

Ecological Context for the Delta: A Lot Can Happen in 150 Years....

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Science Center

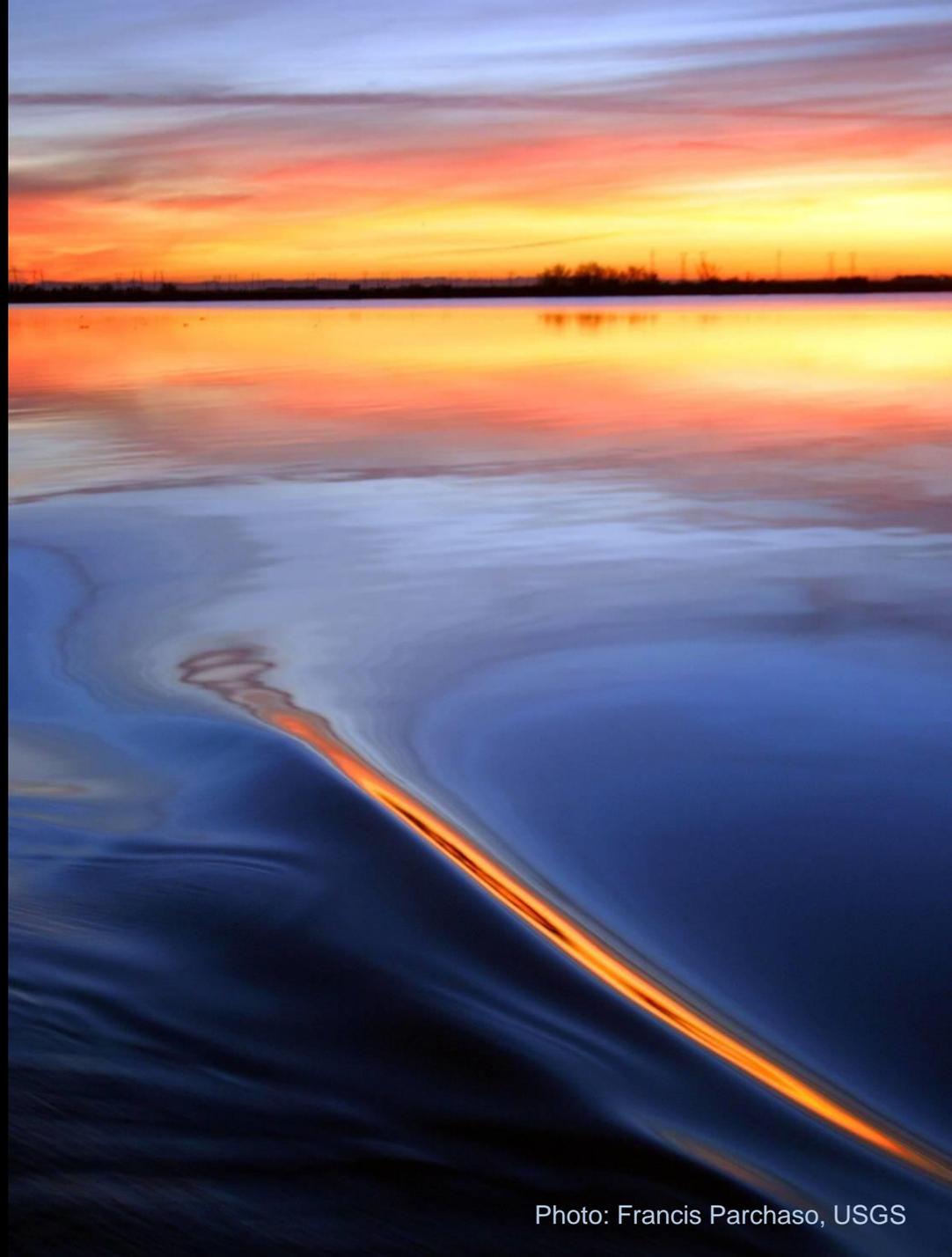


Photo: Francis Parchaso, USGS

This Talk

- Brief overview of “pre-Gold Rush” conditions

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- Agents of change

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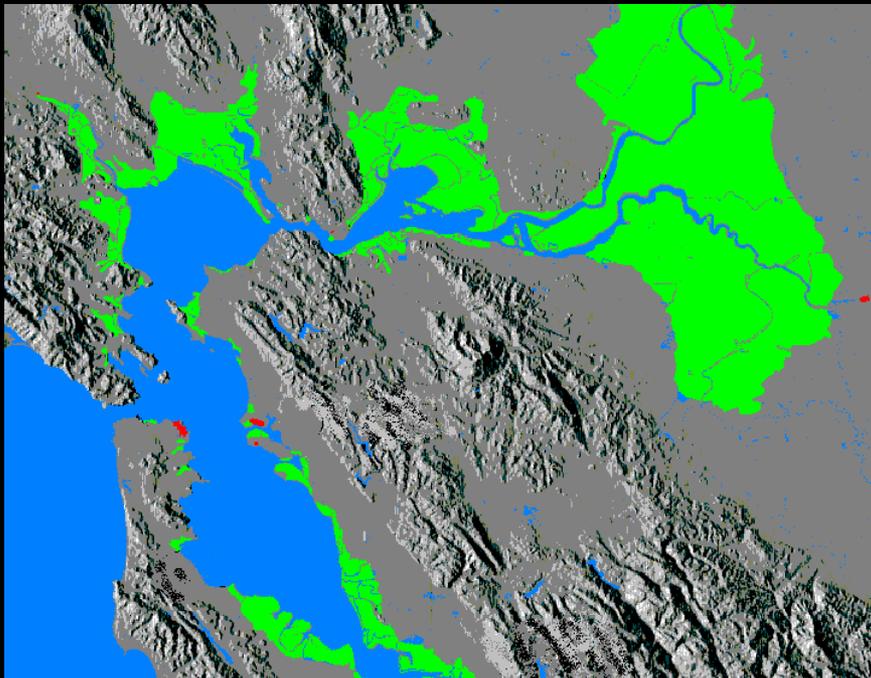
- Brief overview of “pre-Gold Rush” conditions
- Agents of change
- Current general ecological conditions
 - Hydrodynamics and operations already covered

This Talk

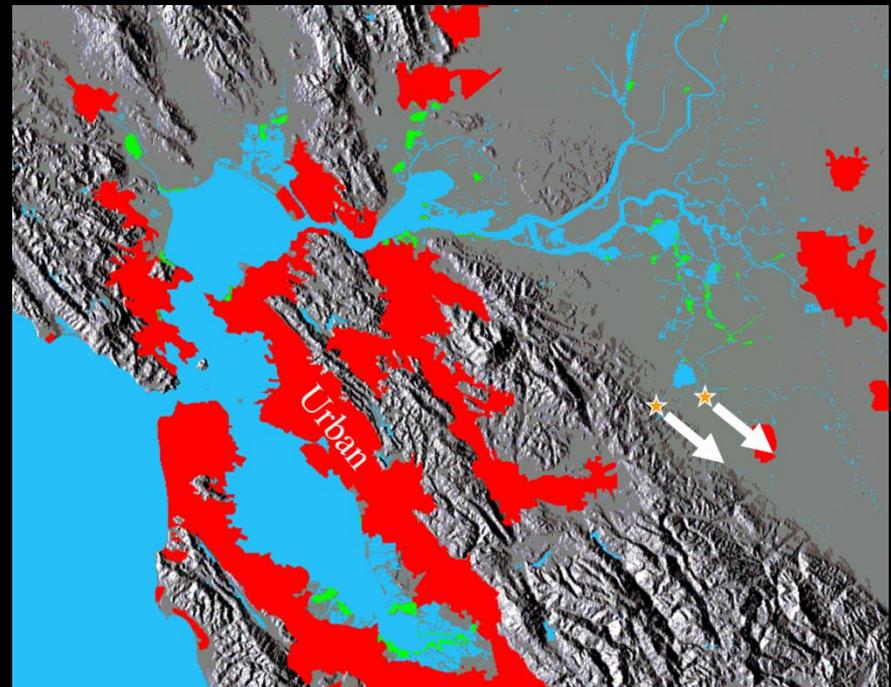
- Brief overview of “pre-Gold Rush” conditions
- Agents of change
- Current general ecological conditions
 - Hydrodynamics and operations already covered
- Salmonids covered next
 - Not my field of expertise

Simple-minded view of landscape change we (...or at least I) started with in the 1990s

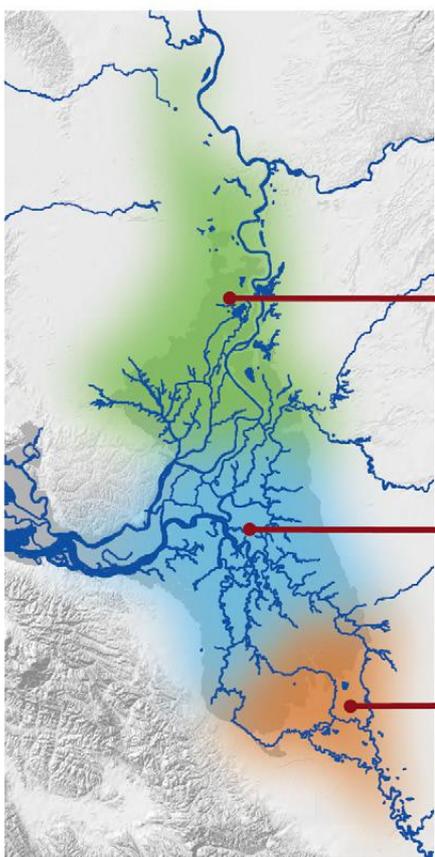
Tidal Wetlands pre-1850s



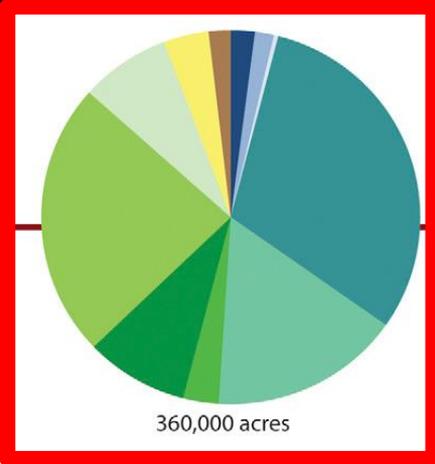
Tidal Wetlands in 1990
(90% loss in SFE and
95% in Delta)



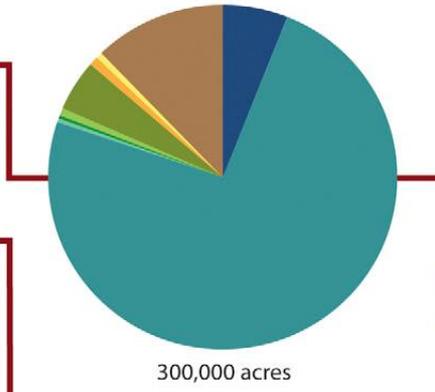
Utterly Fails to Convey Loss of Complexity



