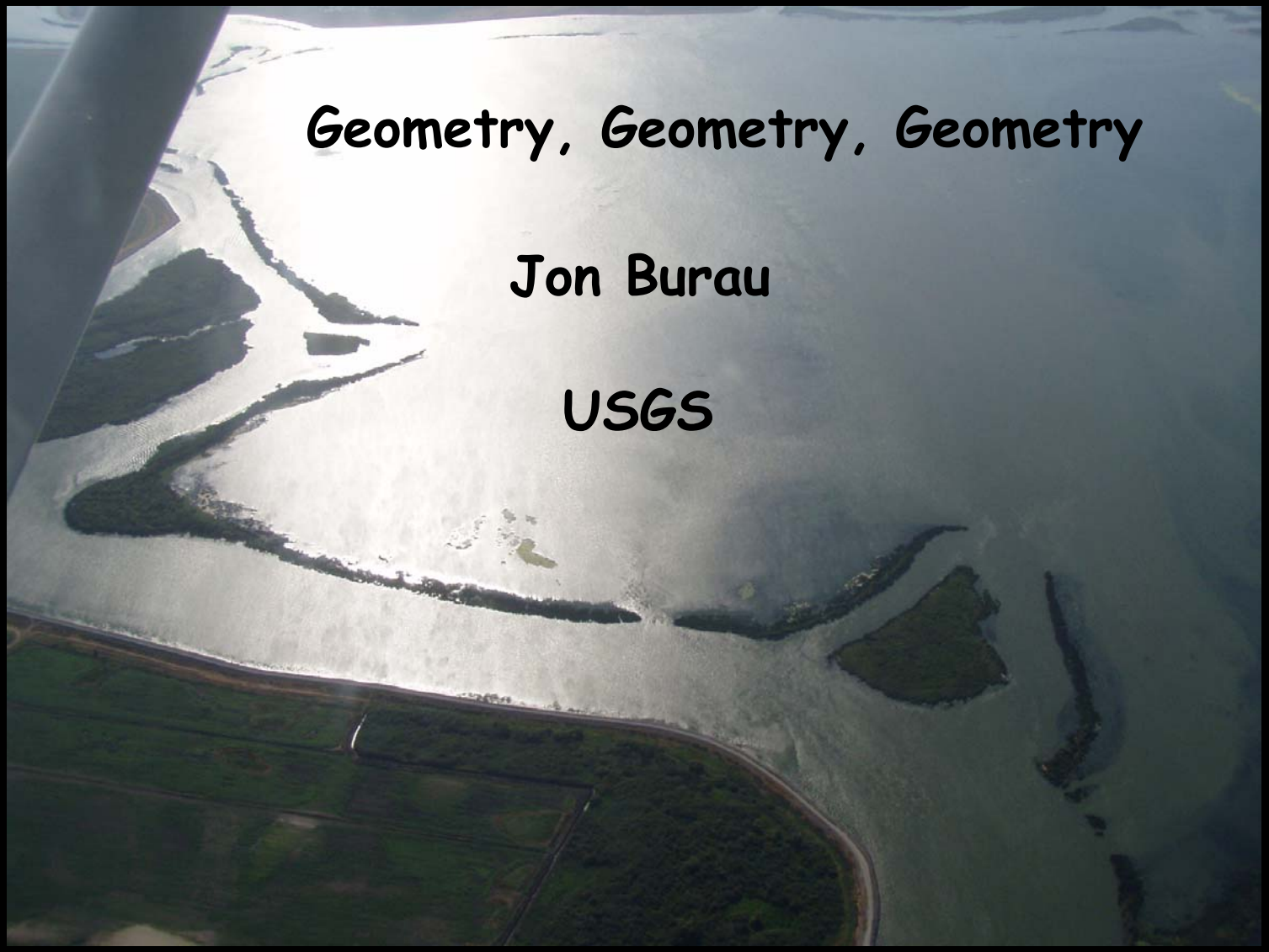
Variable Delta – A Hydrodynamic Perspective



USGS

JRB

Historical Perspective

Three major anthropogenic changes to the Delta:

