DWR-1383

Ecosystem Changes to the Bay-Delta Estuary: A Technical Assessment of Available Scientific Information

State Water Resources Control Board

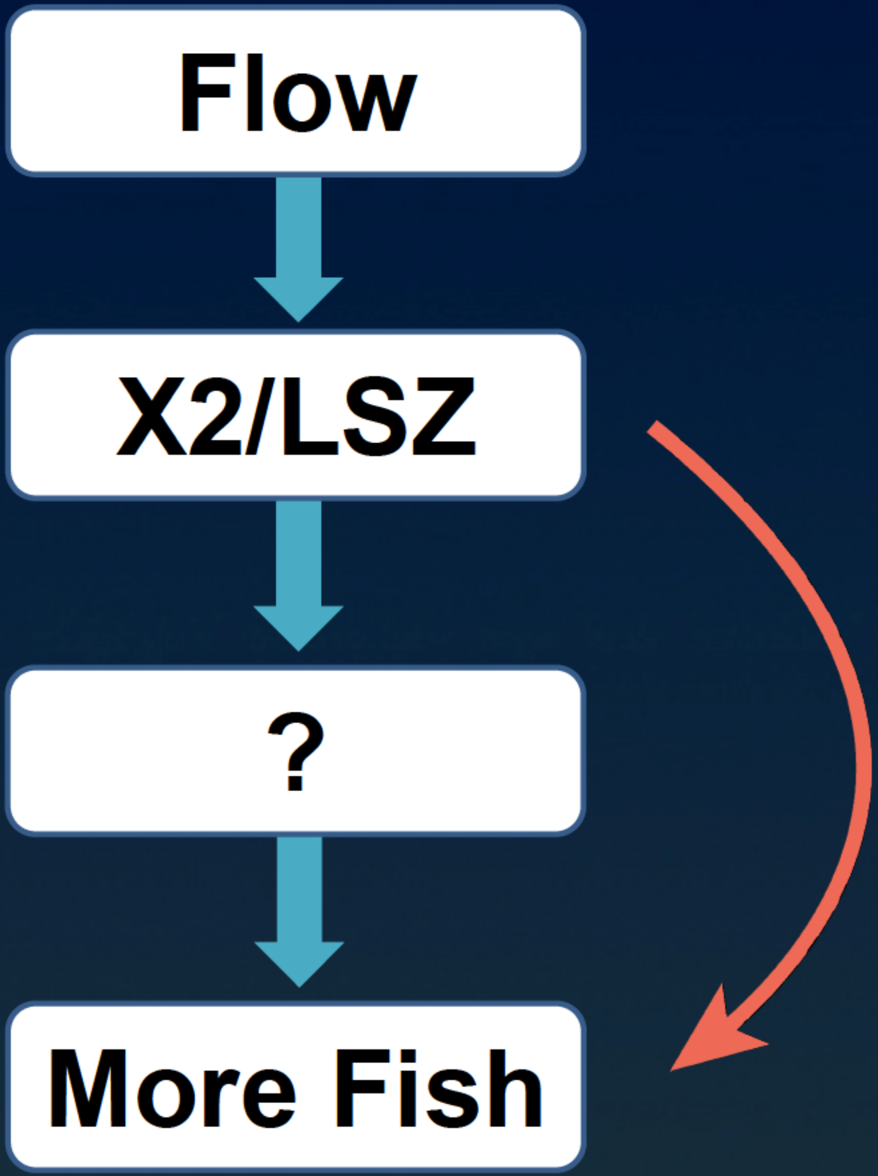
Phase II Comprehensive Review of the Bay-Delta Plan

Workshop 1: Ecosystem Changes and Low-Salinity Zone

September 6, 2012

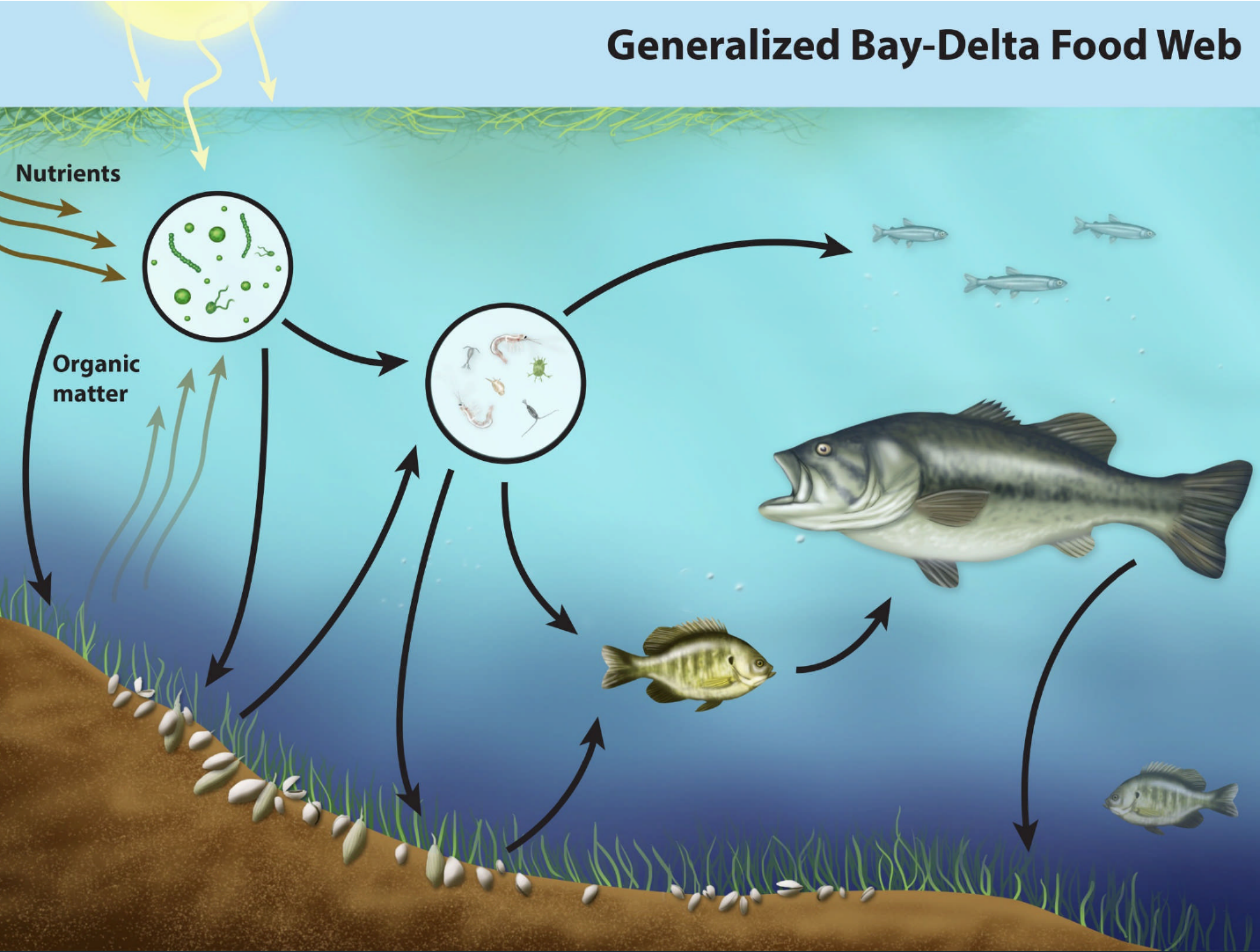
Submitted by: State Water Contractors, Inc.
San Luis & Delta-Mendota Water Authority

Bay-Delta Model?



"Although increases in quantity of habitat may contribute, the mechanism chiefly responsible for the X2 relationship for longfin smelt remains unknown."

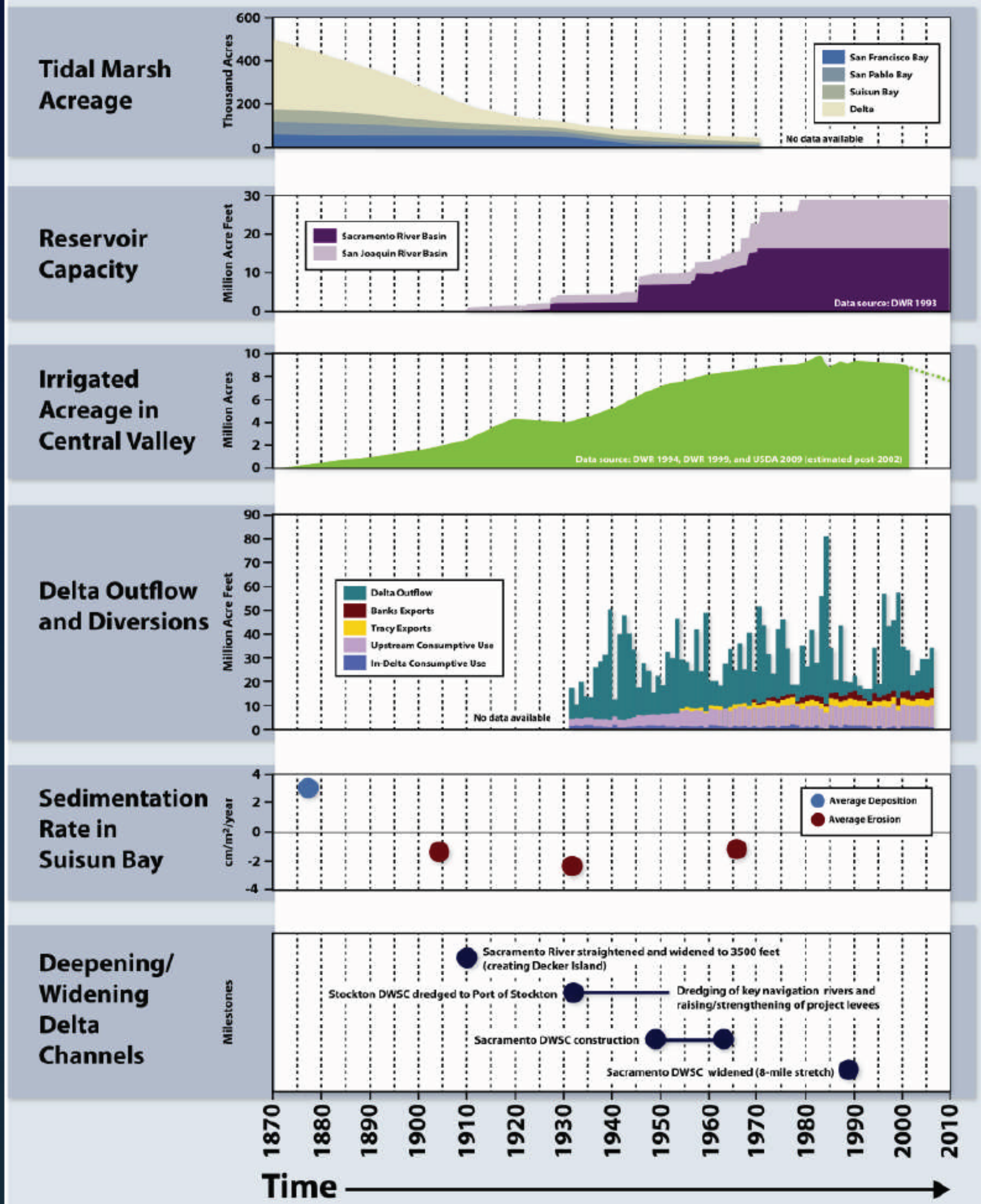
Kimmerer (2009)