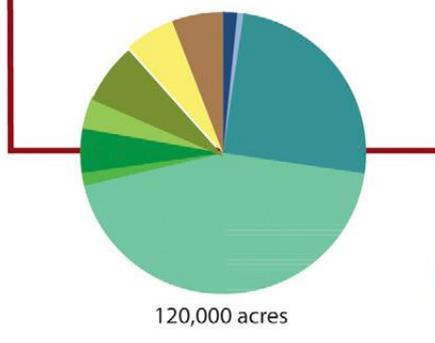
- waterway
- pond/lake
- seasonal pond/lake
- tidal freshwater emergent wetland
- nontidal freshwater emergent wetland
- willow
- valley foothill riparian
- wet meadow/seasonal wetland
- vernal pool complex
- alkali seasonal wetland complex
- inland dune scrub
- grassland
- woodland/savanna



North Delta: flood basins



Central Delta: tidal islands

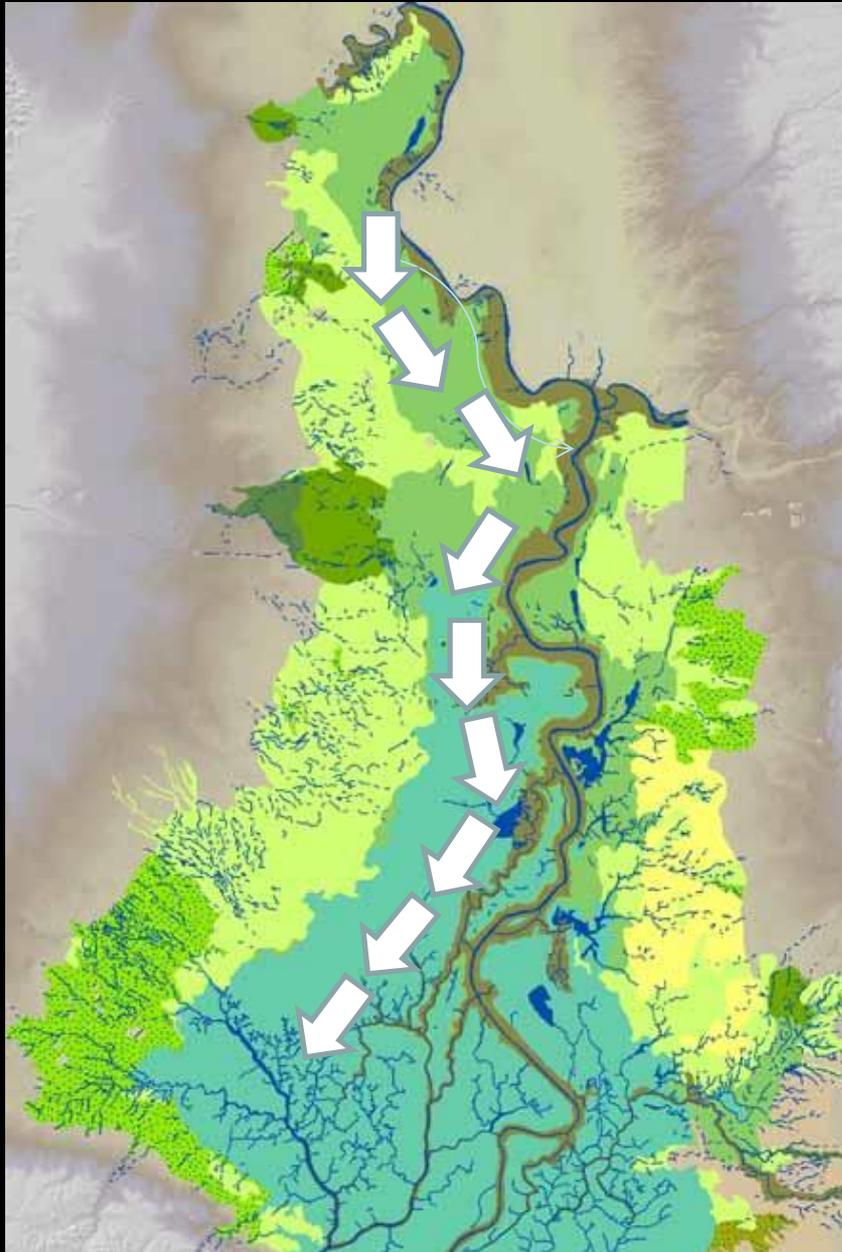


South Delta: distributary rivers

Flood basins/natural levees
 Tidal freshwater emergent wetlands
 Nontidal freshwater emergent wetland
 Seasonal wetlands

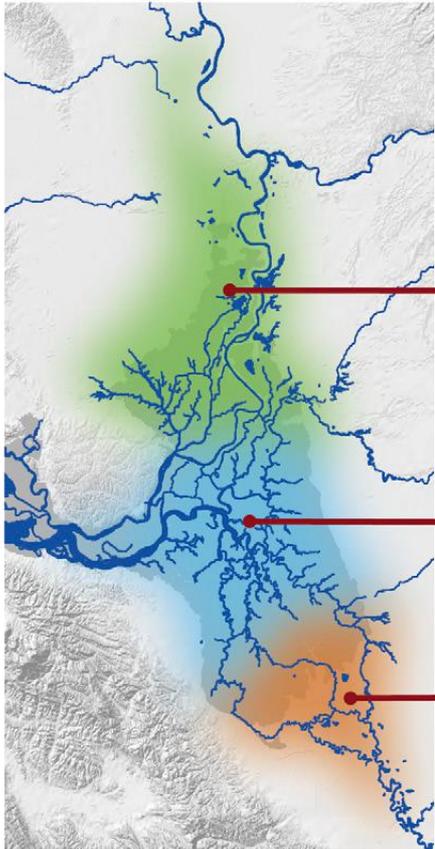
Best Delta
 History ever!

Whipple et al. 2012

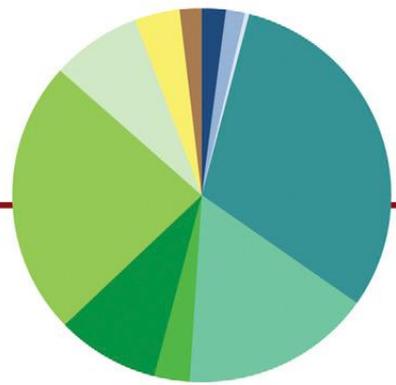


Extensive
Floodplain
Available

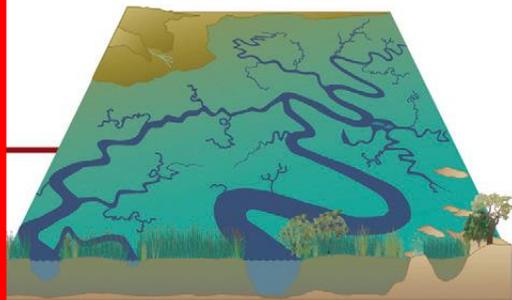
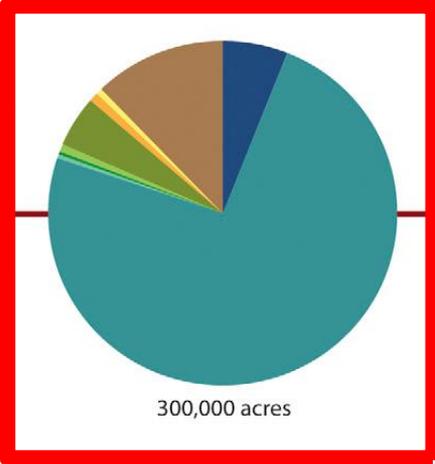
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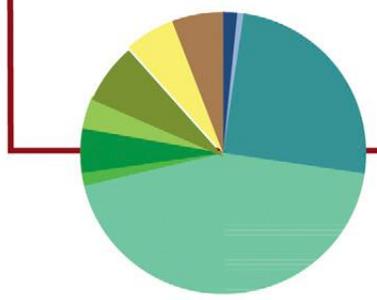
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North Delta: flood basins



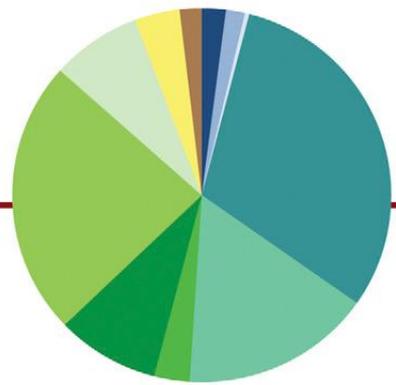
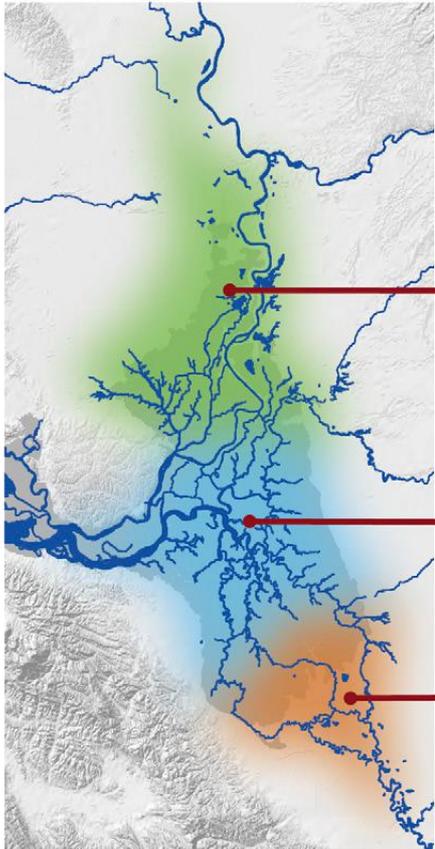
Central Delta: tidal islands



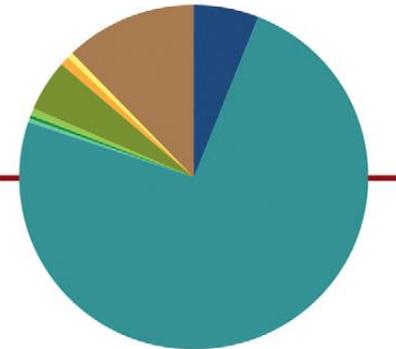
South Delta: distributary rivers

Tidal Islands
Tidal freshwater emergent wetlands

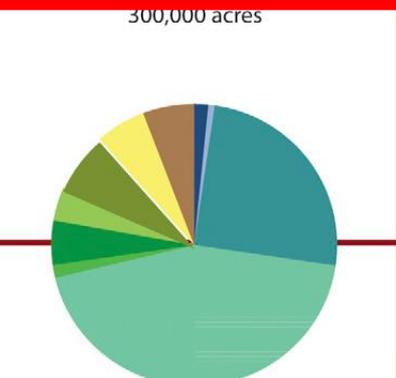
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North Delta: flood basins



