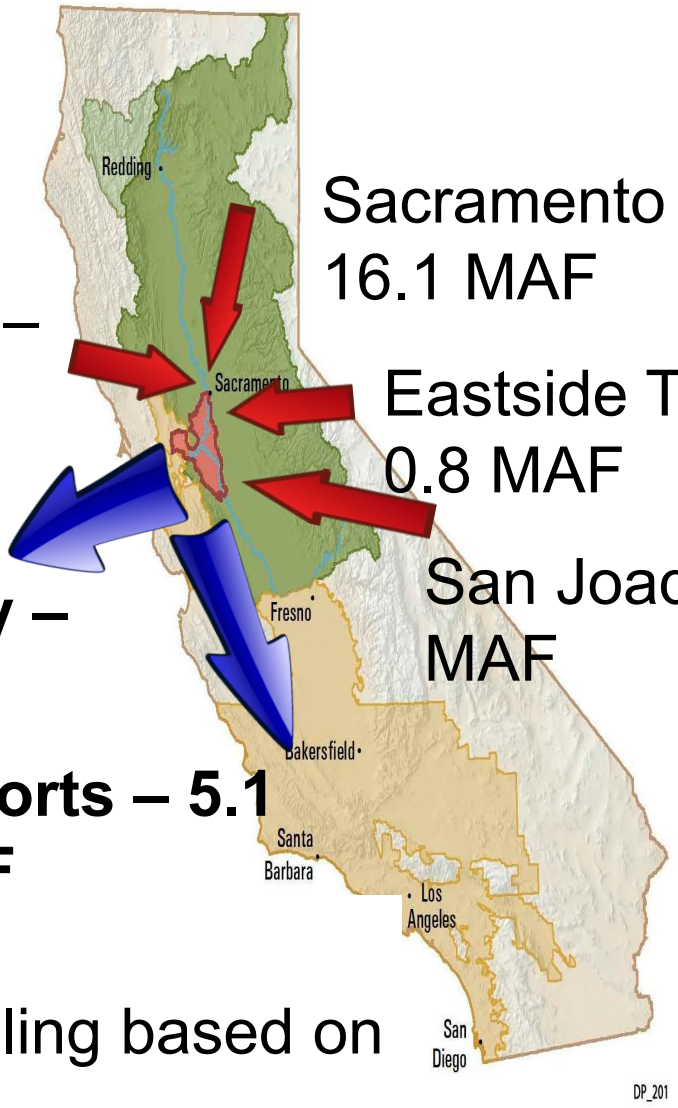
Most of the Population

Precipitation Variability



Source: Dettinger et al. 2016; Figure 1

Hydrology – Sources and Outputs



Sacramento River – 16.1 MAF

Yolo Bypass – 1.8 MAF

Eastside Tributaries – 0.8 MAF

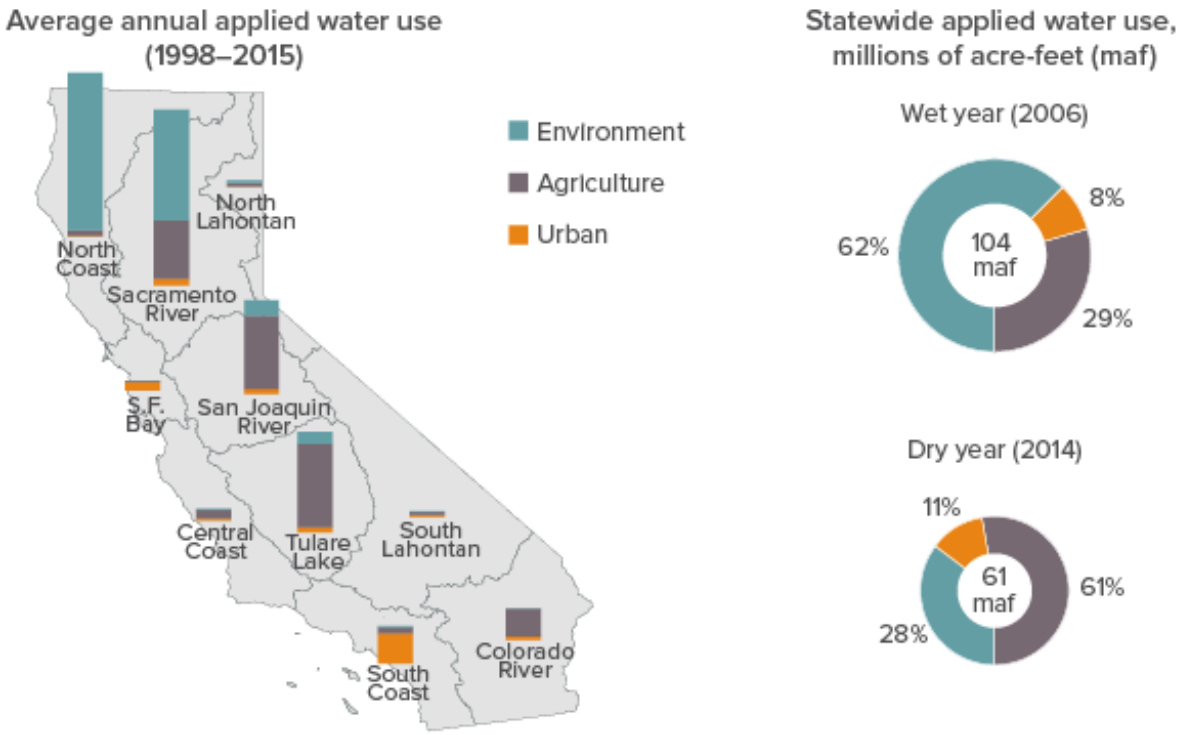
San Joaquin River – 3.1 MAF

Outflow to Bay – 15.8 MAF

Exports – 5.1 MAF

Source: Long term modeling based on CALSIM (DWR 2010)

How is Water Used?