Generalized Bay-Delta Food Web
Nutrients
Organic
matter

Investigating Ecosystem Changes

- Physical
- Biological
- Chemical

Delta Timeline

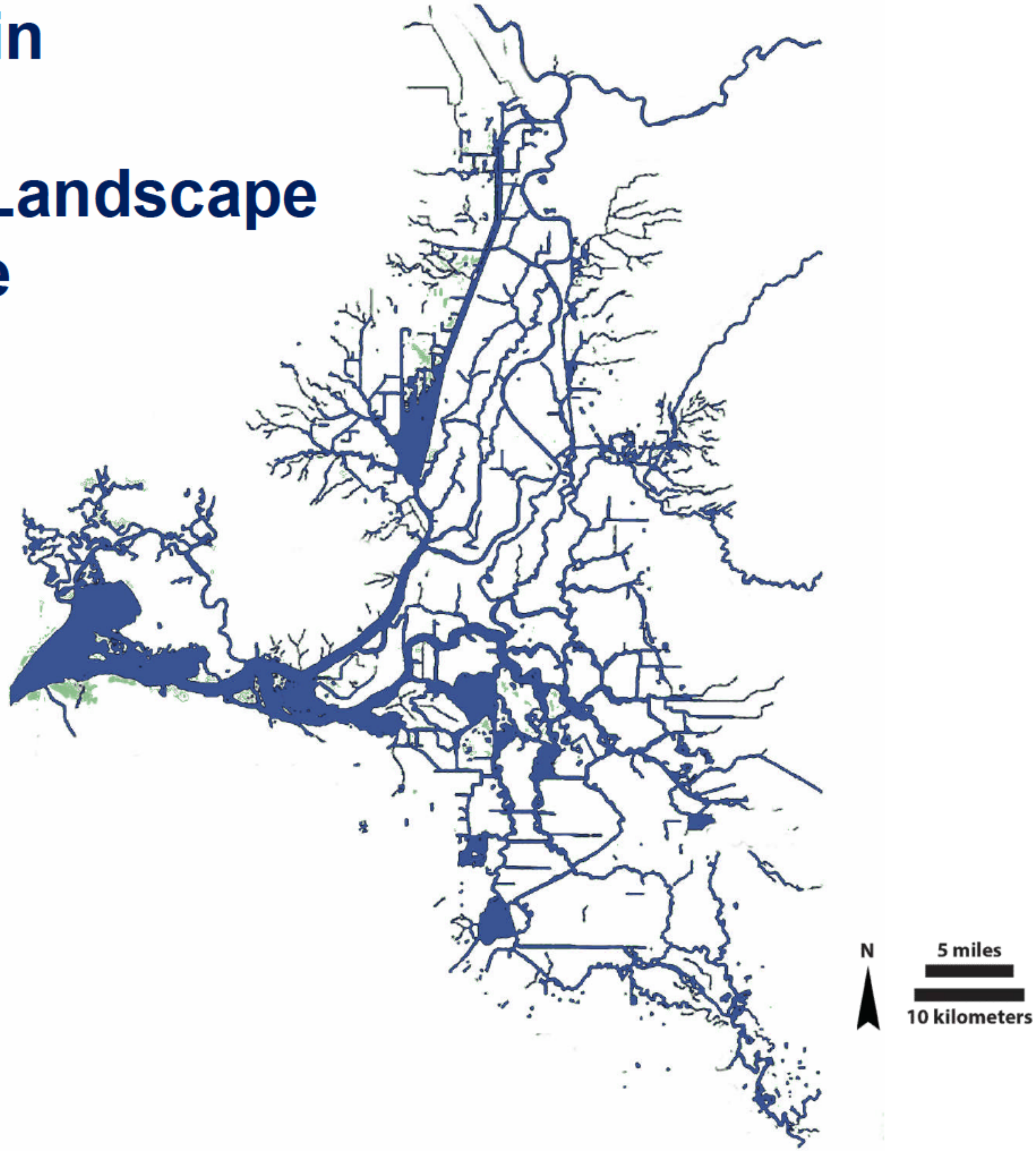


Delta outflow

Exports

Consumptive use

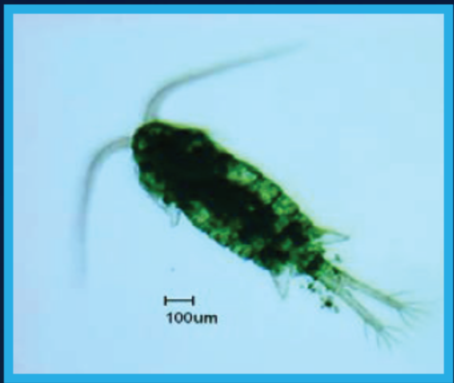
Changes in Bay-Delta Physical Landscape Over Time



- Waterways
- Tidal Wetlands

Bay-Delta Ecosystem Changes

1980 - 2011



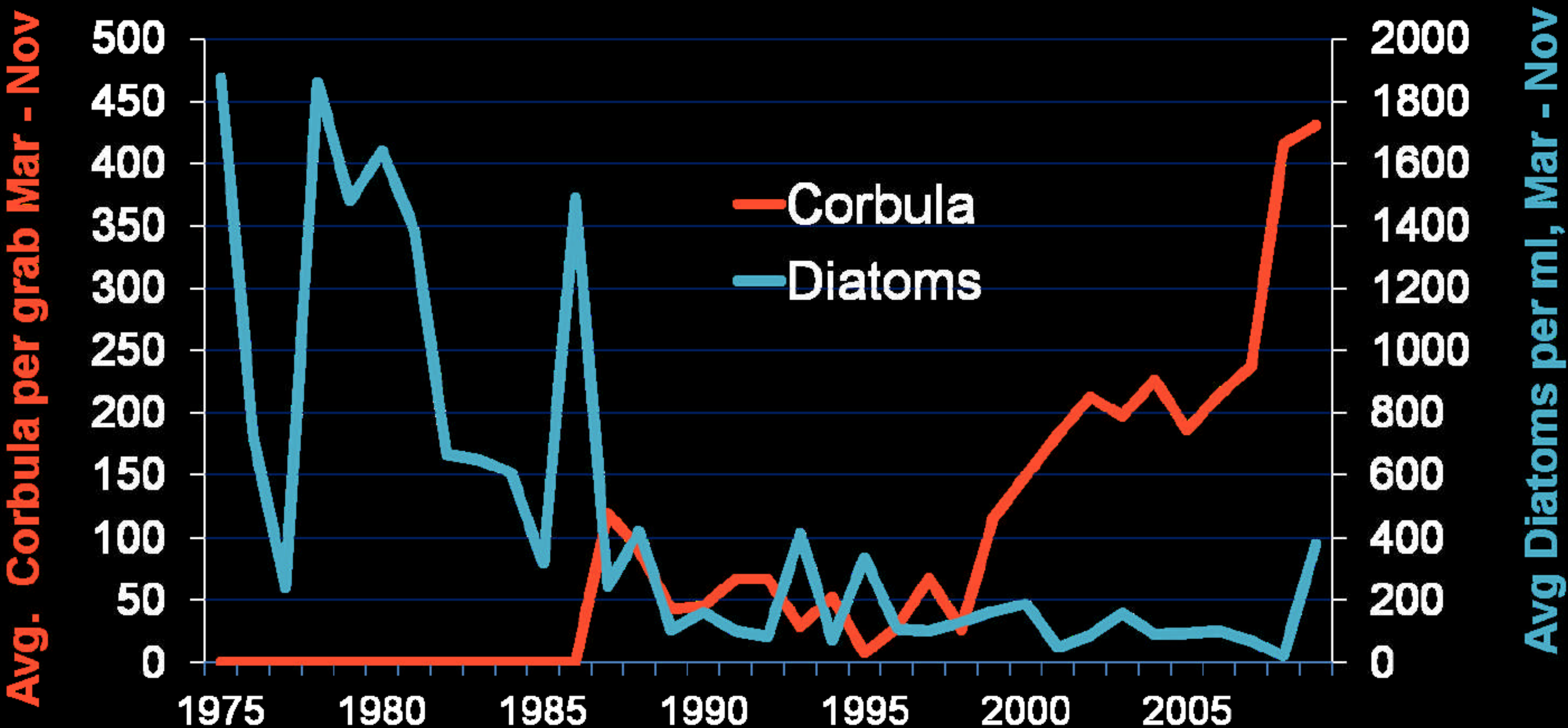
Eurytemora

Limnoithona

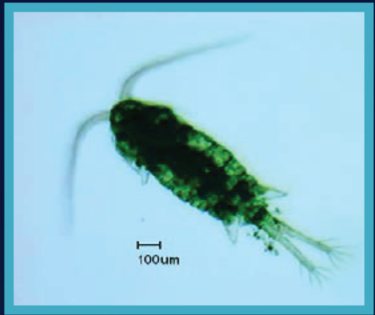
- ↑ Nutrients
- ↑ Clams
- ↓ Diatoms and chlorophyll
- ↓ Summer/fall turbidity
- ↓ *Eurytemora*, high value food
- ↑ *Limnoithona*, low value food
- ↑ Toxic Algae
- ↑ Submerged plants (SAV)
- ↑ Predator Fish (Bass, etc)
- ↓ Pelagic fish

Corbula and Diatoms Suisun Bay 1975 - 2011

Corbula amurensis
(Overbite clam)