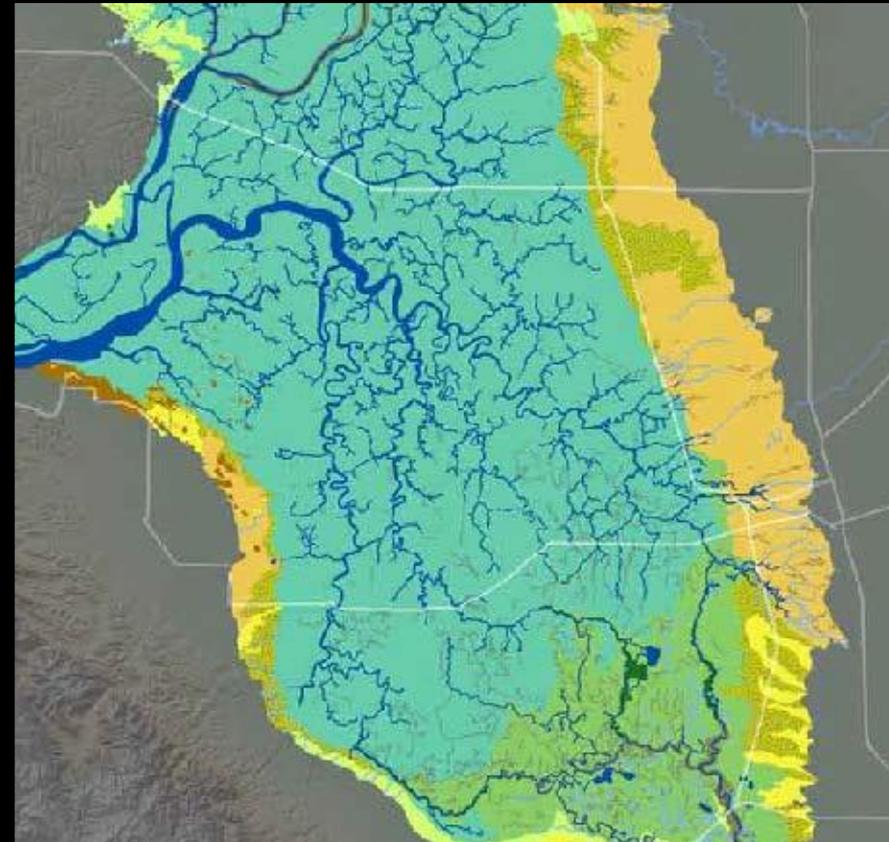
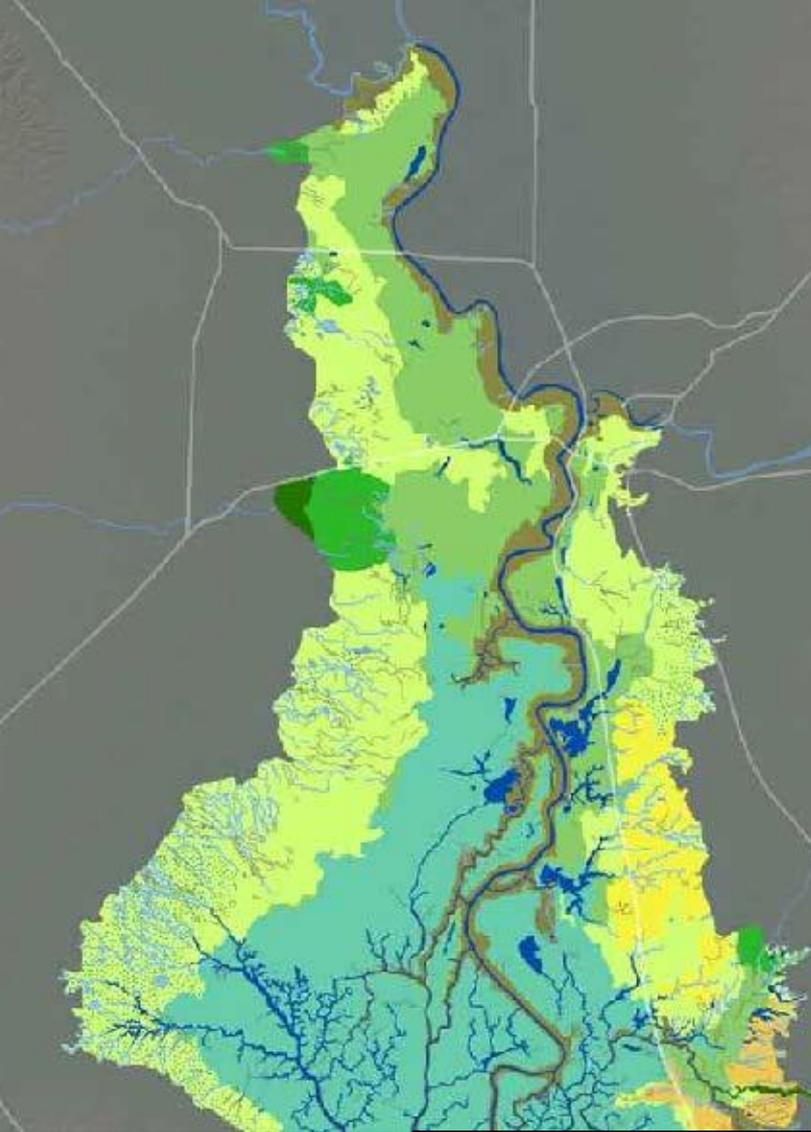
Distributary rivers
 Tidal freshwater emergent wetlands
 Nontidal freshwater emergent wetland



South Delta: distributary rivers

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Extensive low-order channel networks in wetland areas



Provides access to wetland areas
Dead-end sloughs

Native Predators on Juvenile Salmonids

Birds

Herons

Egrets

Cormorants

Mergansers

Etc.



Thicktail chub, globally extinct 1950s



Sacramento pikeminnow, still common



Bull trout, extinct in California 1970s,
only McCloud River



Sacramento perch, extirpated from native range



Rainbow trout? Other salmonids?

What Happened?

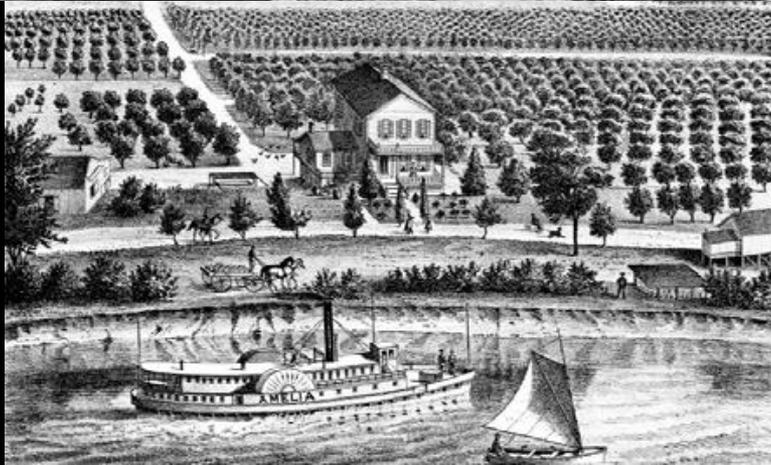
- Filled the rivers with mud
- Delta
 - Drained it
 - Farmed it
 - Re-plumbed it
 - Deliberate and accidental introductions