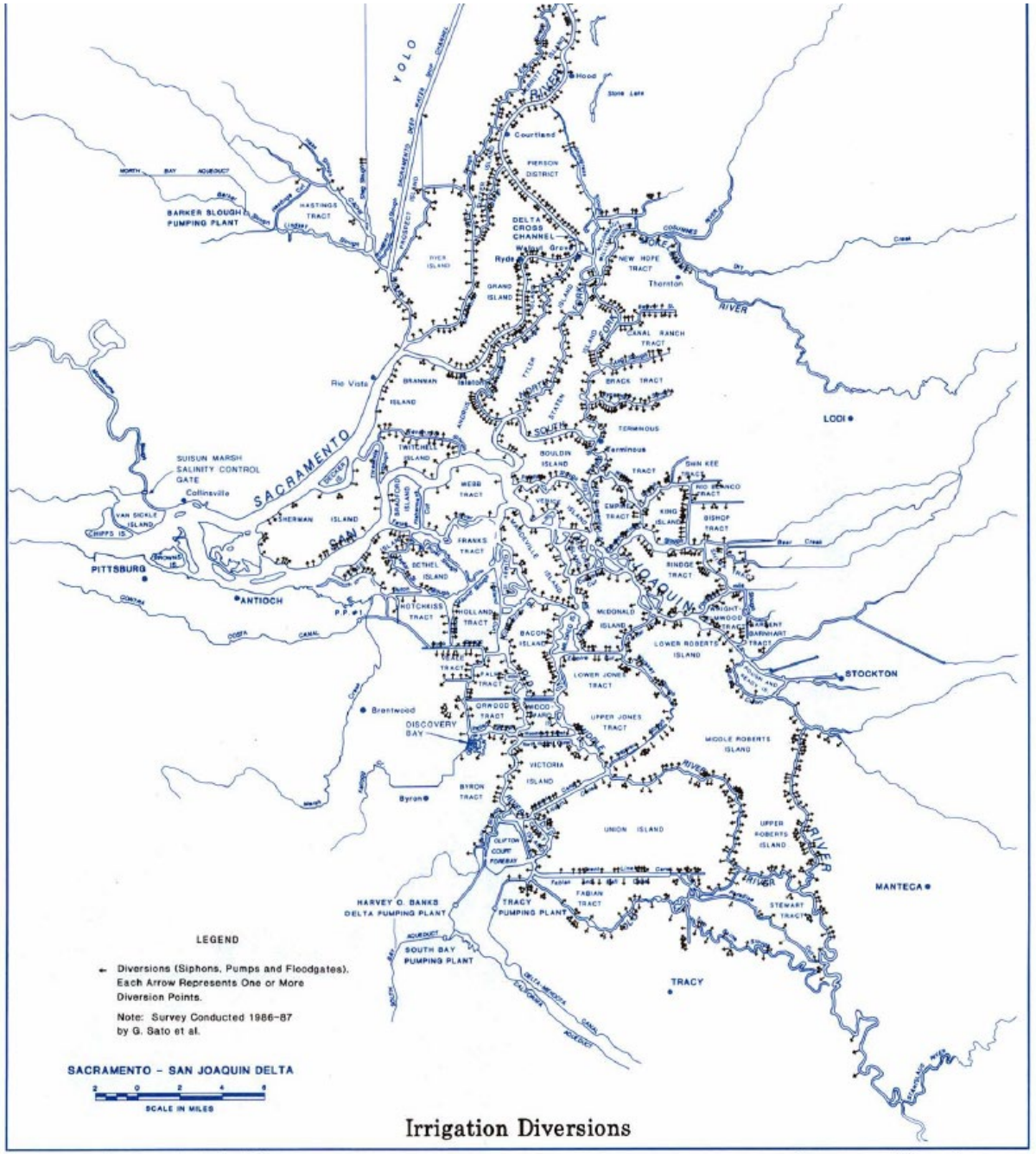
https://www.ppic.org/publication/water-use-in-california/