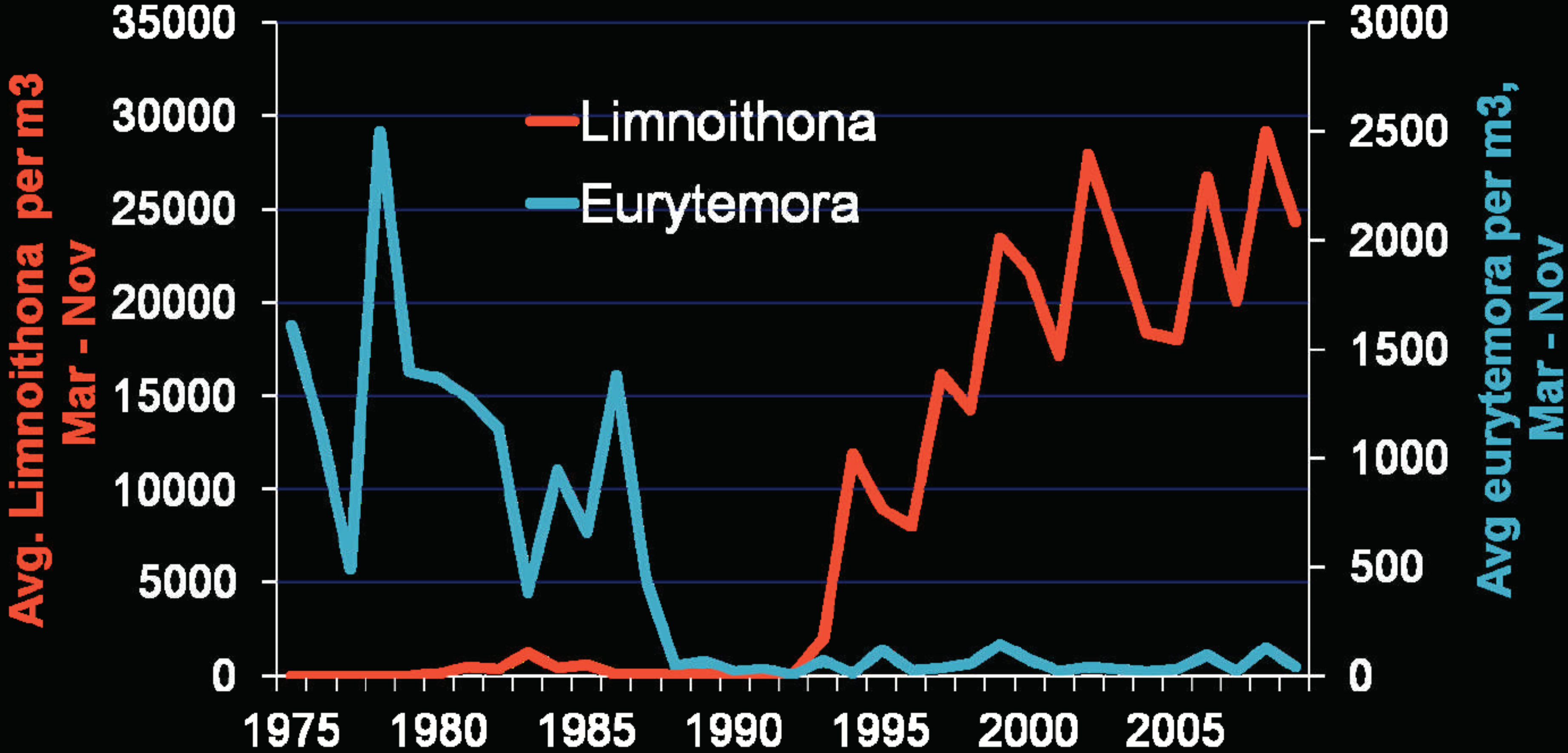


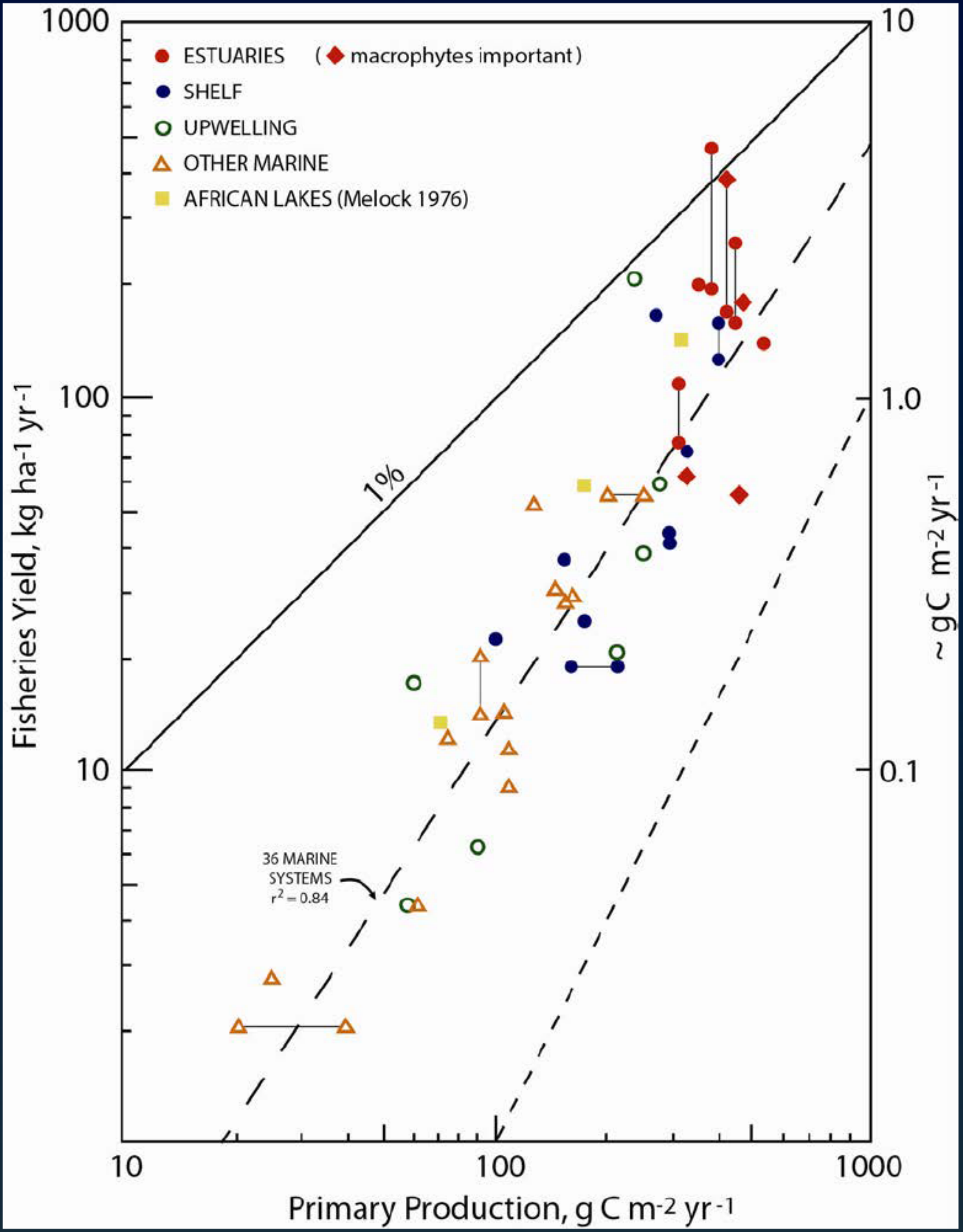
Limnoithona and Eurytemora Suisun Bay **1975 - 2011**