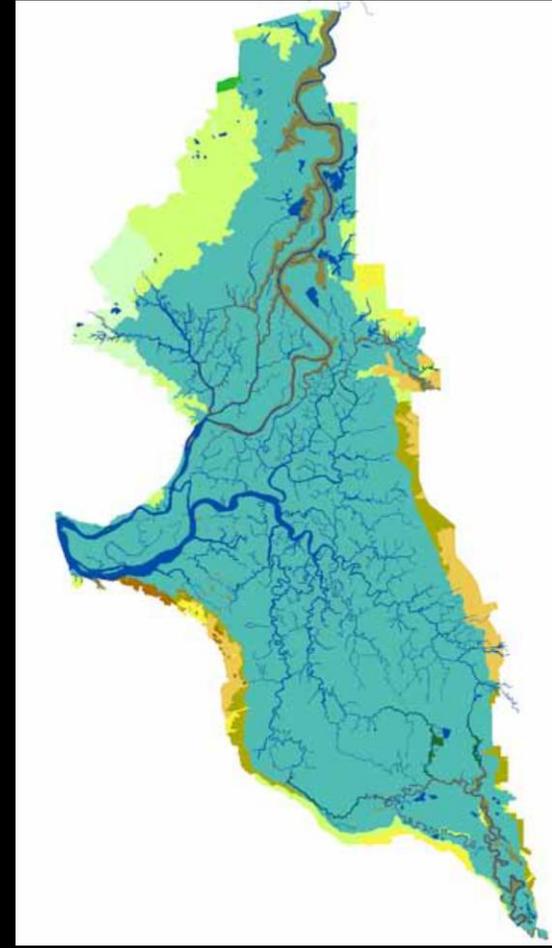
Hydraulic mining
sediment

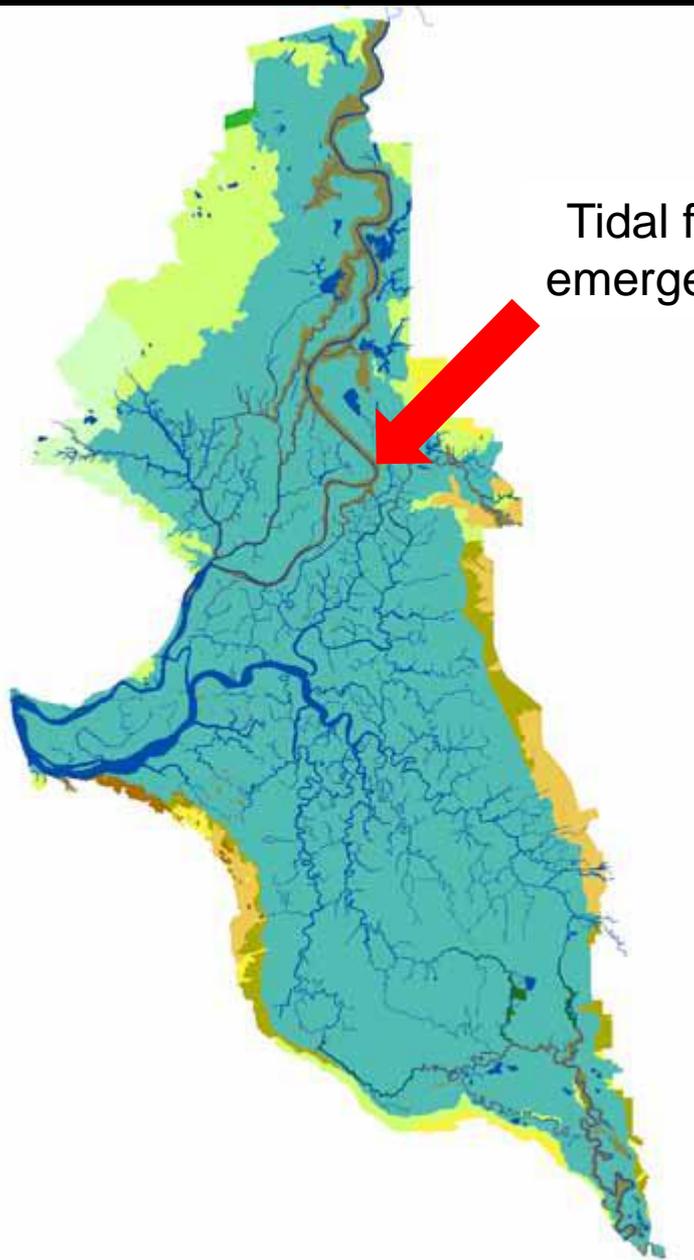


Levees and
altered channels

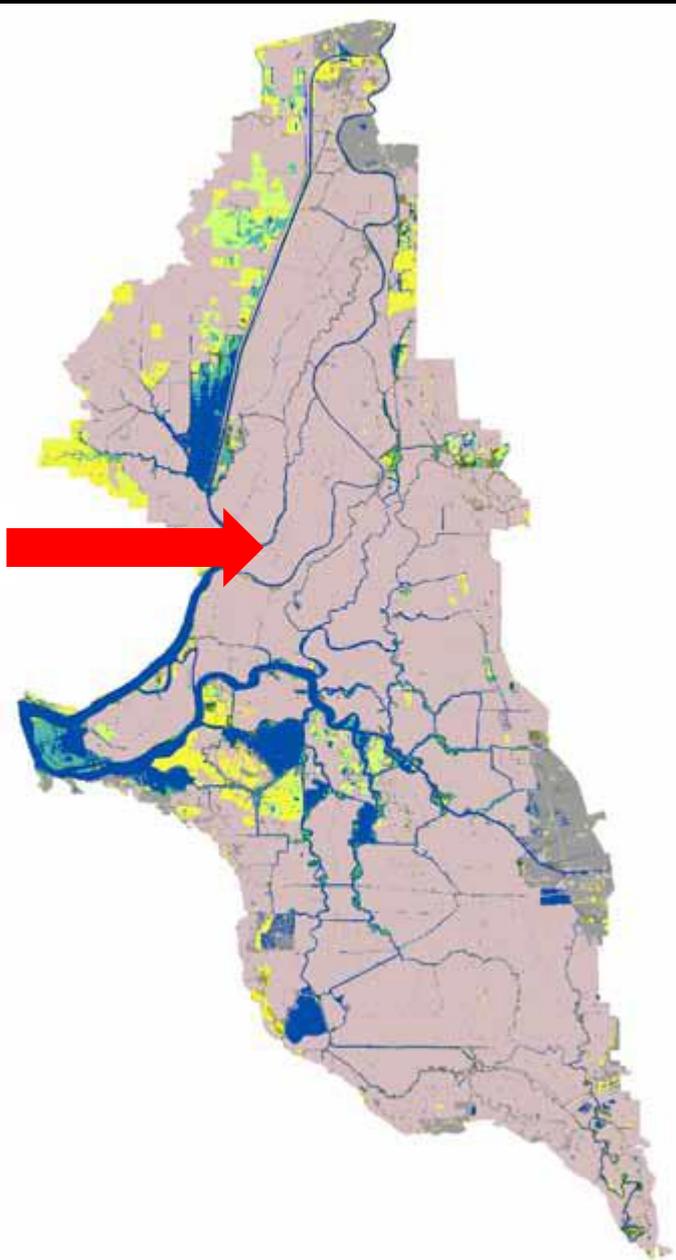
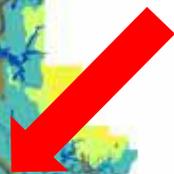


Land use change





Tidal freshwater
emergent wetland



Agriculture



Dams for water storage, flood control, and hydropower

1400 'large' DAMS

1000s of small dams

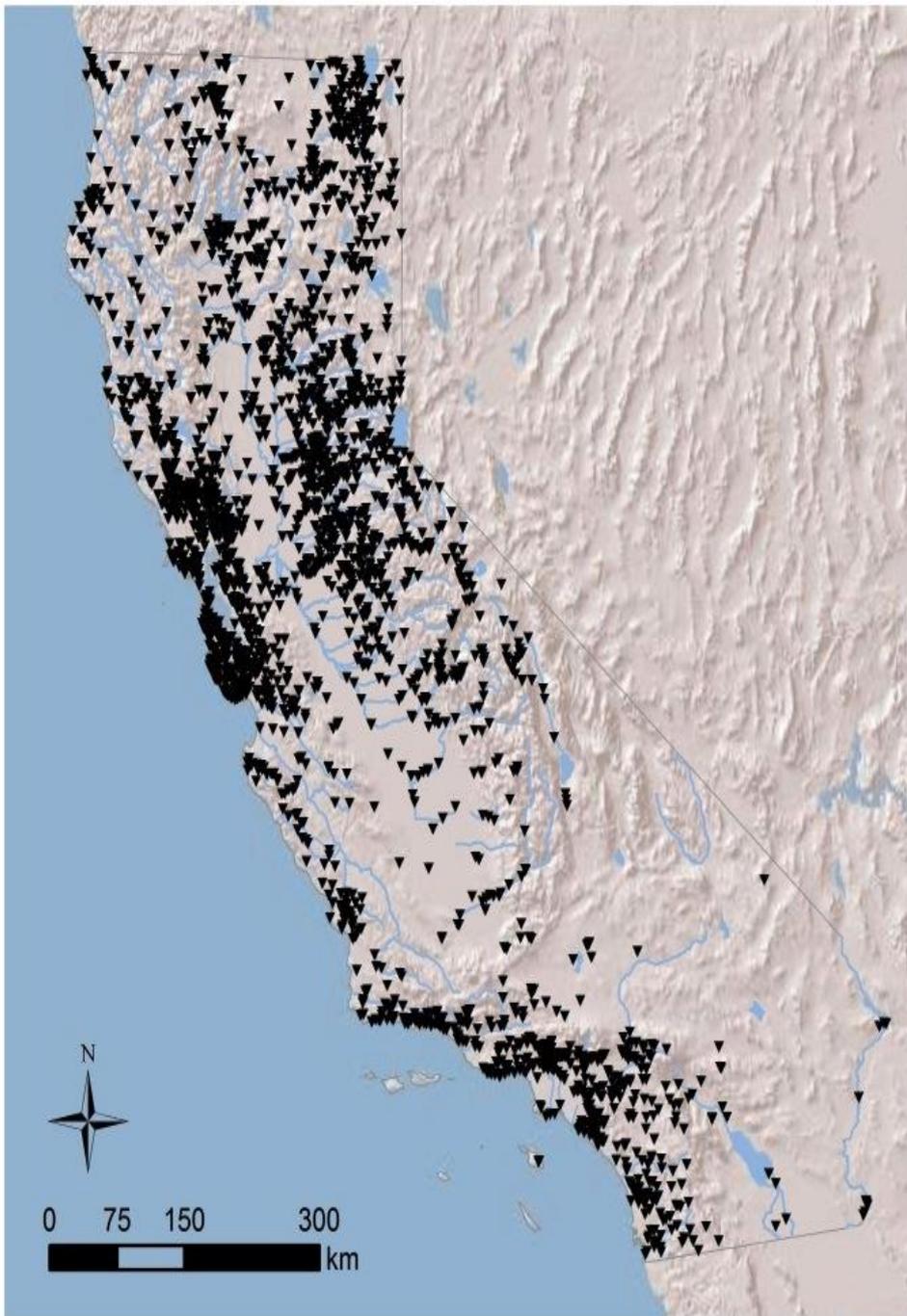
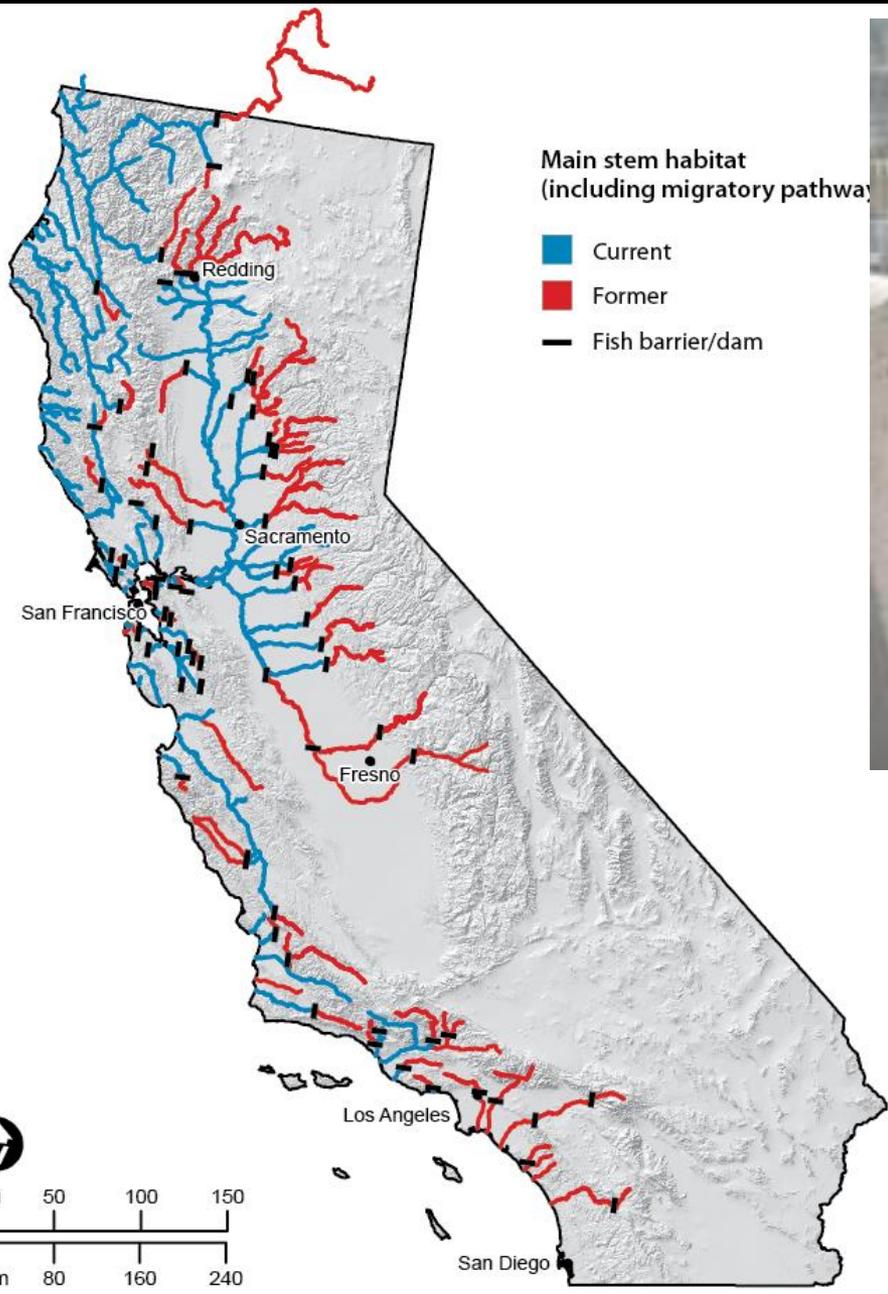


Figure 1.1 Dams in the state of California.