How We Move Water

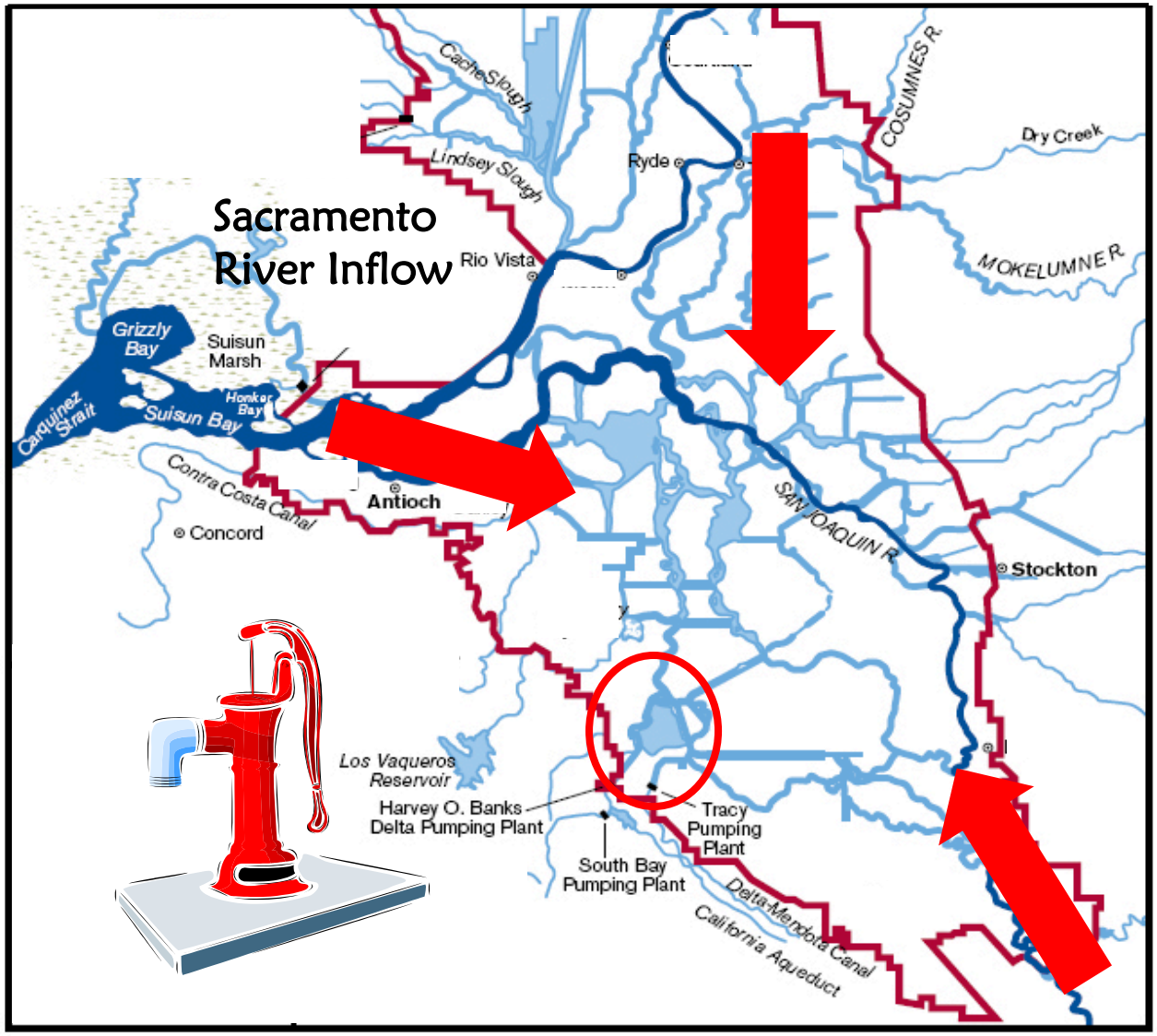
Moving and Storing California's Water, Figure 3-2