Eurytemora

Limnoithona

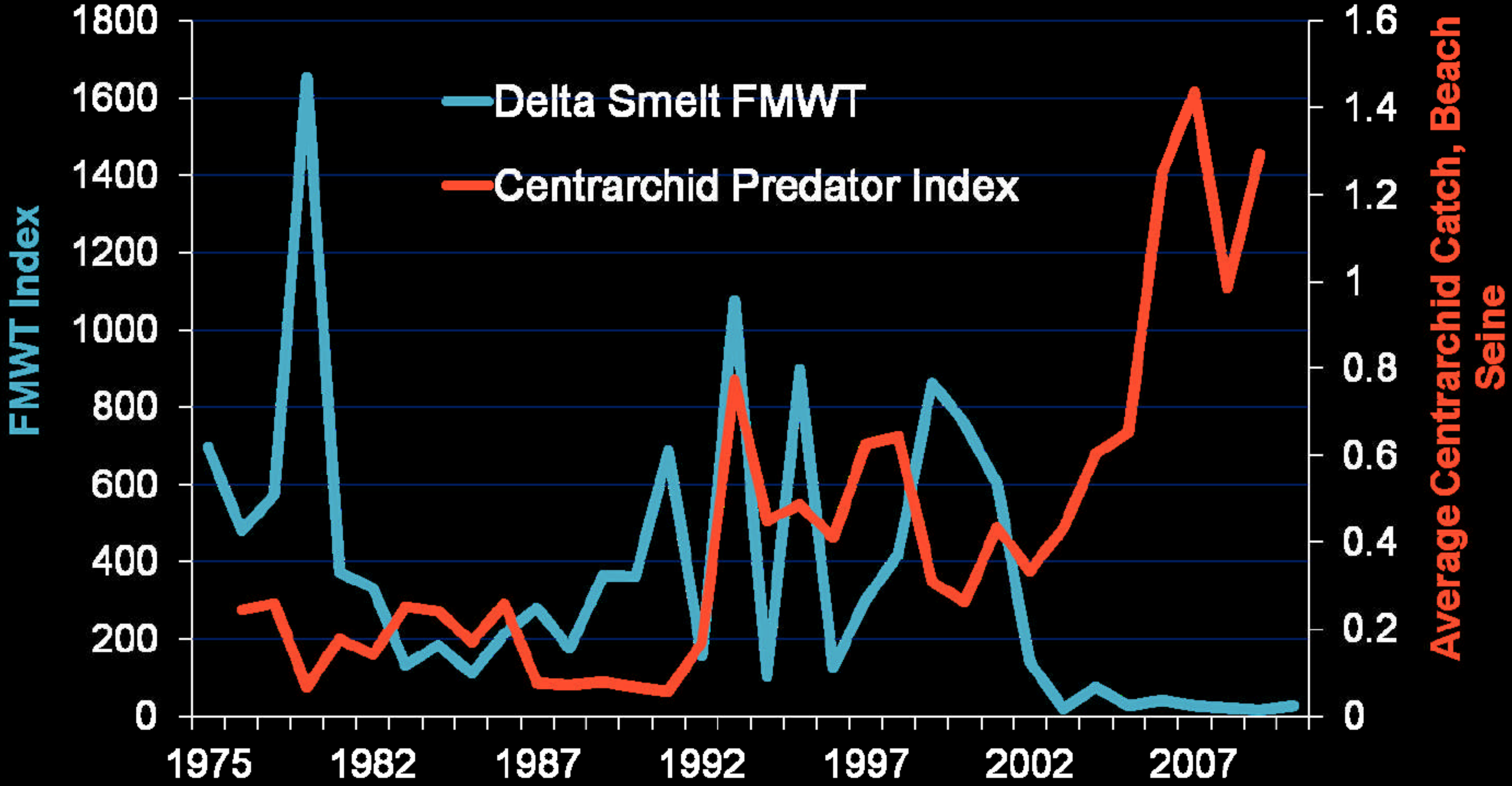




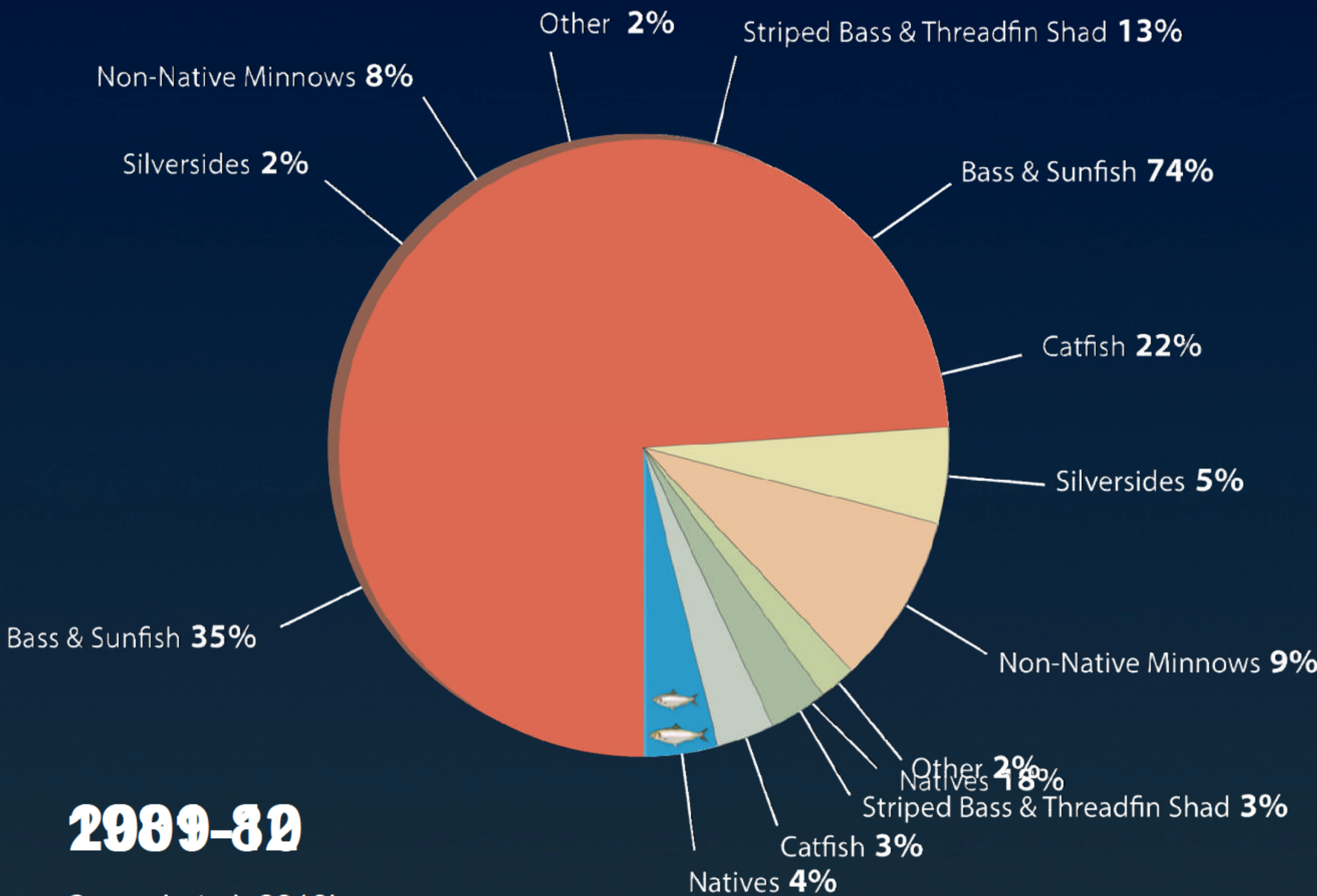
Source: Nixon, 1988

Centrarchid Predator Index and Delta Smelt Fall Abundance

1975 - 2011



Rise of the Centrarchids



Source: Conrad et al. 2010b

Possible Ecosystem Stressors

- Food web
- Physical landscape
- Water Temperature
- Turbidity
- Flows and diversions

Speakers and Topics

David Fullerton	- Overview
Dr. Paul Hutton	- Historical Flows
Sheila Greene	- Natural Flow Functions
Dr. Chuck Hanson	- Habitat & Invasives
Dr. Pat Glibert	- Nutrients & the Food Web

Flow & Salinity Time Trends
in Perspective

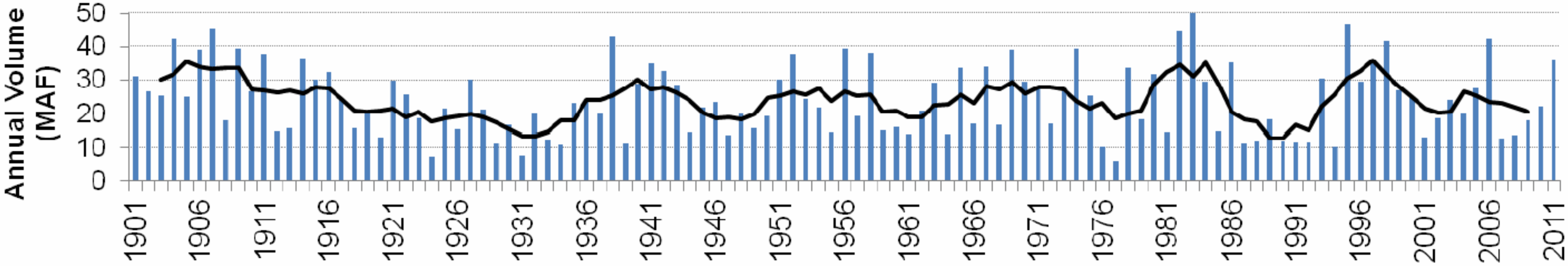
- Unimpaired flow ≠ Natural flow
- Climate must be accounted for when evaluating time trends
- CVP-SWP operation is NOT the primary driver of change between the two most recent decades

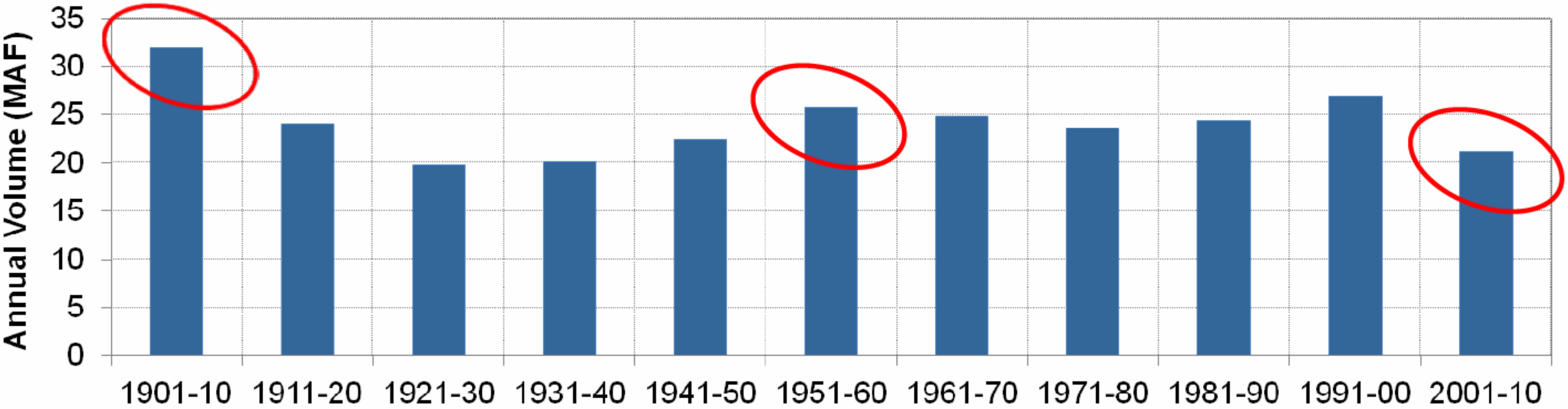
Unimpaired ≠ Natural

- Unimpaired flow is a calculation
- Unimpaired flow calculations are NOT good approximations for natural conditions
  - Levees
  - Channelization and dredging
- Early 20th Century conditions ≠ natural conditions