Source: California Department of Fish and Game (DFG) 2012.



70+% of
anadromous
salmon habitat
above dams



The Delta Today Is a Human Construct

Not a Good
Environment For
Most Native
Fishes





Riprap (1,100 miles of Delta levees,
Mount et al. 2012)

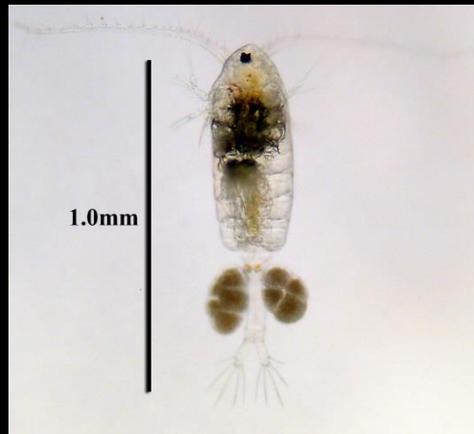
Clifton Court Forebay



Delta Cross Channel



Introduced Species...Lots!



50 species

30 alien (60%) species

Usually > 90% by number

Mostly freshwater

FW species dominated by aliens
natives present but rare

Sources:

Feyrer and Healey 2003

Grimaldo et al. 2004, 2012

Nobriga et al. 2005

Brown and May 2006

Brown and Michniuk 2007

Gewant and Bollens 2011



30.9 mi

Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data MBARI
Image © 2012 TerraMetrics

44 species

28 alien (64%)

Mostly freshwater

FW species dominated by aliens
but natives present

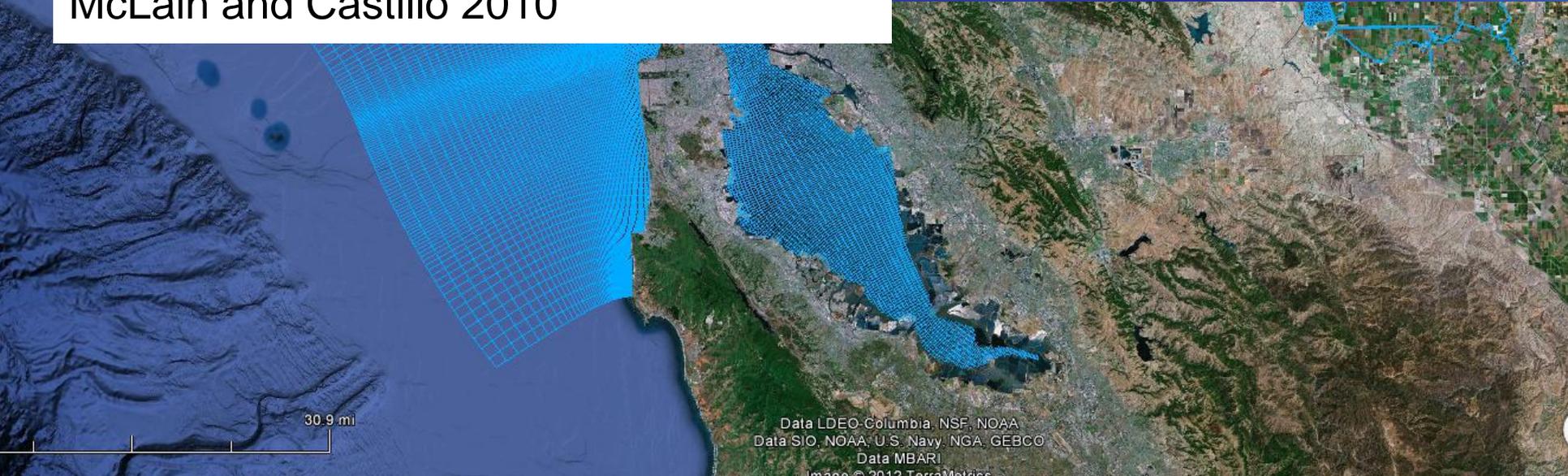
Sources:

USFWS, unpubl data, 2002-04, 2010-12

Harrell and Sommer 2003

Sommer et al. 2004

McLain and Castillo 2010

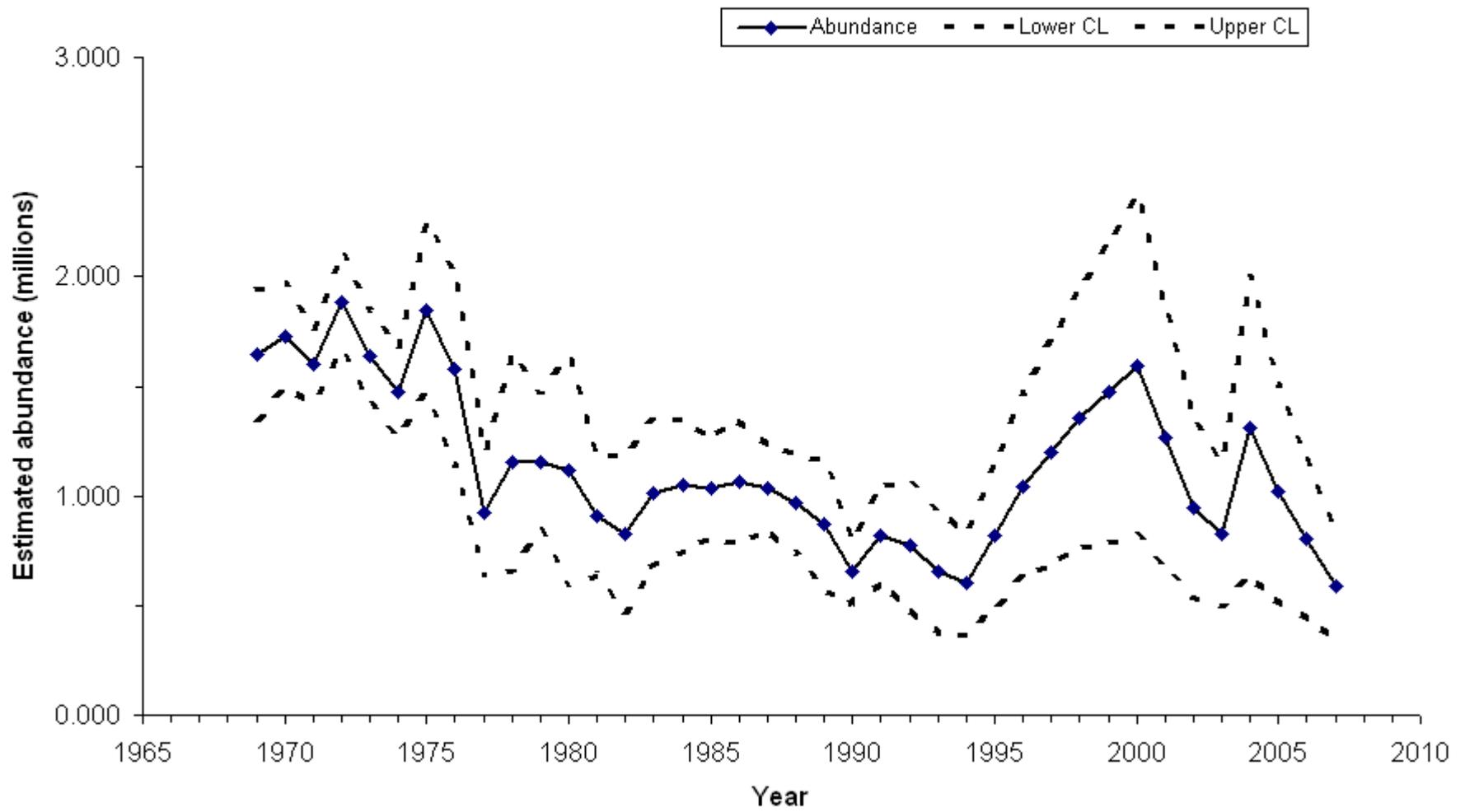


Introduced Predators



- Introduced in 1879 (135 fish)
- 10 years later: commercial fishery till 1935
- Adapted for high turbidity from mining
- Estimated population
 - 1960s: 2-3 million adult fish

Adult Striped Bass Abundance



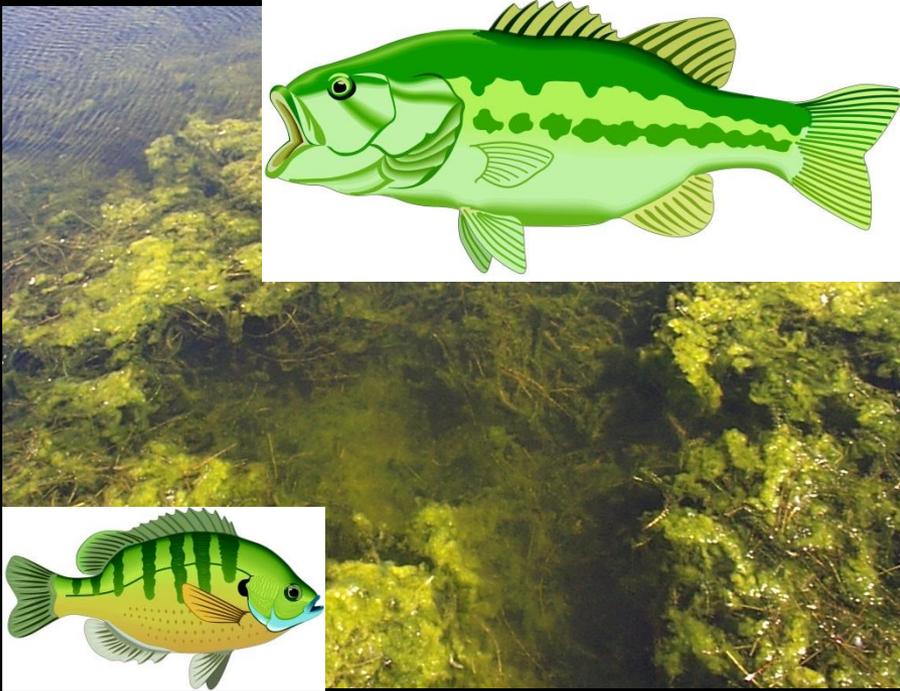
Egeria densa, invasive Ecosystem Engineer
(ca. 13% of surface area of Delta)