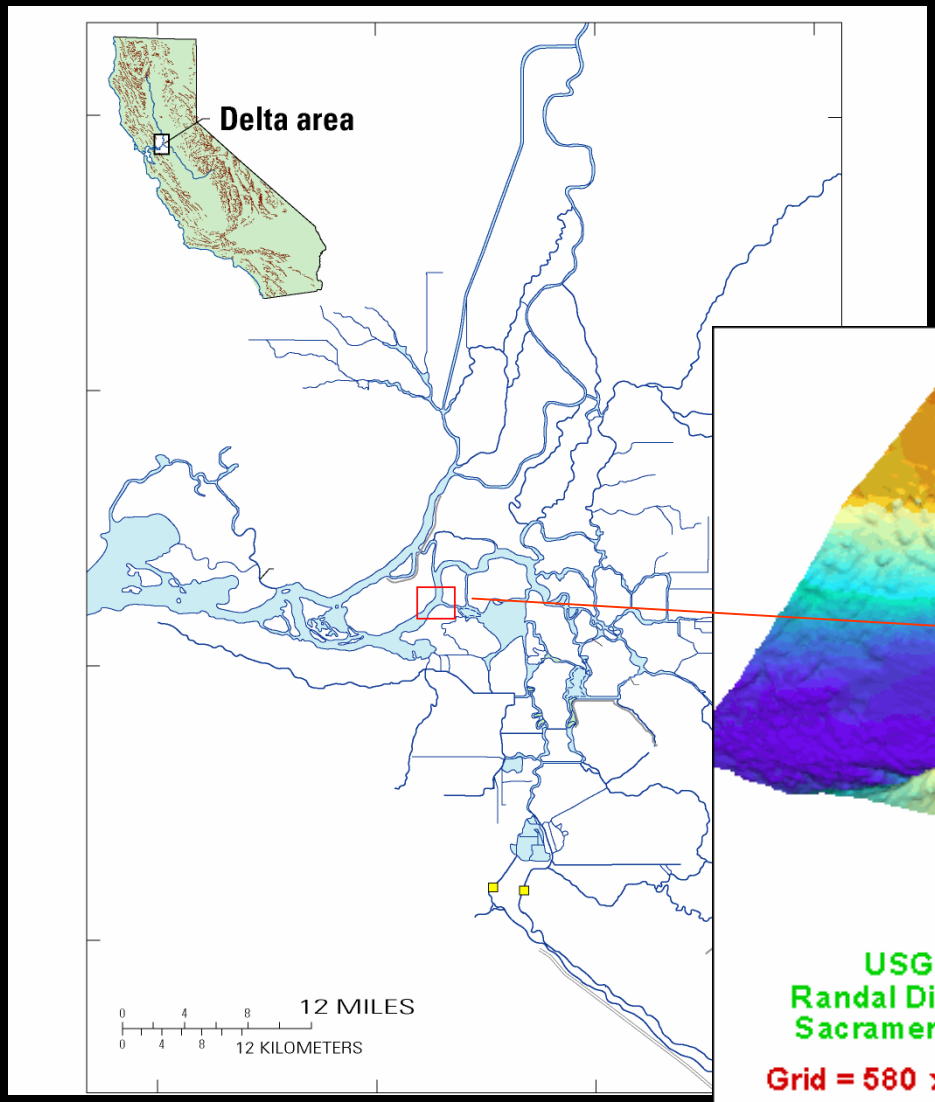
(1) Agricultural Reclamation
(changes in geometry – levees)

(2) Constructed Dams
(flood protection – water supply)