DP 350

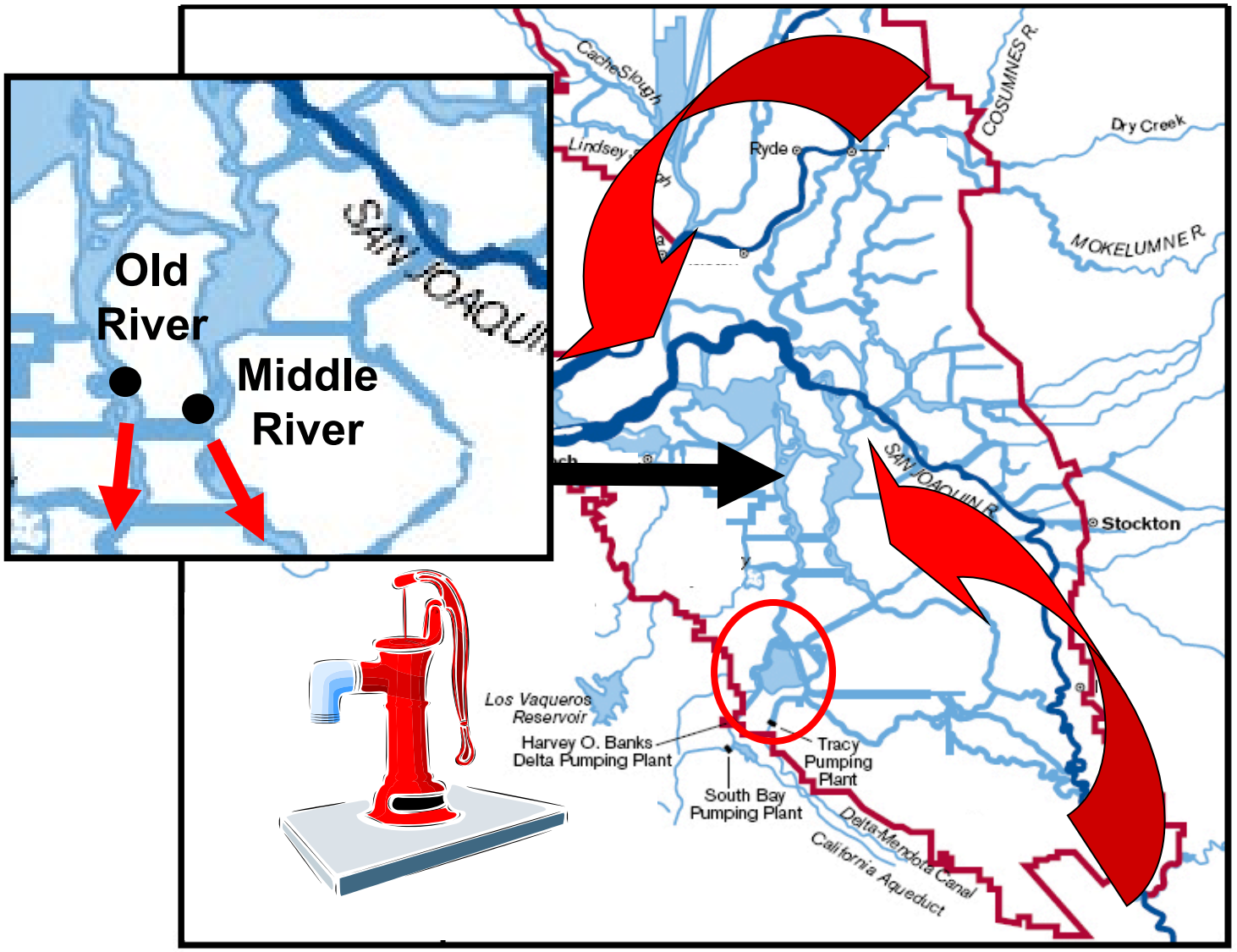
Thousands of Diversions



A Simple Model To Understand Hydrodynamics in the Central Delta



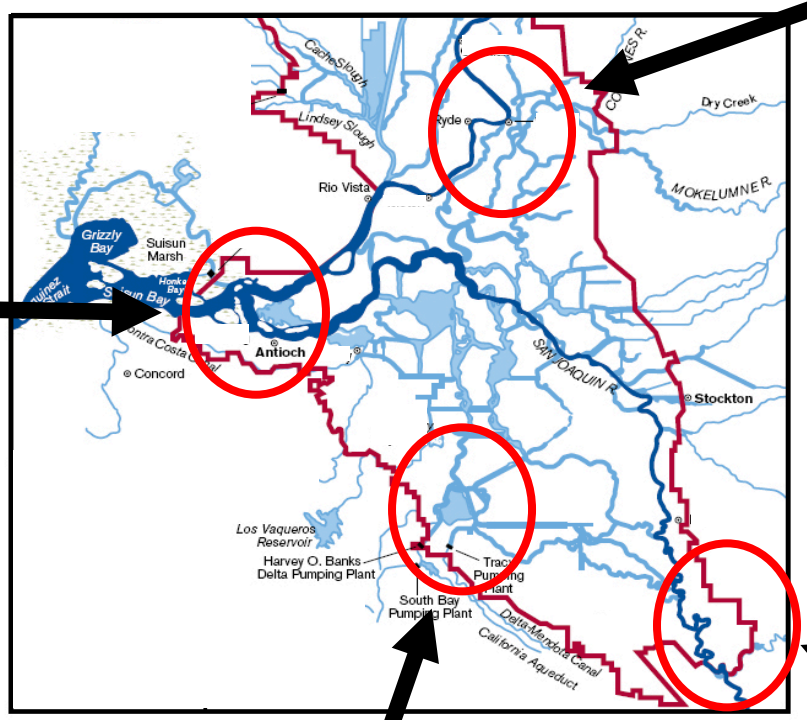
Old and Middle Rivers as an Integrator of Hydrodynamic Effects – OMR