Climate

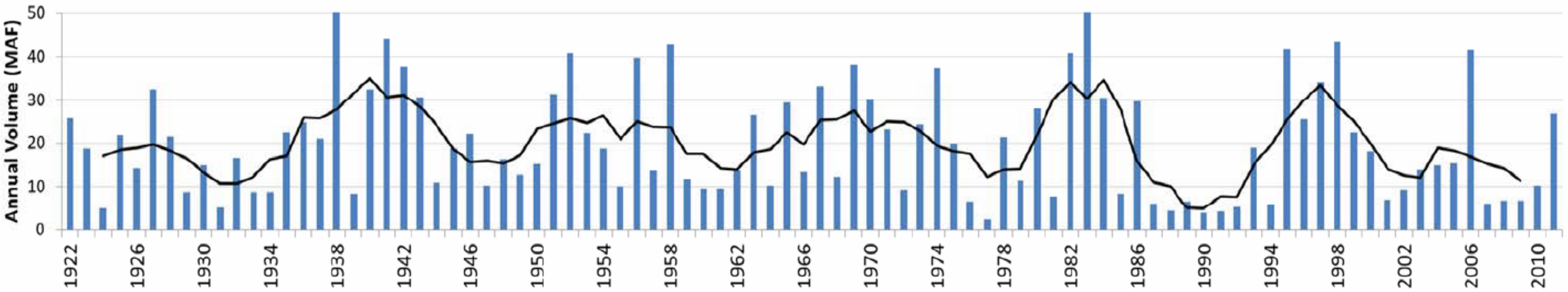
Measured by Eight River Index

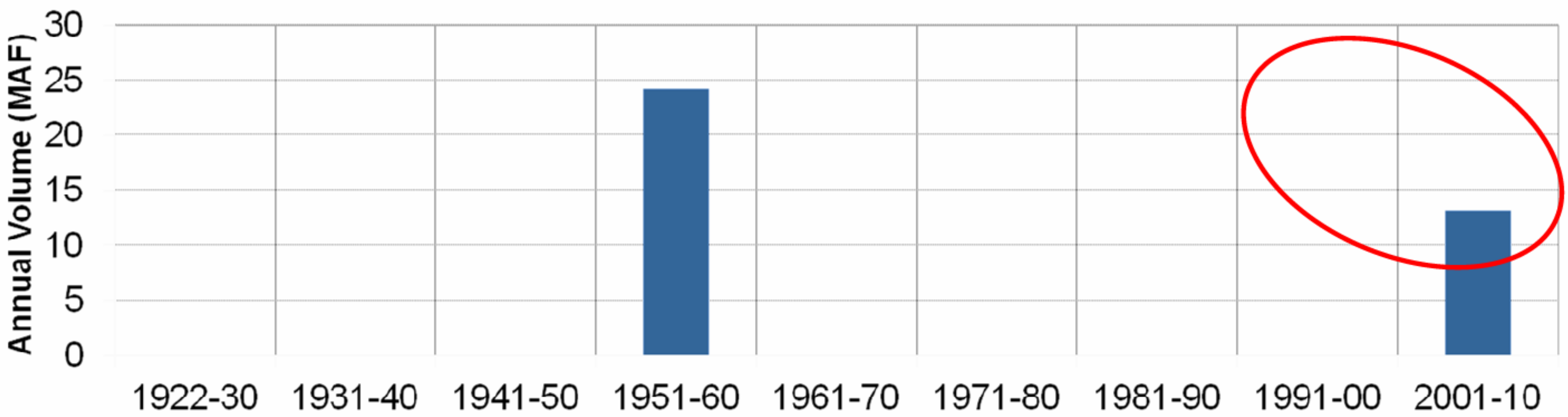




Data Sources: CDEC and Dept. of Public Works (1923) Flow in California Streams

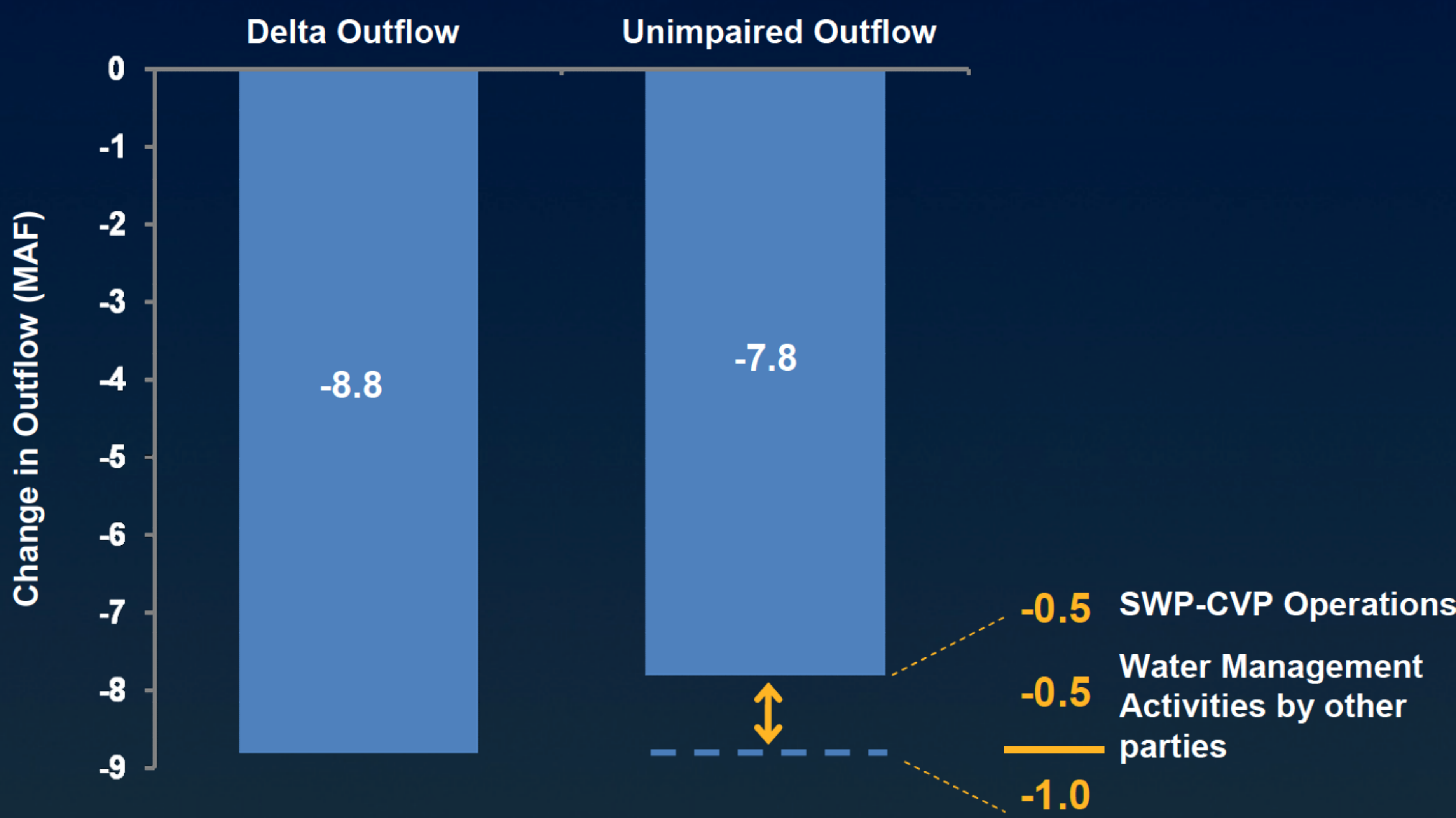
Annual Delta Outflow





Data Sources: DAYFLOW (Water Years 1930-2010) and DWR Bay-Delta Office (Water Years 1922-1929)

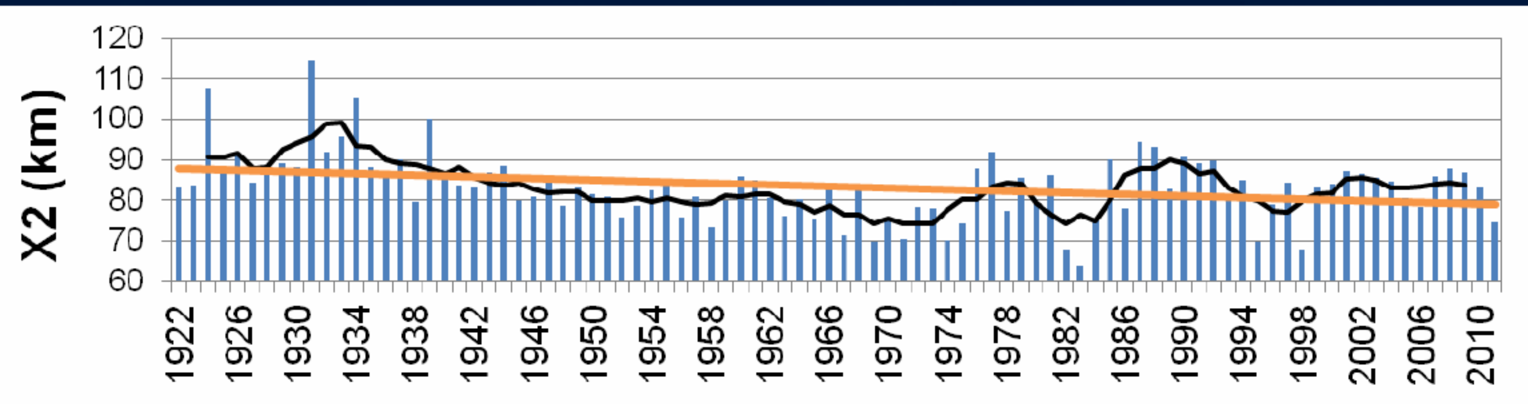
Annual differences between 1990s & 2000s



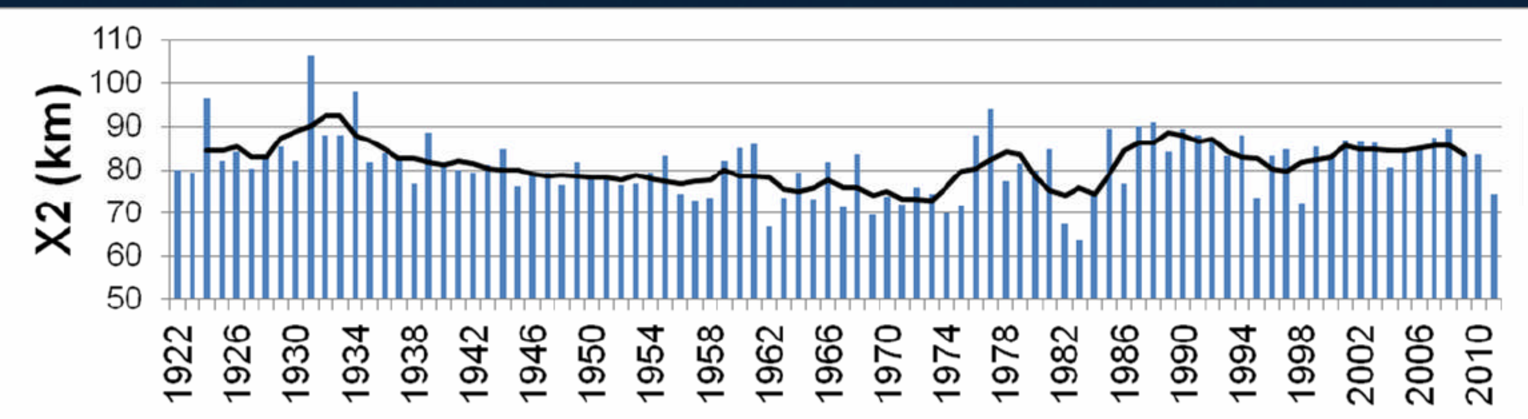
Data Sources: DAYFLOW, CDEC, DWR Bay-Delta Office