(3) Export Water from the Delta

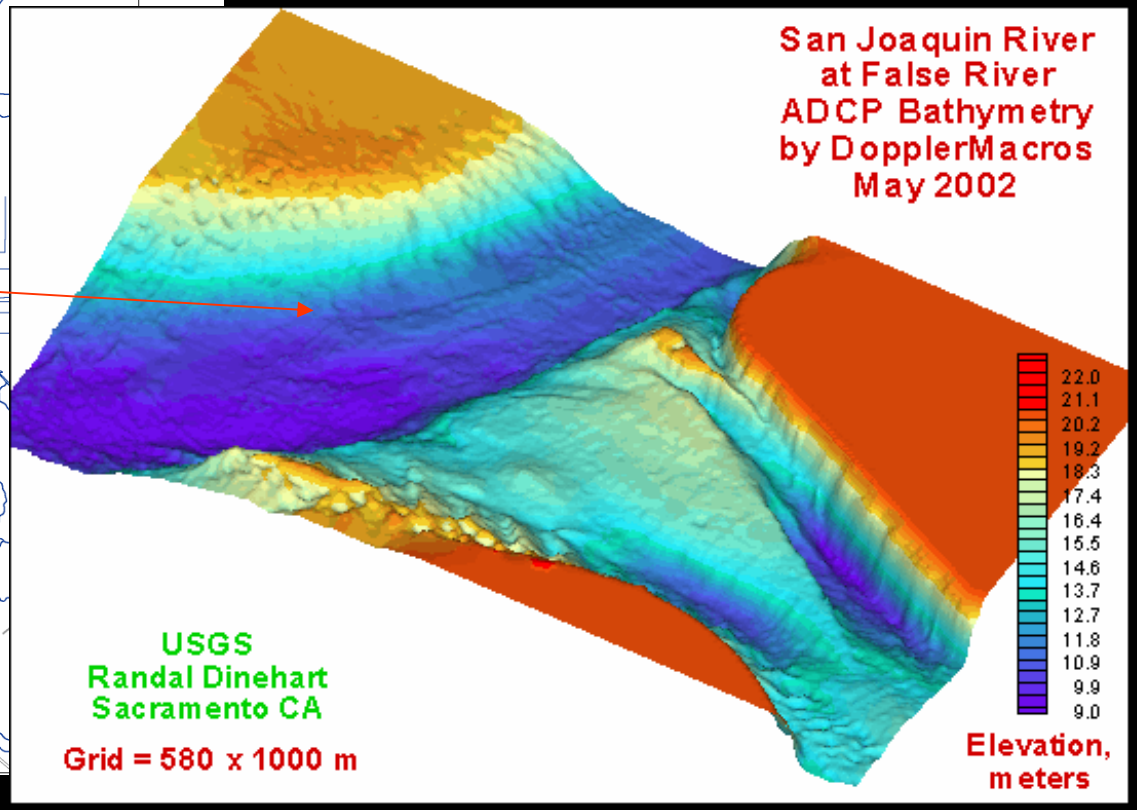
What do I mean by Geometry?