Implications

Why We Have the Delta Cross Channel

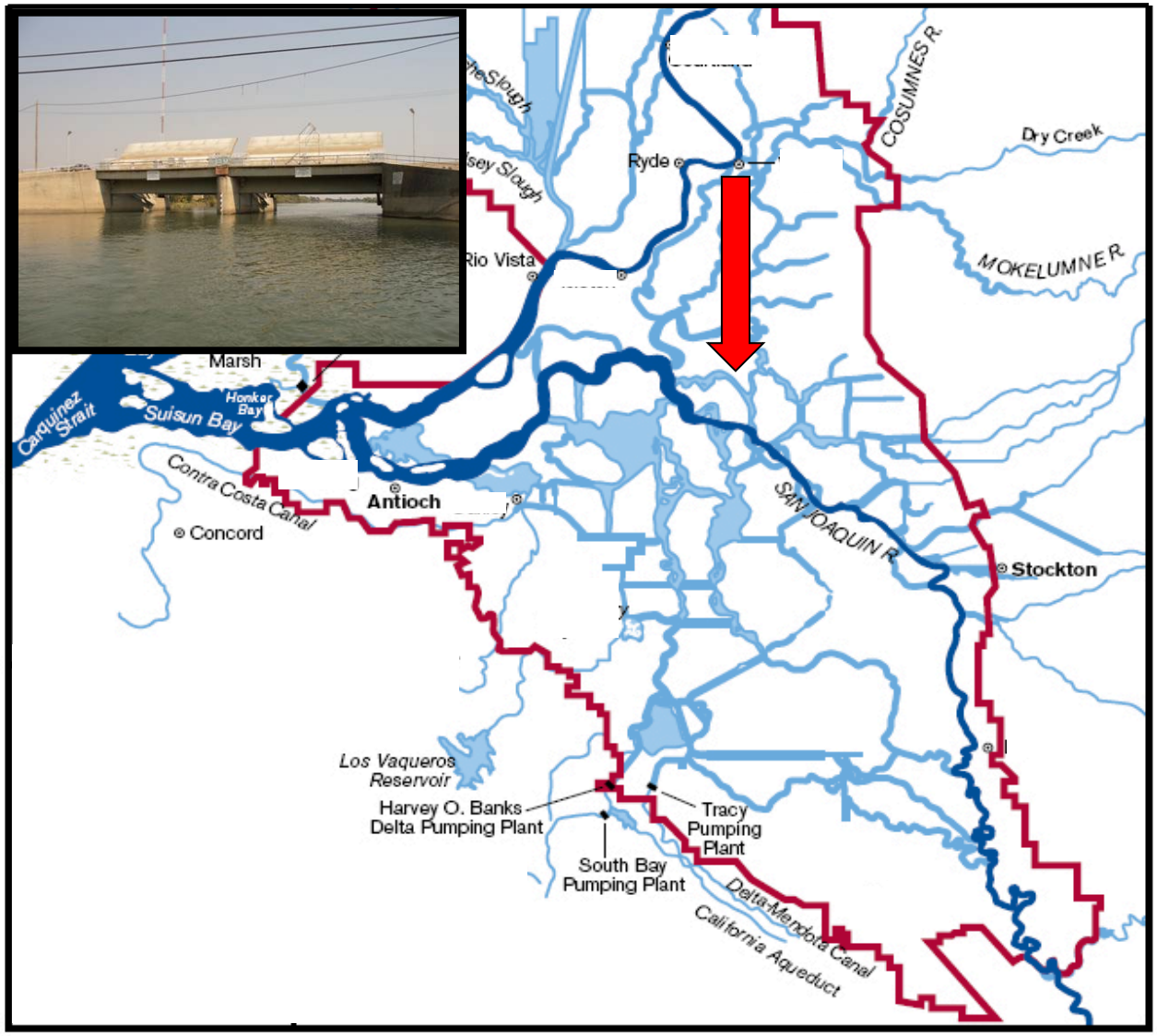
Why Net Flows Can Reverse Here



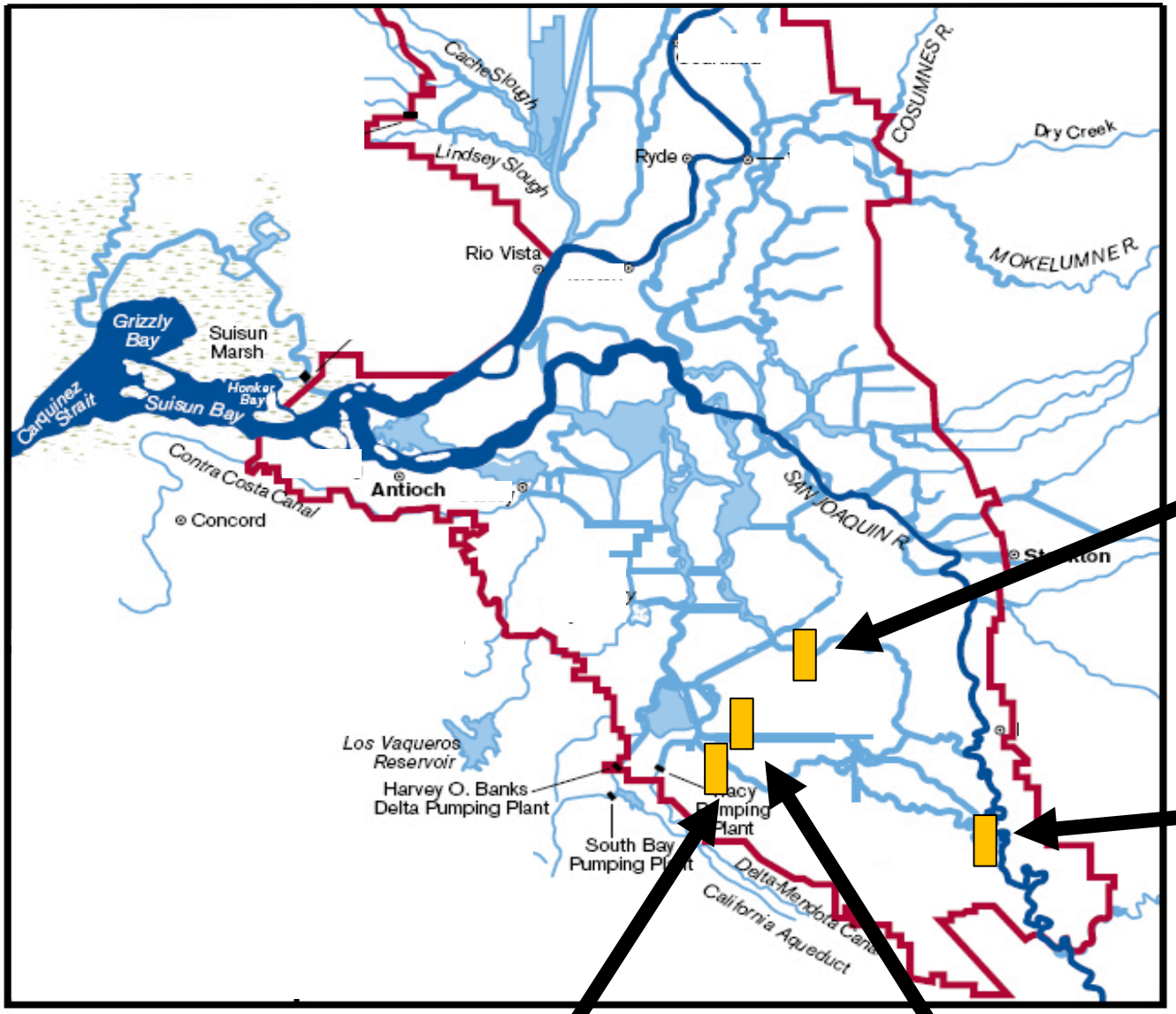
Why The Effects of Exports are so Complicated