Fall X2 Position

September



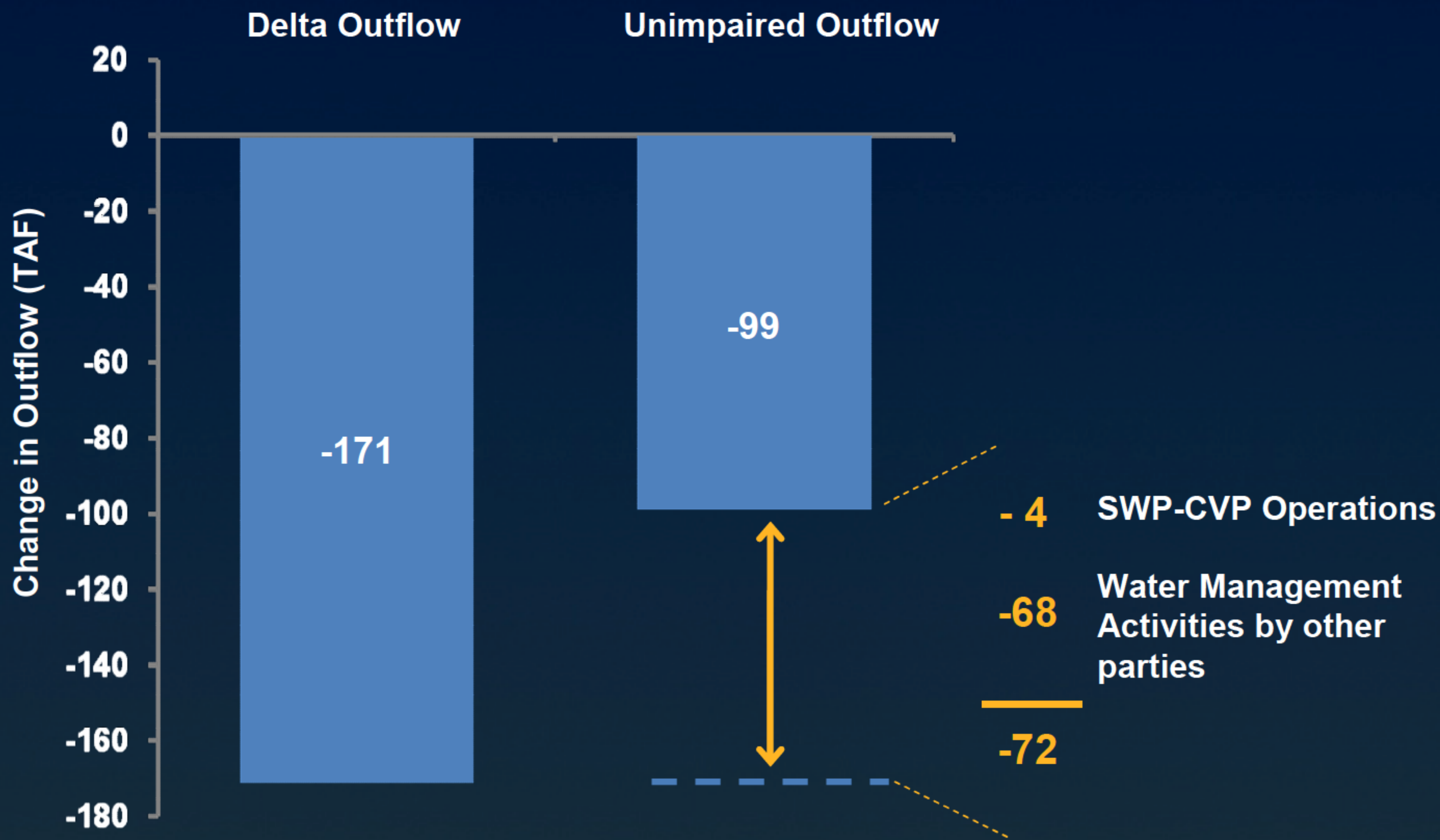
October



FRESHER

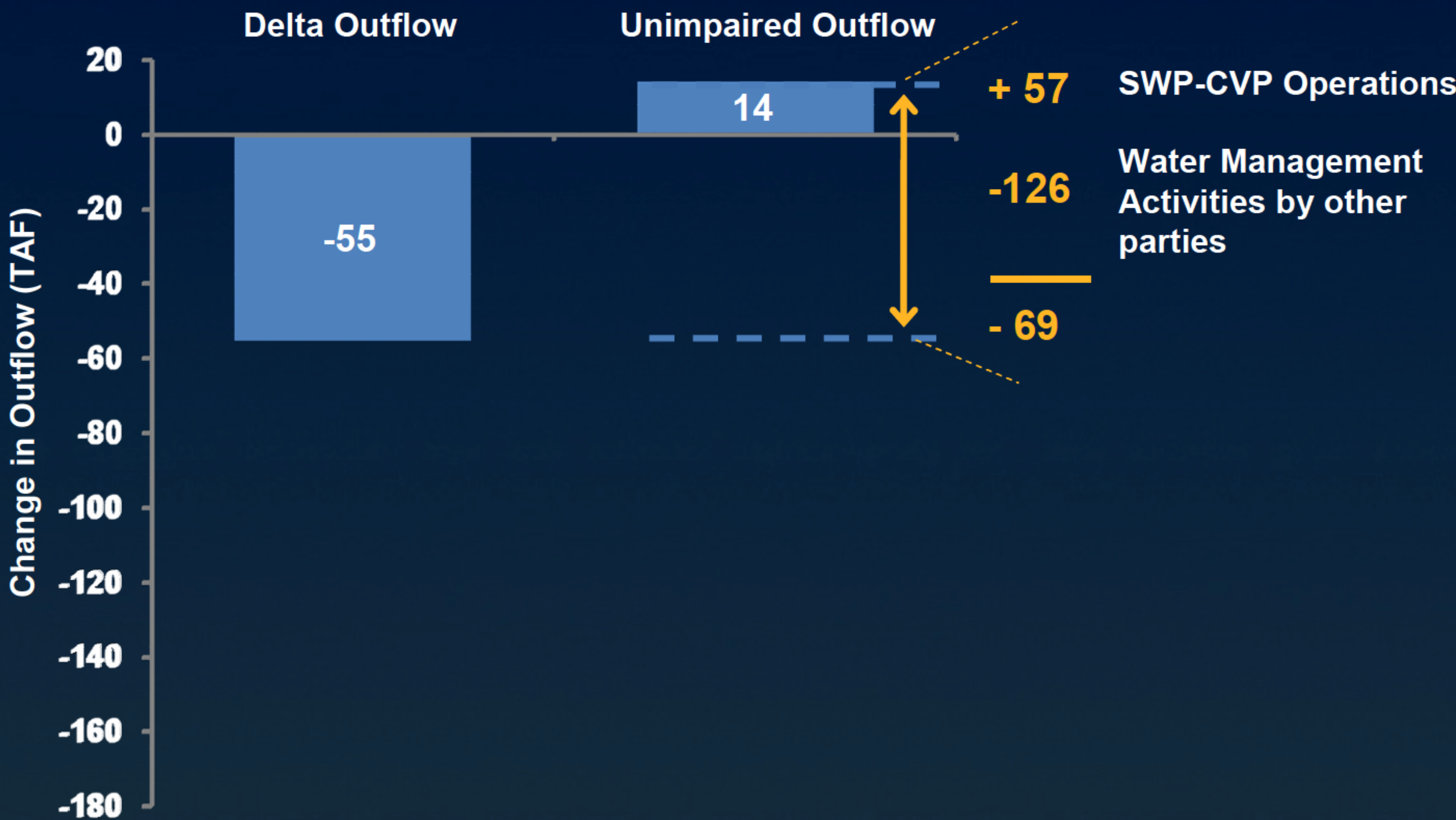
Data Source: X2 position calculated from monthly flow using K-M equation (Jassby et. al. 1995)

September differences between 1990s & 2000s



Data Sources: DAYFLOW, CDEC, DWR Bay-Delta Office

October differences between 1990s & 2000s



Data Sources: DAYFLOW, CDEC, DWR Bay-Delta Office

“Natural Flow” Approach is Uncertain In Highly Altered System

“Can reestablishing the natural flow regime serve as a useful management and restoration goal? We believe that it can, although to varying degrees, depending on the present extent of human intervention and flow alteration affecting a particular river.”

Poff et al. (1997)

"Natural Flow" Approach is Uncertain In Highly Altered System

The advice from aquatic ecologists on environmental flows might be regarded at this point in time *"as largely untested hypotheses about the flows that aquatic organisms need and how rivers function in relation to flow regime."*

Bunn and Arthington (2002)

Fluvial and Estuarine Systems Differ

Characteristic	Rivers	Estuaries
Body of pertinent literature	**Large**	**Small**
Understanding of flow effects	**Limited**	**Very limited**
Biota	**Limited diversity**	**More diverse**
Ecological interactions	**Less complicated**	**Much more complicated**
Water masses	Fresh only	Fresh and salt
Flow direction	Unidirectional	Reversing
Antecedent effects	Moderate	Potentially very important
Pollutant flushing	Rainfall runoff	Rainfall runoff and tidal flows
Water Quality changes	Downstream of source	Both upstream and downstream of source
Depth determined in	Flow	Primarily tides
Flow cross section determined by:	Sedimentary regime	Sedimentary regime, flocculation, littoral drift
Nutrient levels	Richer	Poorer

Source: Adapted from Pierson et al. 2002

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"Natural Flow" Approach is Uncertain In Highly Altered System

Conservation/ Restoration of:

1. Unaltered River/ Stream
2. Altered River/ Stream
3. Unaltered Estuary
4. Altered Estuary
5. Highly Altered Estuary

GREATER UNCERTAINTY

Uncertainty in the Bay Delta System

Changes in reservoir releases cannot:

- Restore habitat complexity
- Supply depositional materials
- Restore widespread seasonal floodplain inundation
- Restore natural nutrient balance
- Decrease Delta water temperature

Proposed management of the LSZ at 60 – 74 km

Without citation, and unsupported / inconclusive within the scientific literature:

- No citation provided
- No correlation between flow and phytoplankton in Suisun Complex after the clam (Alpine/Jassby 1992, Kimmerer 2002)
- No correlation between X2 and Delta smelt abundance or summer distribution (Kimmerer 2002, Nobriga et al, 2008)
- Delta smelt distribution shifted to more northerly and fresher location; Cache Slough Complex (Sommer et al 2011)

Proposed management of the LSZ at 60 – 74 km

USEPA conceded:

"There are large scale declines over time in the abundance of species, especially pelagic species, but there is not good information, and a wider range of opinion, on the cause(s) / mechanisms leading to these declines. The role of the LSZ in these abundance declines is uncertain."

USEPA Workshop Summary: Technical Workshop on Estuarine Habitat in the Bay Delta Estuary (2012)

Proposed management of the LSZ at 60 – 74 km

Preliminary results in Brown et al., stated:

"Many of the predictions either could not be evaluated with the data available or the needed data are not being collected. Most of the predictions that could be addressed involved either the abiotic habitat components (i.e., the physical environment) or delta smelt responses. In general, the FLaSH investigation has been largely inconclusive as of the writing of this report."

Brown et al (2012)

Proposed management of the LSZ at 60 – 74 km

Asserted with no exploration of the biological mechanisms underlying correlations.

Jassby cautioned:

"By ignoring variables other than X2 (or Q_{out}) we could therefore be in danger of imposing inappropriate standards, either too stringent or too lenient. The mere fact of a correlation between some ecosystem property and an indicator such as X, is therefore not sufficient grounds for using the indicator as a policy variable."

Jassby 1995

Proposed management of the LSZ at 60 – 74 km

Asserted with no exploration of the biological mechanisms underlying correlations.