Horizontal Plan Form



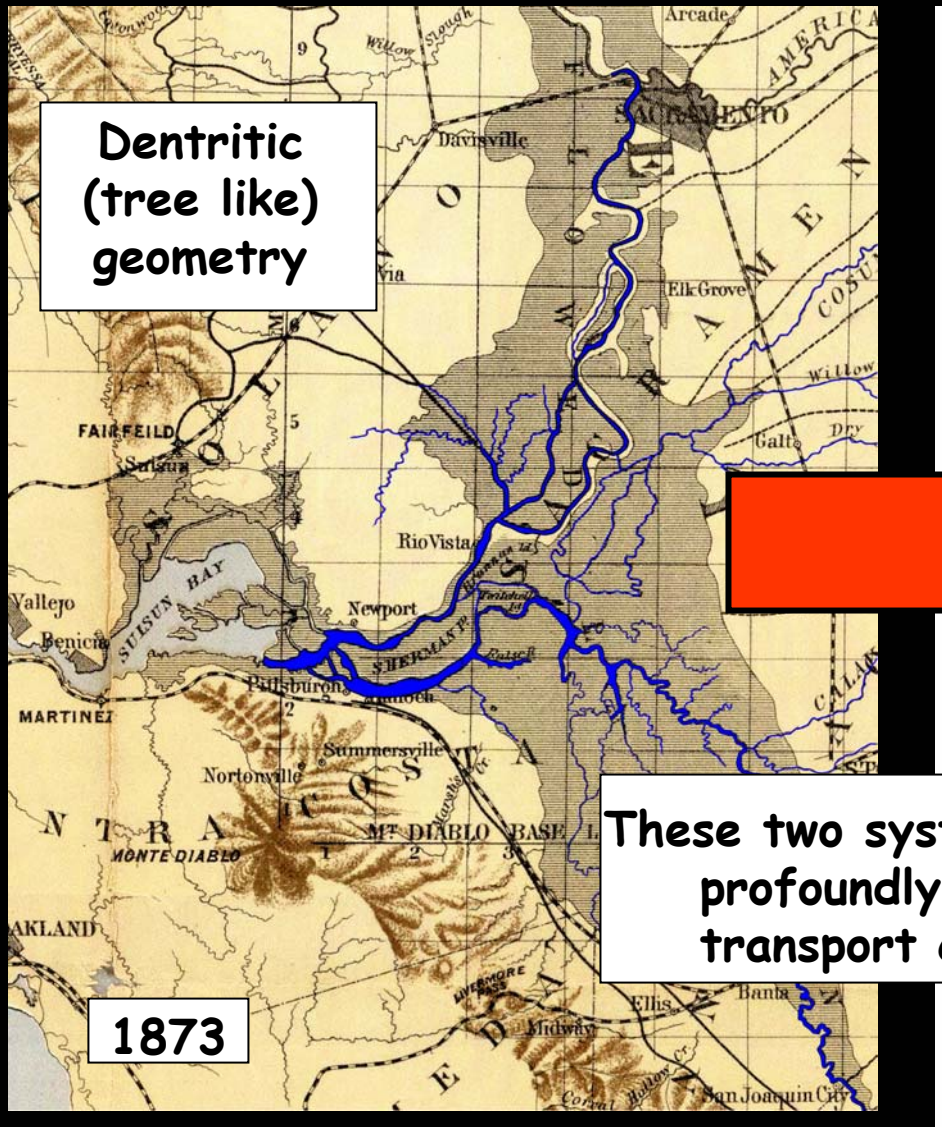
Bathymetry

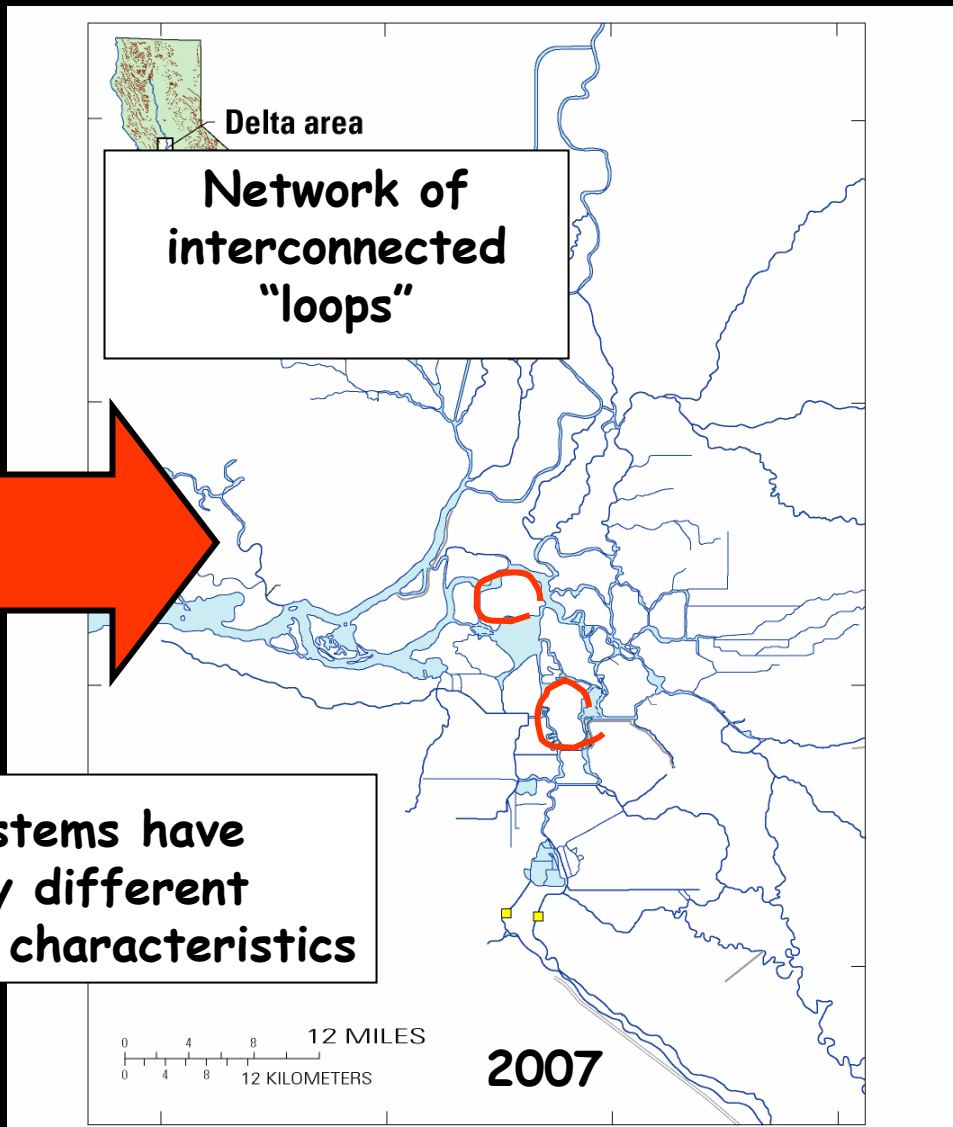
(bottom topography)