Why San Joaquin River Inflow is a Big Deal

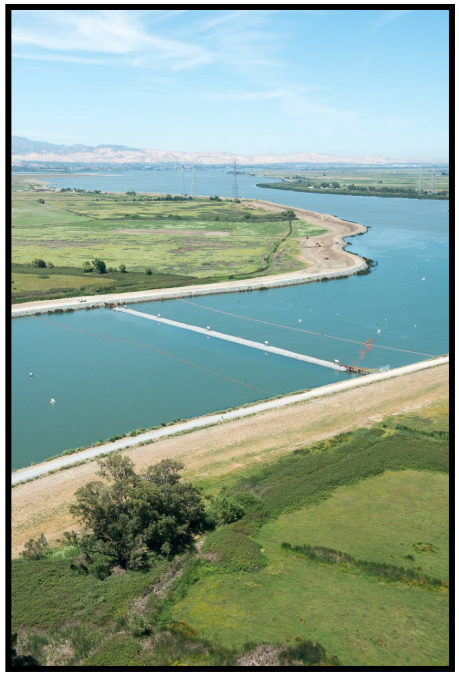
Delta Cross Channel



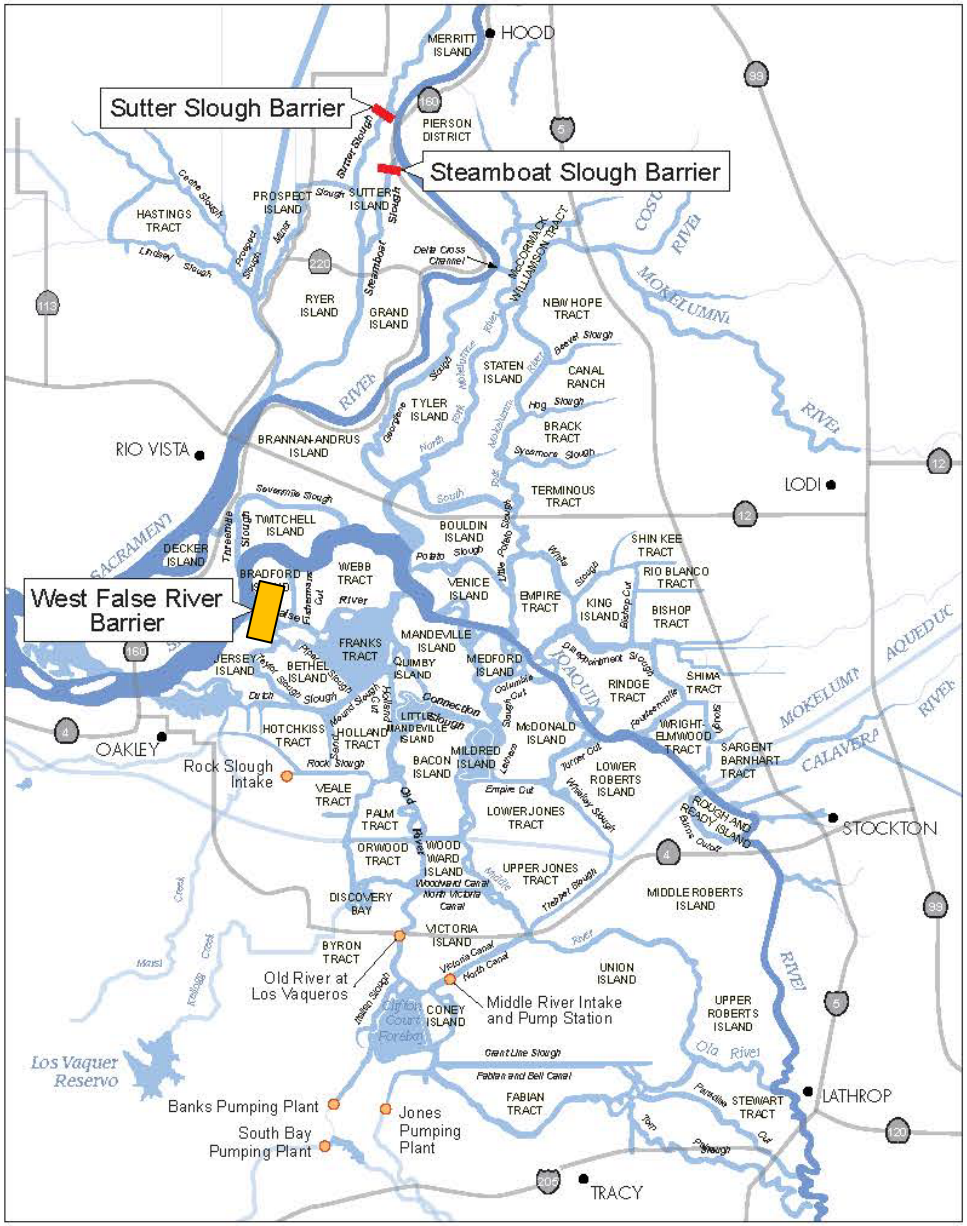
South Delta Barriers



Drought Barriers



Potential Barrier Locations on Sutter Slough Steamboat Slough and West False River



Going, Going, Gone…

San Francisco Bay Conservation and Development Commission

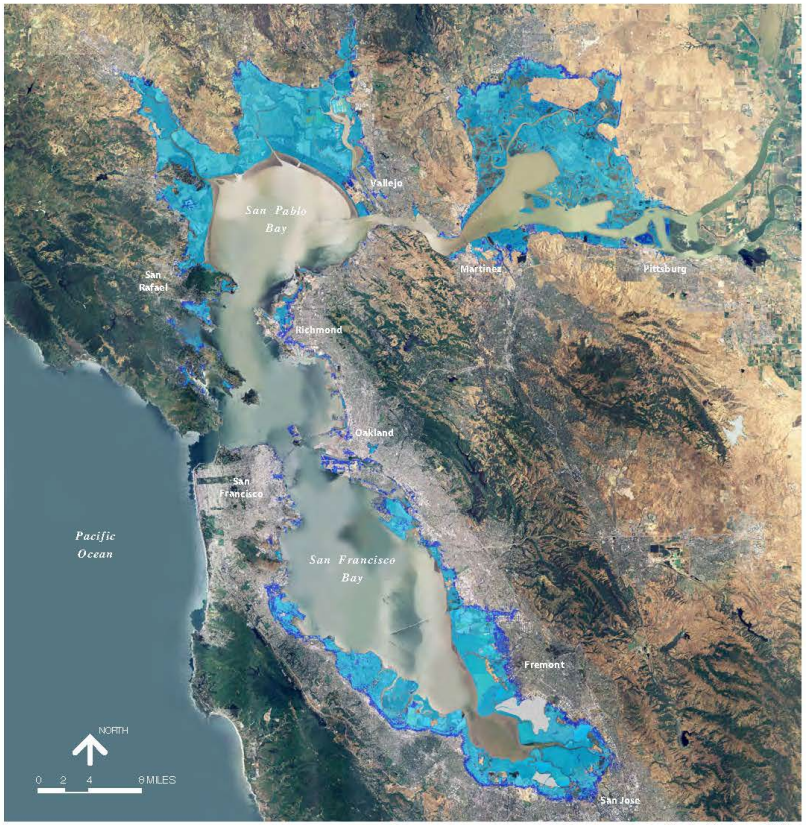
Area potentially exposed to an approximate 16-inch sea level rise

Area potentially exposed to an approximate 55-inch sea level rise

No data

San Francisco Bay Area Shoreline Areas Potentially Exposed To Sea Level Rise