Kimmerer recognised:

"These relationships to flow may be due to several potential mechanisms, each with its own locus and period of effectiveness, but no mechanism has been conclusively shown to underlie the flow relationship of any species."

kimmerer 2002

Disconnect between the LSZ and food and turbidity

Uncertain or inconclusive or sometimes contradicted in the scientific literature

- **No positive correlation between flow and phytoplankton in Suisun Bay, because of the invasion of the clam and nutrient imbalance (Alpine/Cloern 1992, Kimmerer 2002).**

- **The FLaSH studies reported lower phytoplankton in Suisun and higher outside Suisun, AND delta smelt growth was not related to salinity (FLaSH 2012).**

- **Potential food supply in Suisun Marsh, therefore recommended restoring marsh habitat (Muller et al 2002)**

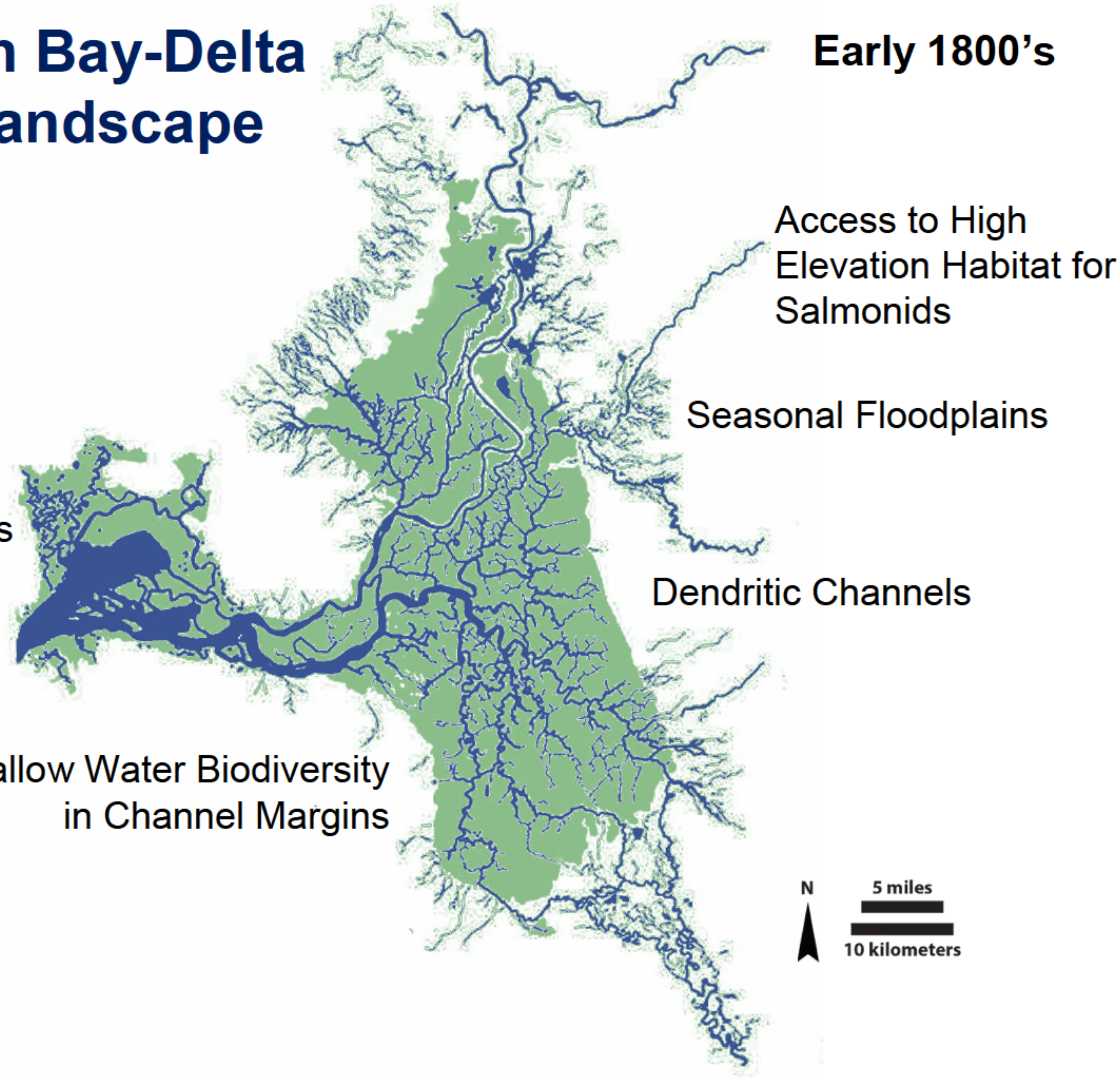
Based on our review of the available science:

Given the highly altered state of the Bay-Delta estuary, it is highly uncertain that mimicking "natural" flows would restore biological functions.

Based on our review of the available science:

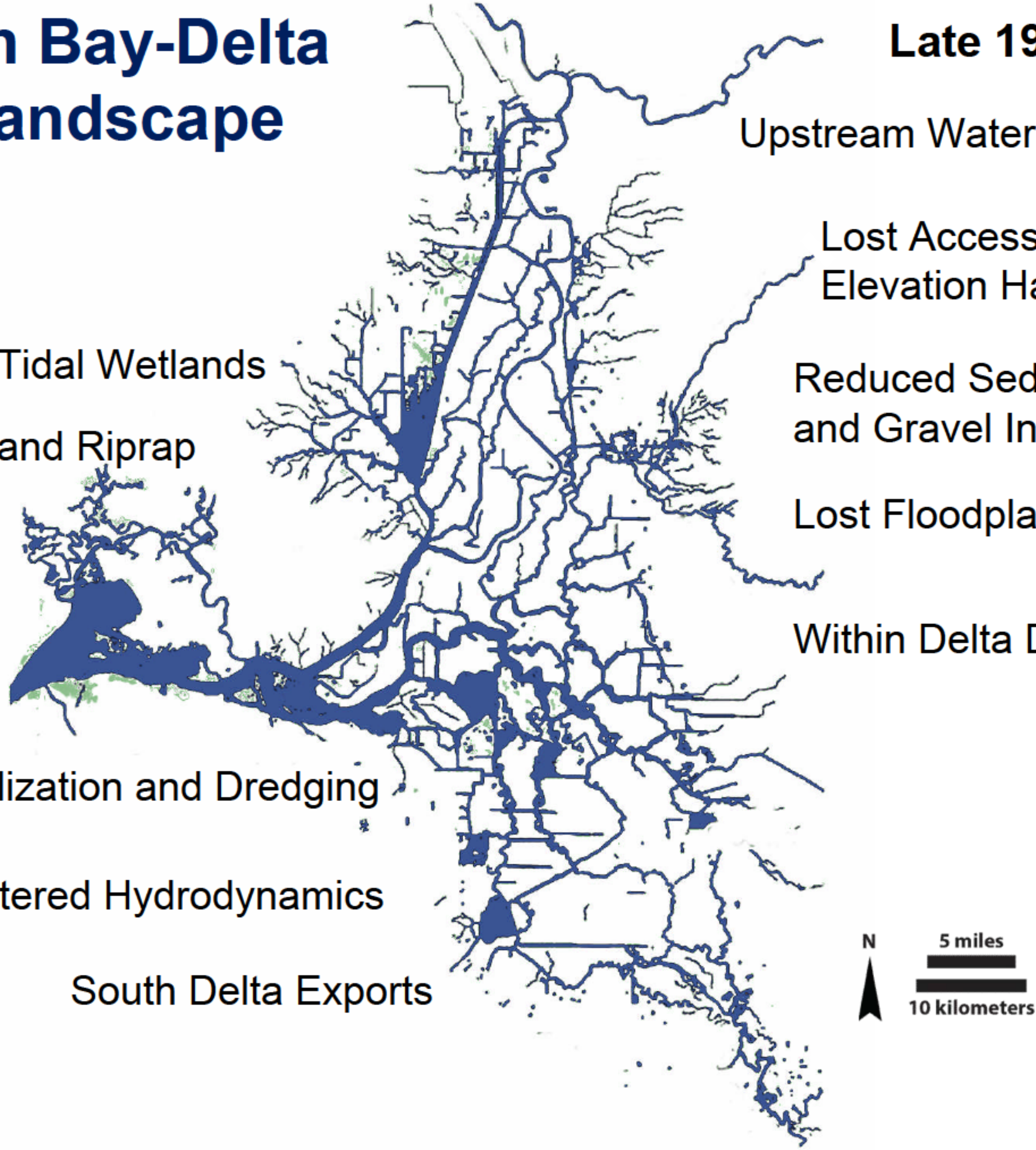
Large changes in flow made under scientific uncertainty could lead to large adverse impacts to beneficial uses.