Egeria densa, Ecosystem Engineer



Egeria densa, Ecosystem Engineer



Egeria densa extremely important because it provides ideal habitat for many alien fishes

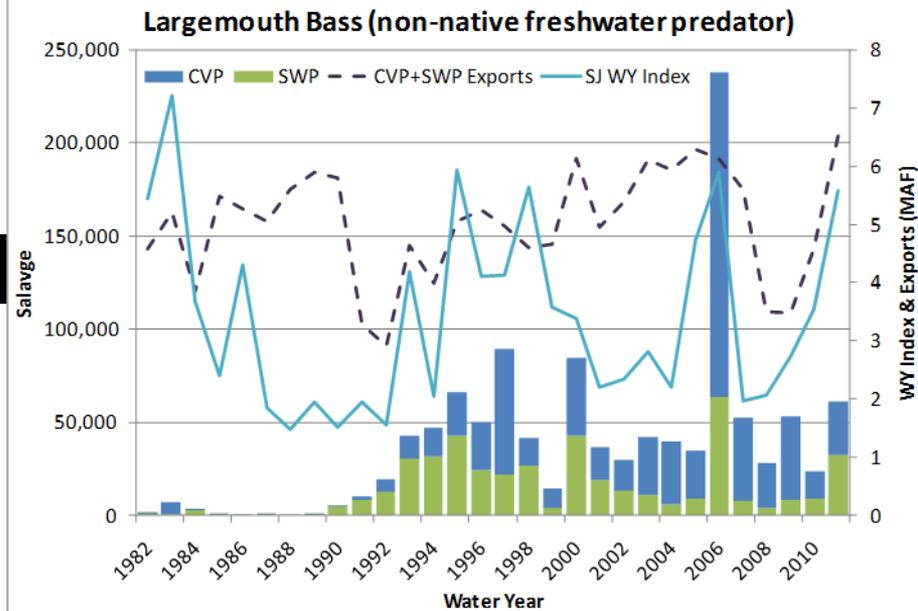
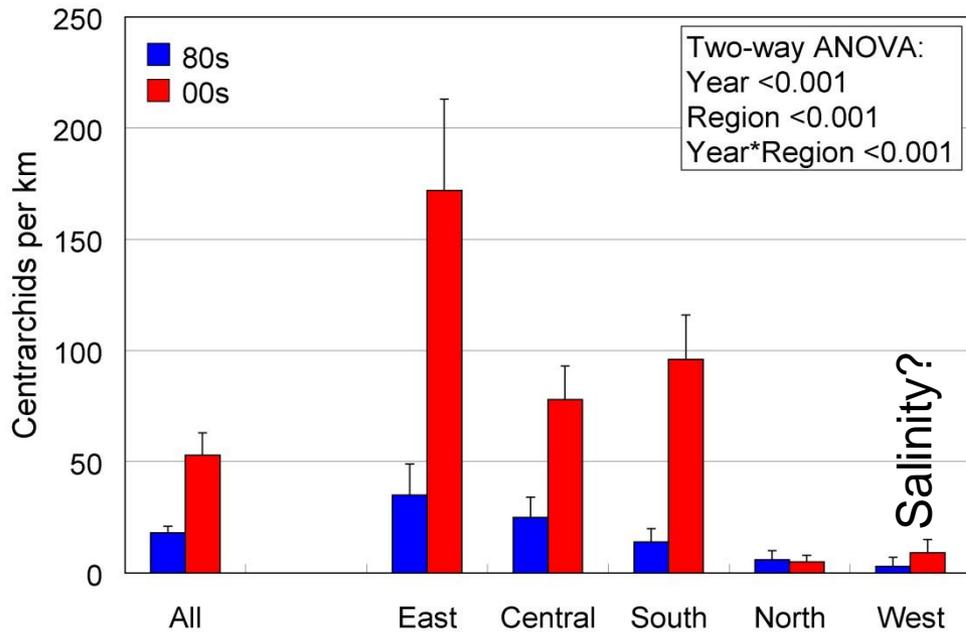
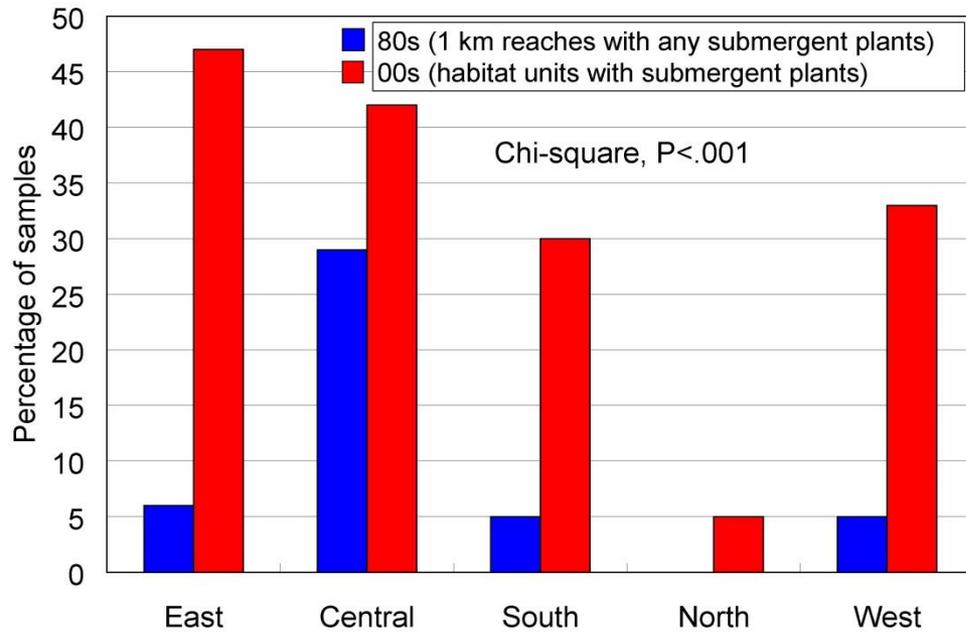


Introduced Predators



- Introduced in 1890s
- Increased in abundance as *Egeria densa* spread
 - 1980s-2000s
- World class fishery

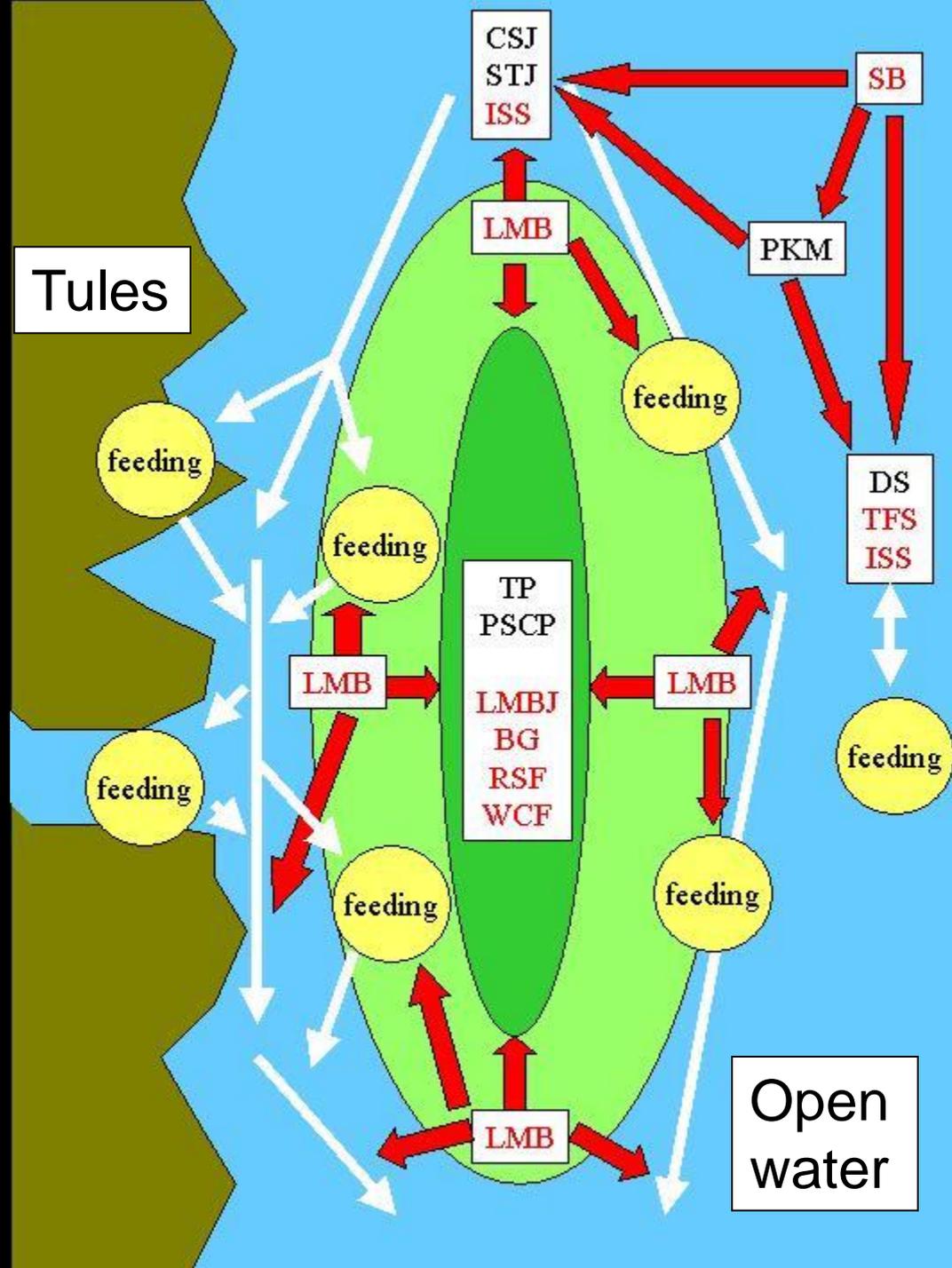
Introduced Predators



Brown and Michniuk 2007
SWP salvage data

FW tidal wetlands, *Egeria* can cause a disconnect

- White arrows = movement
- Red arrows = predation
- Red spp. are alien
- Dark green = dense *Egeria*
- Light green = sparse SAV