(1) Agricultural Reclamation

The geometry of the Sacramento/San Joaquin Delta has been incredibly manipulated by man





These two systems have profoundly different transport characteristics

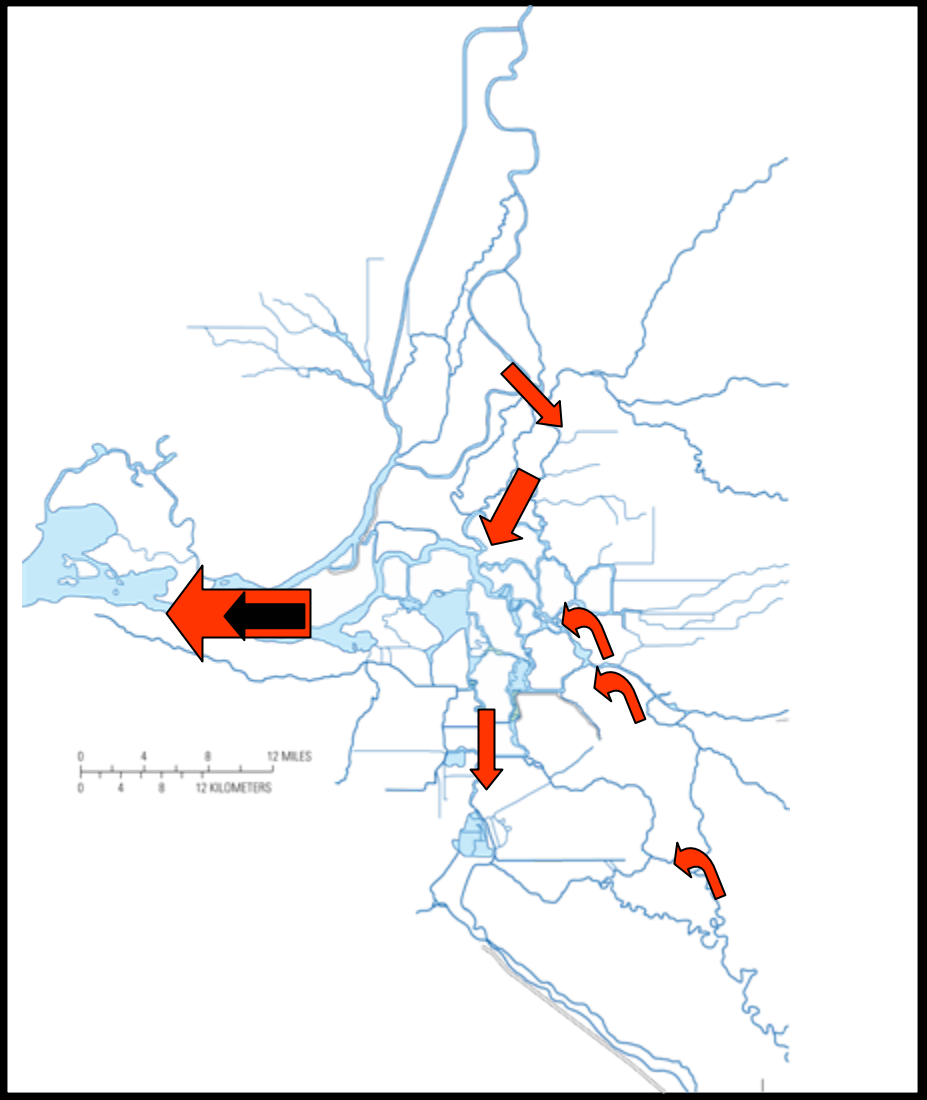
(2) Constructed Dams
(flood protection – water supply)