Changes in Bay-Delta Physical Landscape Over Time



Changes in Bay-Delta Physical Landscape Over Time

Late 1990's



Upstream Water Diversions

Lost Access to High Elevation Habitat

Reduced Sediment and Gravel Input

Lost Floodplain Access

Within Delta Diversions

Loss of Tidal Wetlands

Levees and Riprap

Channelization and Dredging

Altered Hydrodynamics

South Delta Exports

Resultant Changes to Ecosystem Functions

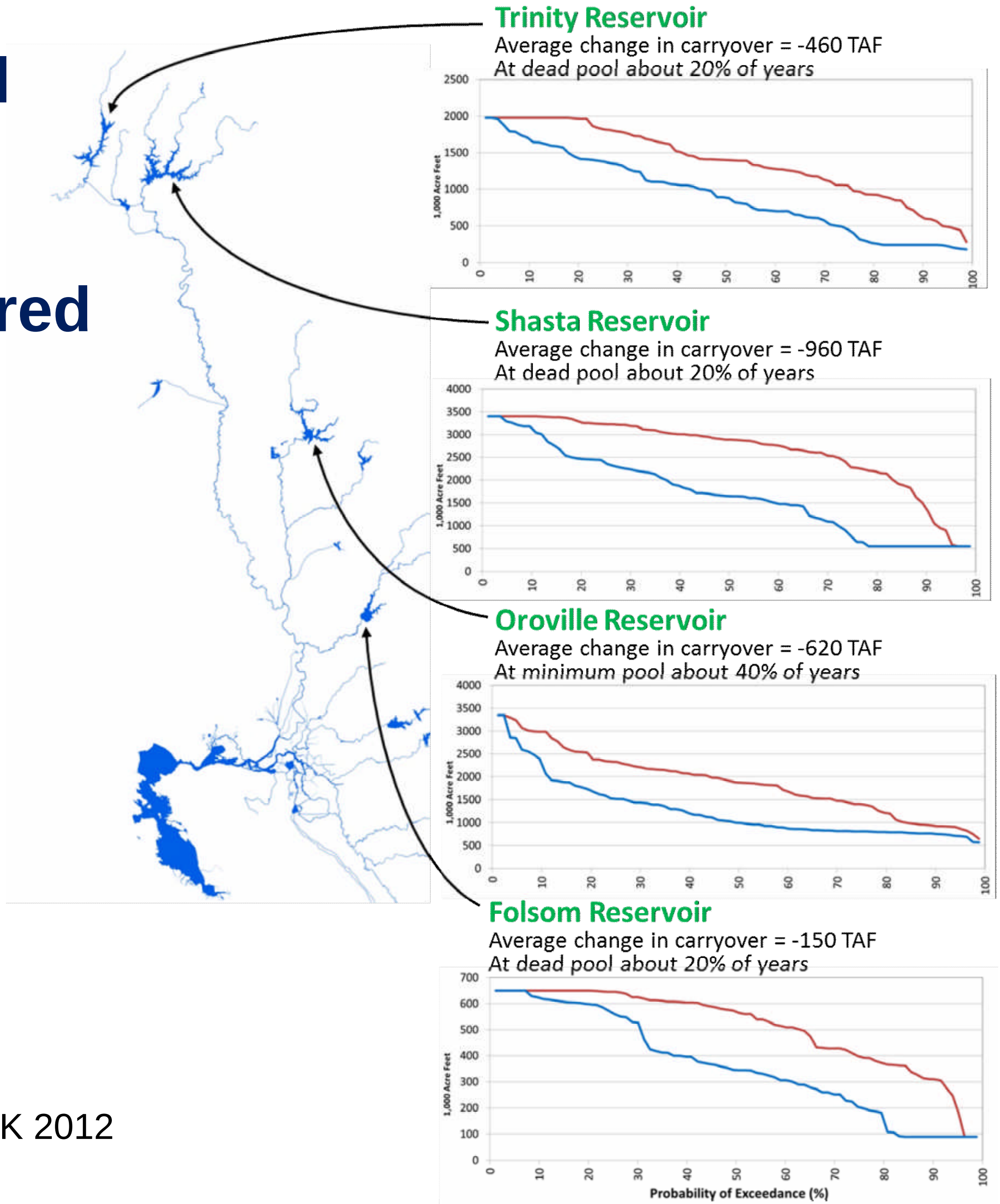
- Loss of wetland habitat
- Loss of access to floodplains
- Loss of shallow-water channel margin habitat
- Reduced production of organic matter and food

Potential Impacts of Flow Changes

In a highly altered system…

- Unimpaired flow could result in adverse impacts
- Increased winter-spring flow may provide uncertain benefits for some species and adversely impact others, such as Salmonids

Potential Impact of 50% Unimpaired Flow



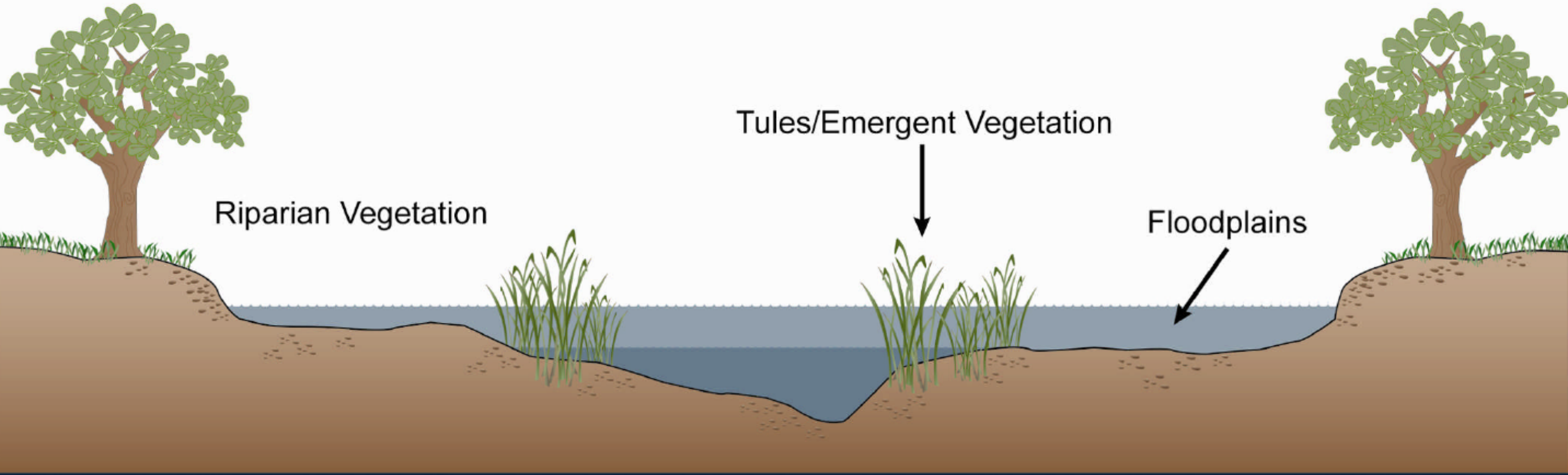
Source: MBK 2012

Effect of Rim Dams on Salmonids

- Dams block access to higher elevation habitat
  - Spawning and rearing occurs in downstream reaches
  - Exposure of eggs to high temperatures results in mortality
- Requires balance between flow and coldwater pool management
- Maintaining suitable temperature is challenging in dry years
- Increased winter-spring flows may reduce coldwater pool storage in the summer
  - Adverse impacts winter-run Chinook salmon

Sacramento River Cross-Section

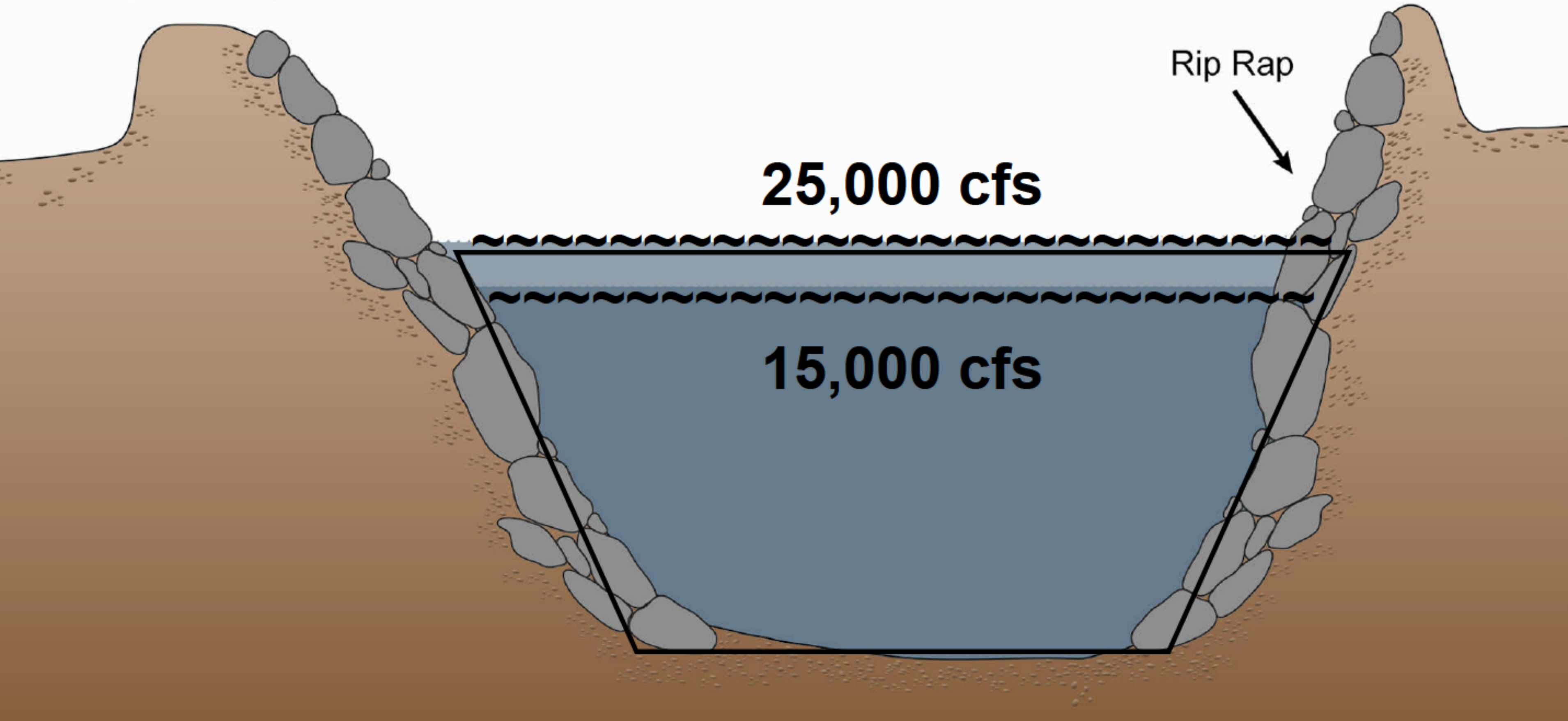
HISTORIC



Sacramento River Cross-Section

CURRENT

No Riparian Vegetation



Improving Aquatic Species Functions

- Tidal wetlands
  - Cover, rearing, food production
- Seasonal floodplains
  - Spawning, rearing and connectivity
- Shallow water low velocity channel margin
  - Food production

Dealing with Uncertainty in Restoration

- Based on current research (at Liberty Island & Northwest), habitat design should be:
  - Based on suitability and natural functions/processes
  - Compatible with tidal and river hydrodynamics, water quality, and natural processes such as sediment resuspension (turbidity)
  - Promote complexity such as depth, tidal currents, emergent vegetation
  - Dispersed to support various species and functions
  - Facilitate adaptive management
- Requires multidisciplinary collaborative monitoring

Outflow and Invasive Species

- Recent study suggest without support that water exports have produced “waves of invertebrate invasions”
- Exotic species have changed the ecological community
- Winder et al. (2011) cite prolonged drought and increased salinity intrusion as dominant factors for non-native invertebrate colonization
- Water operations also maintain Delta outflow and control salinity
- In dry years, there are dynamic interactions between salinity intrusion and water project operations
- The potential effect of water project operation on colonization by invasive species <u>has not been analyzed</u> and is an untested hypothesis

Key Points

- The SWB should seek to understand the physical, chemical and biological changes that have occurred in the Bay Delta Estuary
- The SWB should endeavor to understand the underlying mechanisms stressing or the functions that flow serves in the Bay Delta Estuary, before considering whether to dedicate more water for environmental purposes
- Scientific literature shows habitat restoration and nutrient regulation could produce meaningful, positive changes to the Bay-Delta Estuary