Invasive Clams Have Caused Changes in Food Web

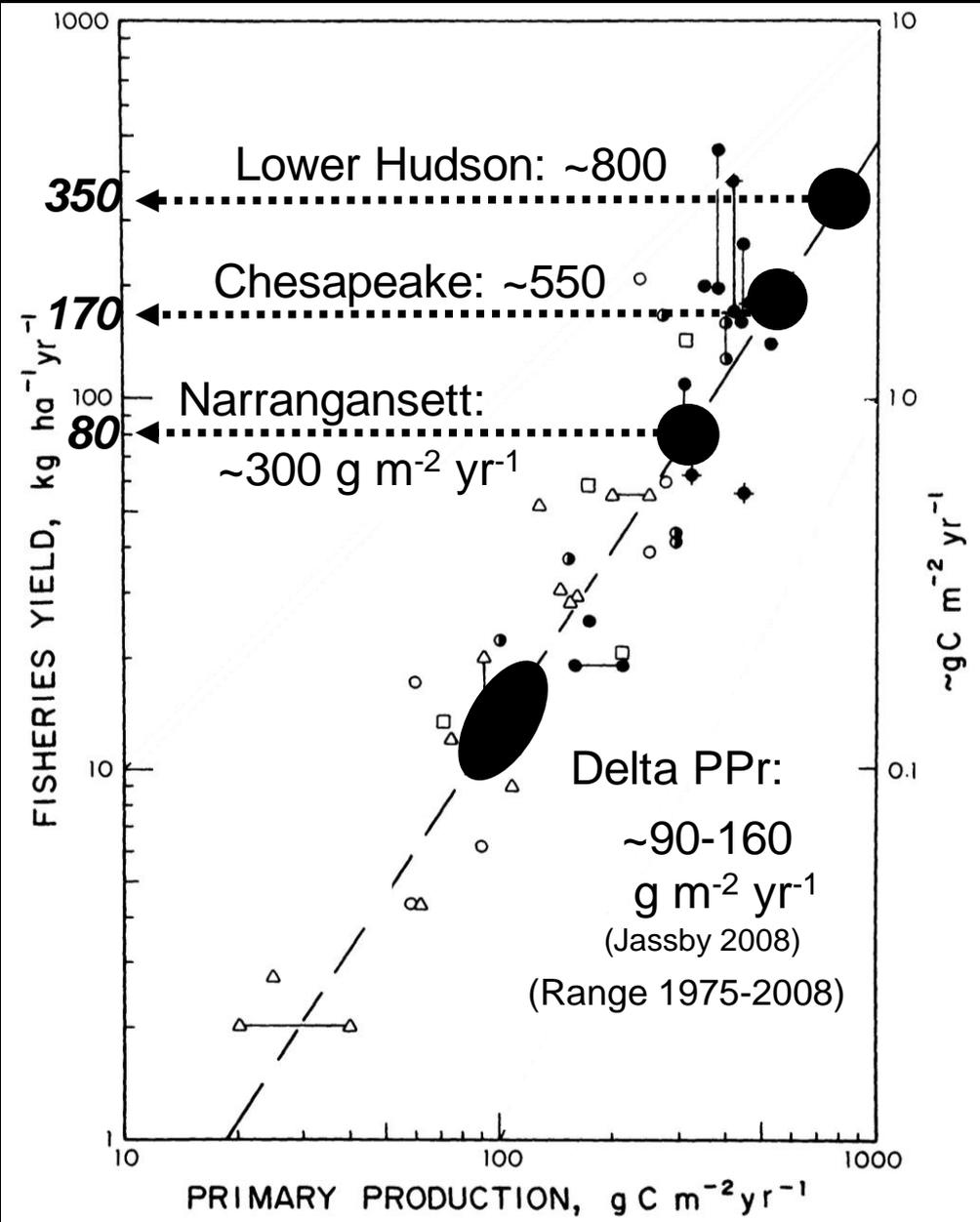


Corbicula fluminea
freshwater, 1940s



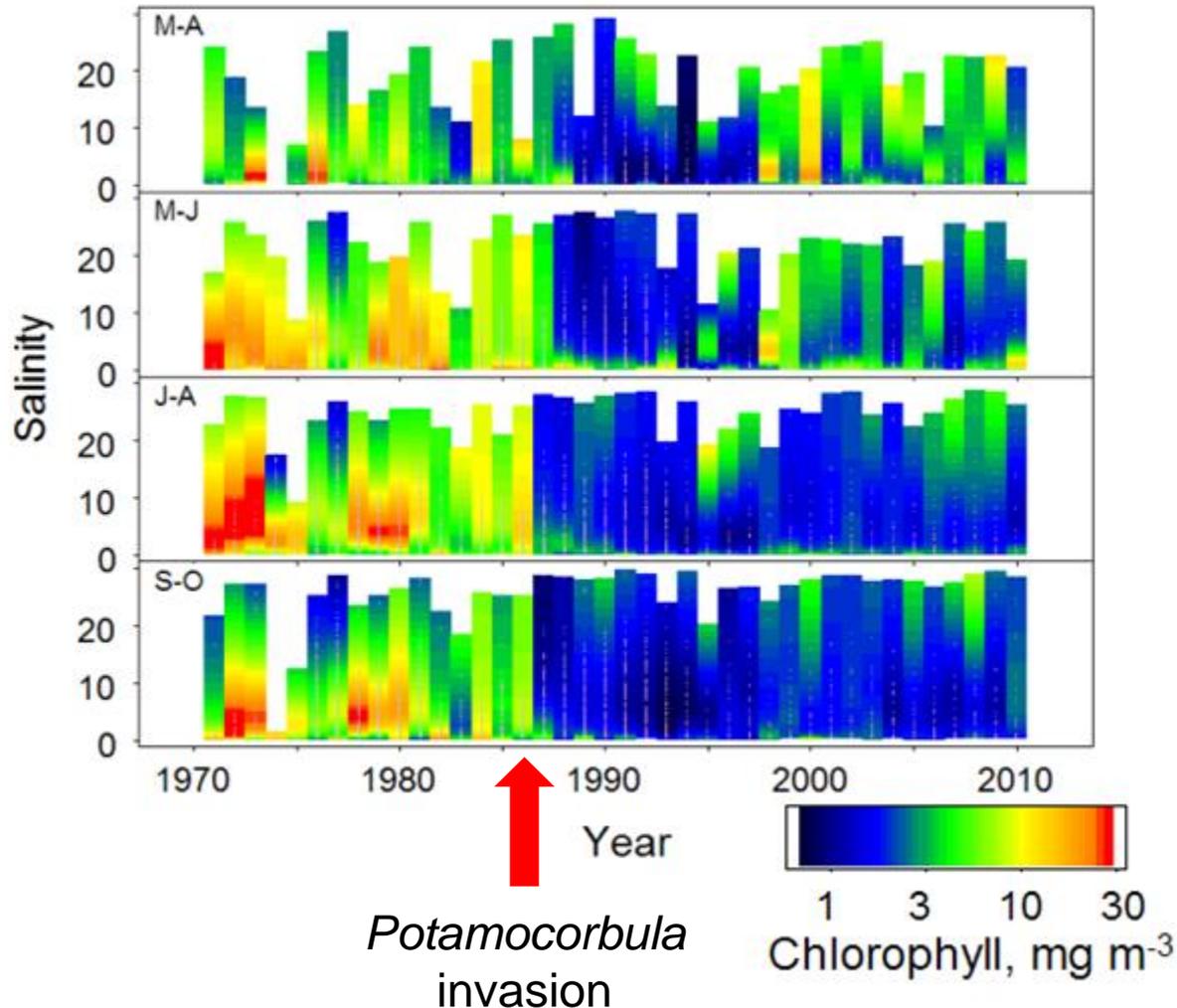
Potamocorbula amurensis
brackish water, 1986

The Delta Has Never Been a Productive System (light limited)

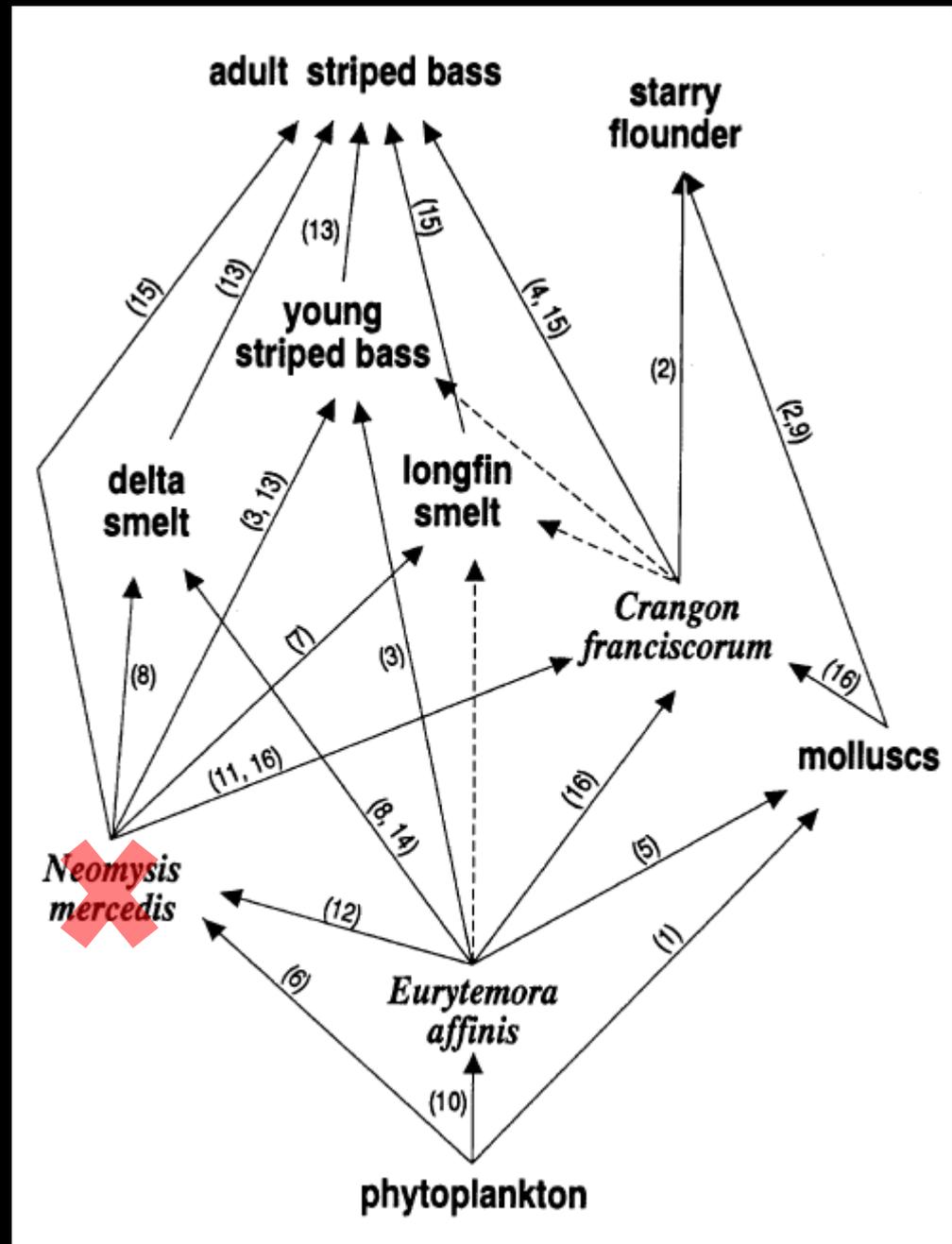


(modified from Nixon 1988, using results in Jassby 2008 and Jassby et al. 2002 and data provided by James Cloern, U.S. Geological Survey).