DISCLAIMER: *The inundation data used in these maps do not account for shoreline protection or wave activity. These maps are for informational purposes only. Users agree to hold harmless and blameless the State of California and its representatives and its agents for any liability associated with the use of the maps. The maps and data shall not be used to assess actual coastal hazards, insurance requirements, or property values or be used in lieu of Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).*



Sea level rise data provided by: USGS science for a changing world

SOURCE: Knowles, N. 2008. Siegel, S.W. and P. A. M. Bachand, 2002.

Heavily Subsided Lands

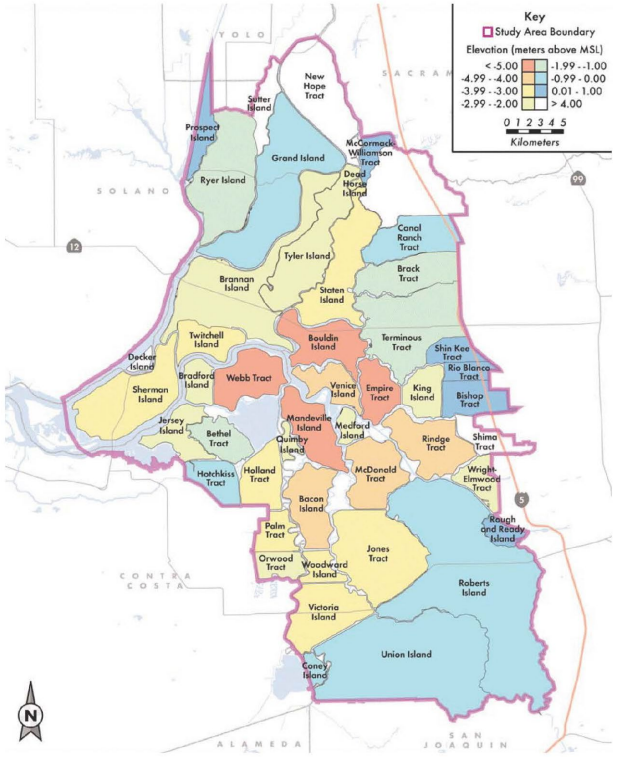


Figure 2 Map of average island elevations throughout the Sacramento–San Joaquin Delta. Source: Mount and Twiss 2005.