Salmon: reduction in spawning areas

Delta: Change in the timing and magnitude of river inputs

Change in the position and structure of the salt field

(3) Export Water from the Delta



Change in the position and structure of the salt field

Which had (has) the greatest impact on ecosystem function?

(1)Changes in Geometry

(2) Dams
(reservoir releases)

(3) Export of Water from the Delta

When I think of "variable Delta"
I think heterogeneity –in all things
(velocity gradients, residence times,
nutrients, algae, zooplankton – and salinity)

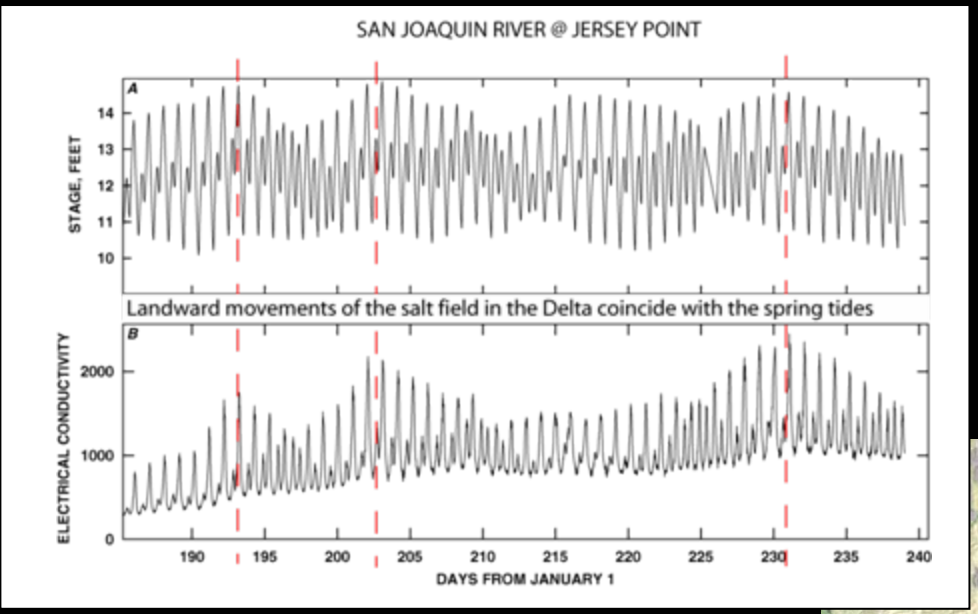
One of the best ways to create heterogeneity
in aquatic ecosystems is geometric variability

What does "variable Delta" mean to:

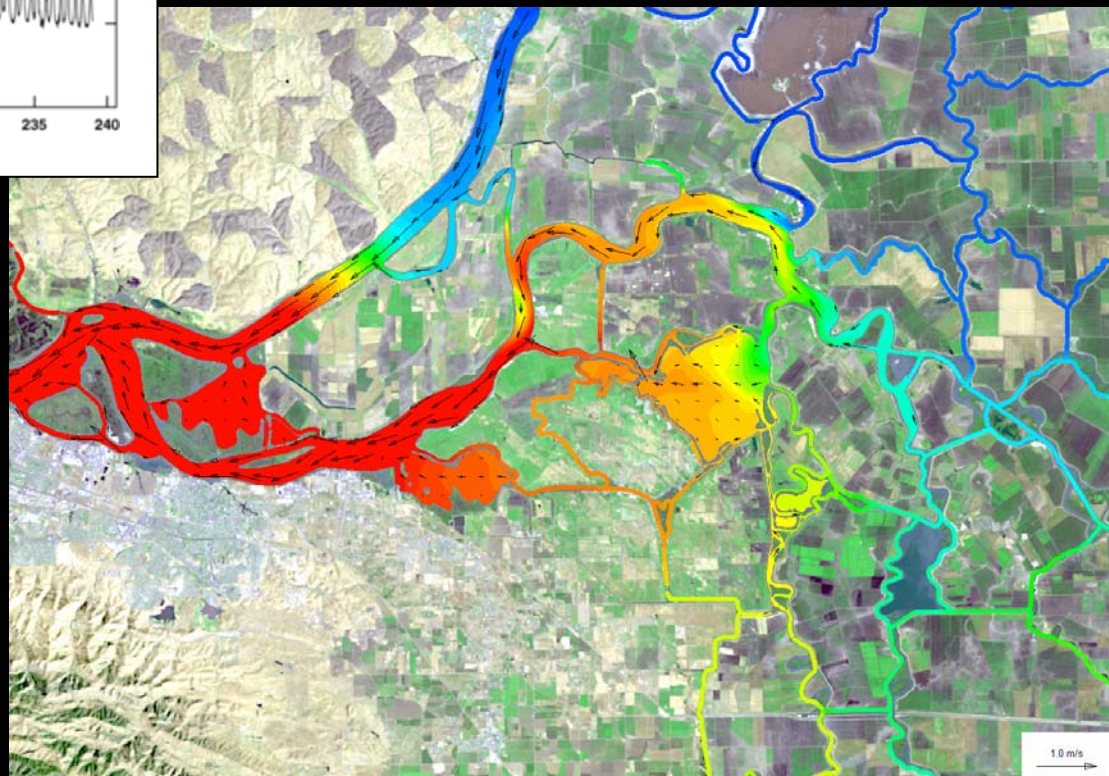
(a) Pelagic organism (Lagrangian)

(b) Benthic Organism (Eulerian)

Most of "variability" in Delta involves Slowly evolving gradients sloshing back and forth