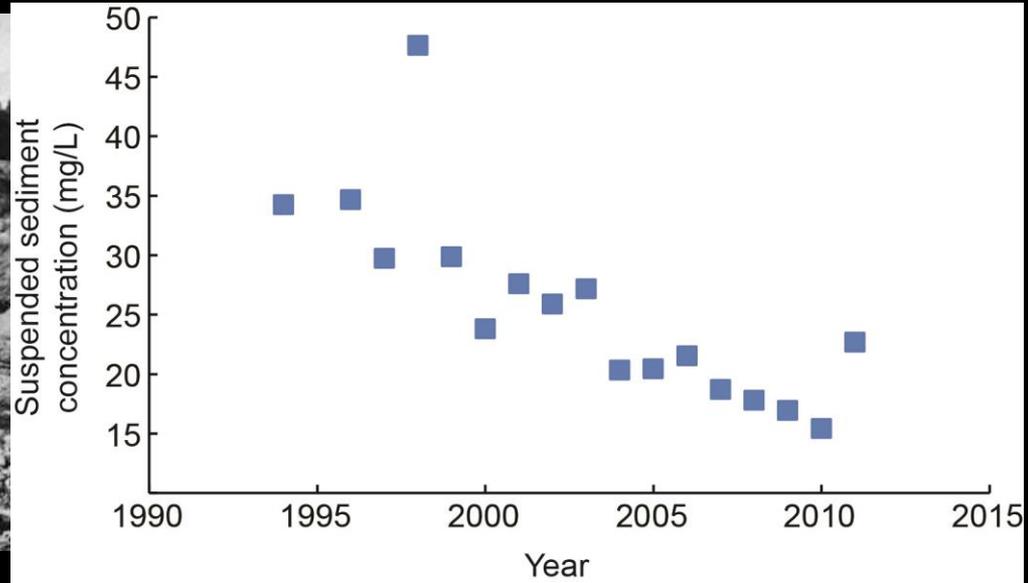
Clams Suppressing Phytoplankton Biomass



Neomysis mercedis
a key prey for many
species collapsed
(competition and
predation)

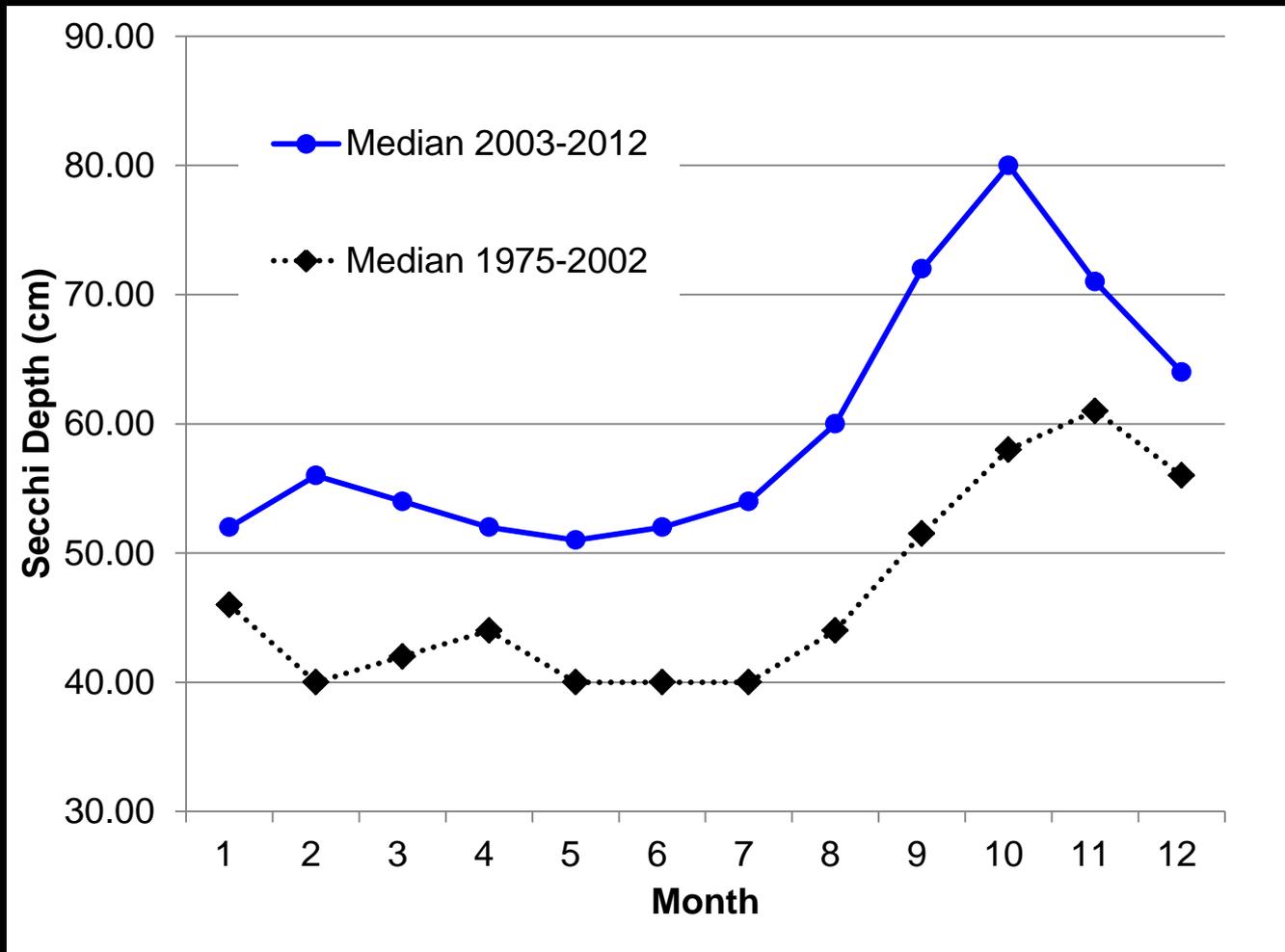


What About All That Mud...Gone!



- 50% decrease in Sep-Oct 1994-2011
 - Morgan and Schoellhamer, unpublished data)
- 50% decrease in Delta TSS 1975-1995
 - Jassby et al. 2002
- 36% decrease in SSC in SF Bay, as mining sediment depleted
 - Schoellhamer 2011

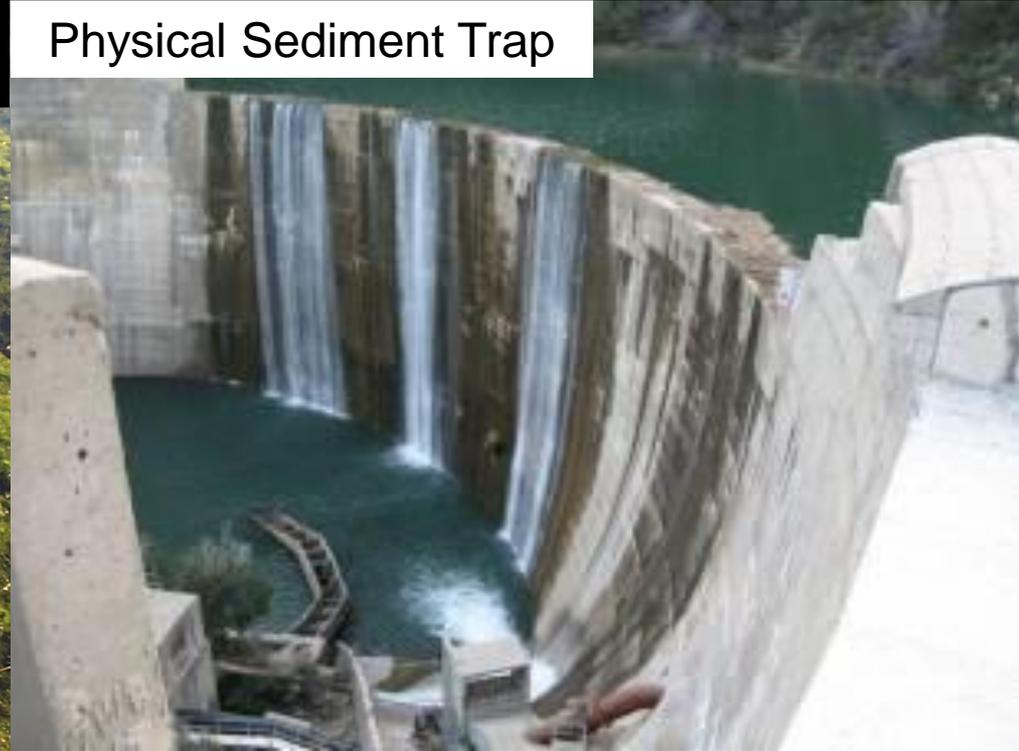
What About All That Mud...Gone!



Water clearer by 10+ cm

What About All That Mud...Gone!

Physical Sediment Trap



Biological Sediment Trap



Prevent Bank Erosion



The Future of Delta Ecology

- We can't go back

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- Habitat restoration will be an important tool in the way forward

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- Restoring and reconnecting habitats likely a good idea for aquatic ecosystems
 - Challenge: our desire to channel benefits to a subset of currently rare consumers

The Future of Delta Ecology

- We can't go back
- Habitat restoration will be an important tool in the way forward
- Restoring and reconnecting habitats likely a good idea for aquatic ecosystems
 - Challenge: our desire to channel benefits to a subset of currently rare consumers
- Expect change, it is inevitable
 - Climate change, invasions, other?
 - Retain flexibility to adapt