Sea Level Rise

(Plus Earthquakes & Floods!)

High Annual Risk of Levee Failure

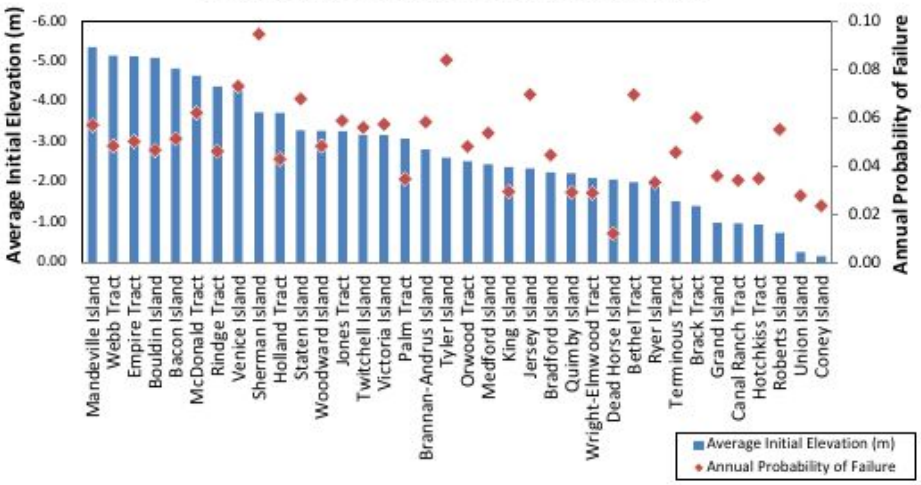


Figure 1 Independent annual probabilities of levee failure and average elevations relative to mean sea level for modeled Sacramento–San Joaquin Delta islands (probability data from URS 2009a; elevation data from Mount and Twiss 2005).

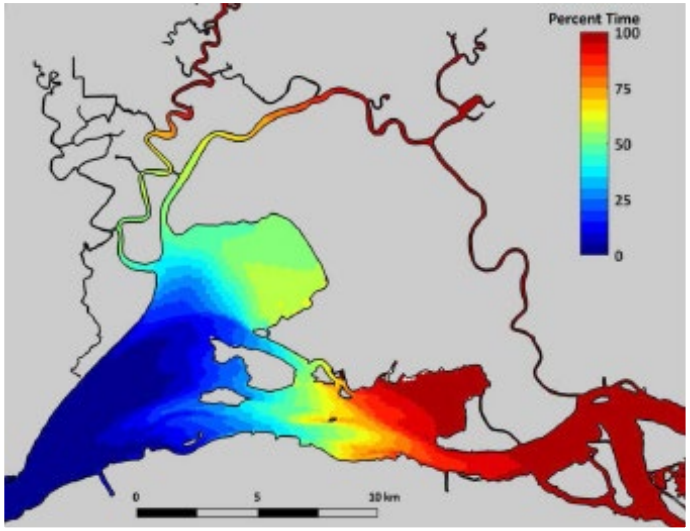
Effect of Hydrology on Regulations

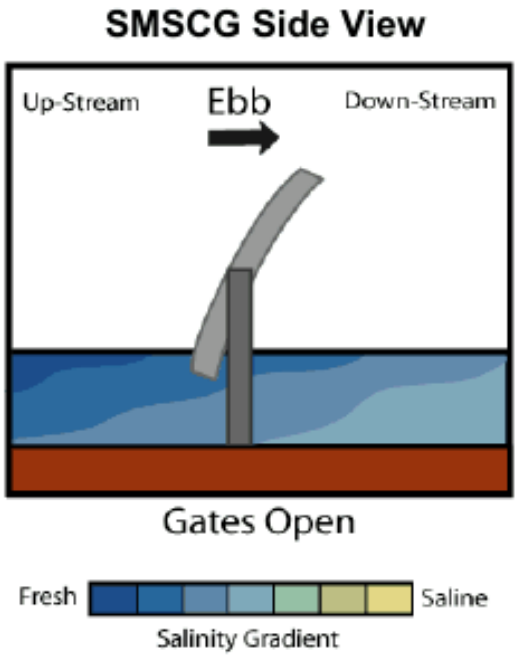
1) Habitat – Floodplain, Tidal Wetlands
2) X2 Standards
3) Delta Cross Channel Operations
4) Old and Middle Rivers
5) Exports
6) Suisun Marsh Salinity Control Gates
7) South Delta Barriers

Extra Slides

Suisun Marsh Salinity Control Gates

Typically operated in fall to freshen marsh





Other Stuff You Should Know……Models!

- Hydrology – Basic flow patterns
  - *DAYFLOW* - Historical monthly
  - *CALSIM* - Monthly model
- Hydrodynamics – Salinity, velocity
  - *DSM2* – 1D DWR model
  - *UnTrim* – 3D
- Particle tracking – Uses above models to look at transport.
  - *DSM PTM*