Eulerian – Benthic reference frame

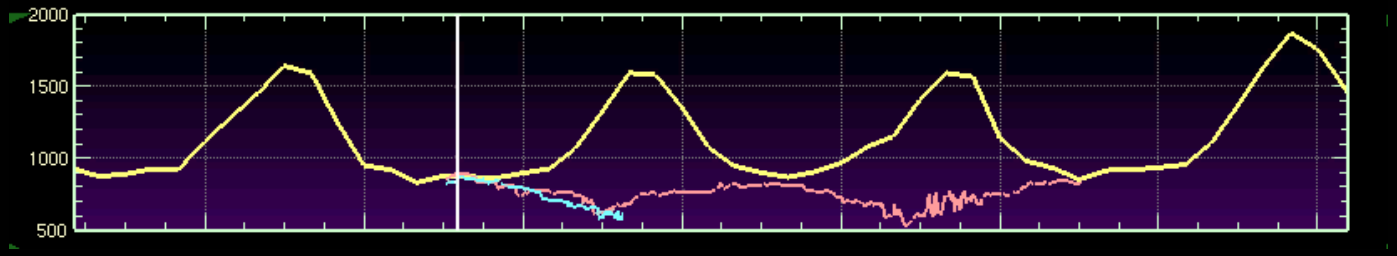


Pelagic Organisms move with the water

Courtesy of RMA

Variability – Euler vs Lagrange

Aug. 12, 2002 at 03:30 PM



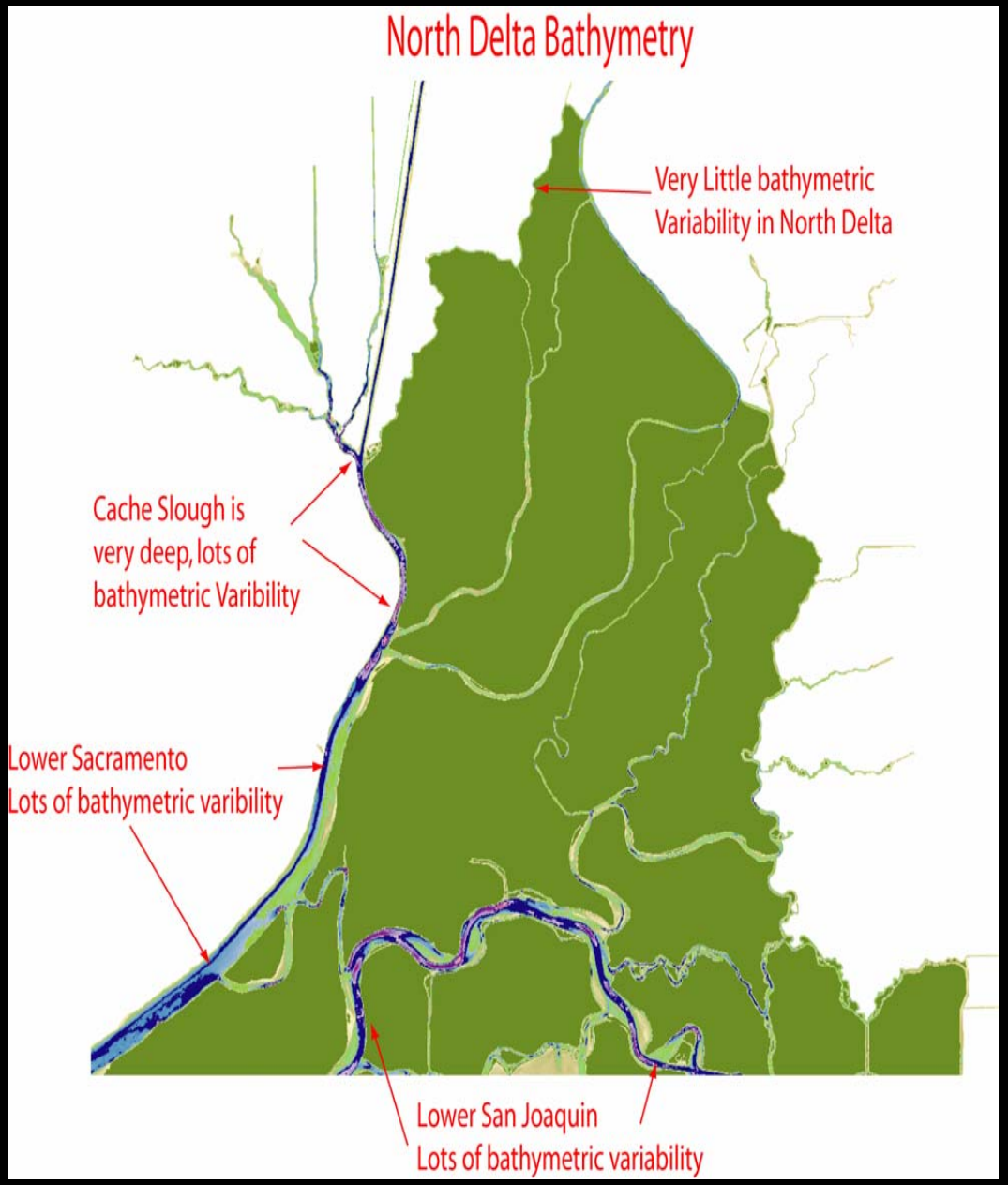
Primary message:
Geometry has an incredible influence on transport

Secondary message:
Delta's geometry (at local and regional scales) creates homogeneous pelagic habitats

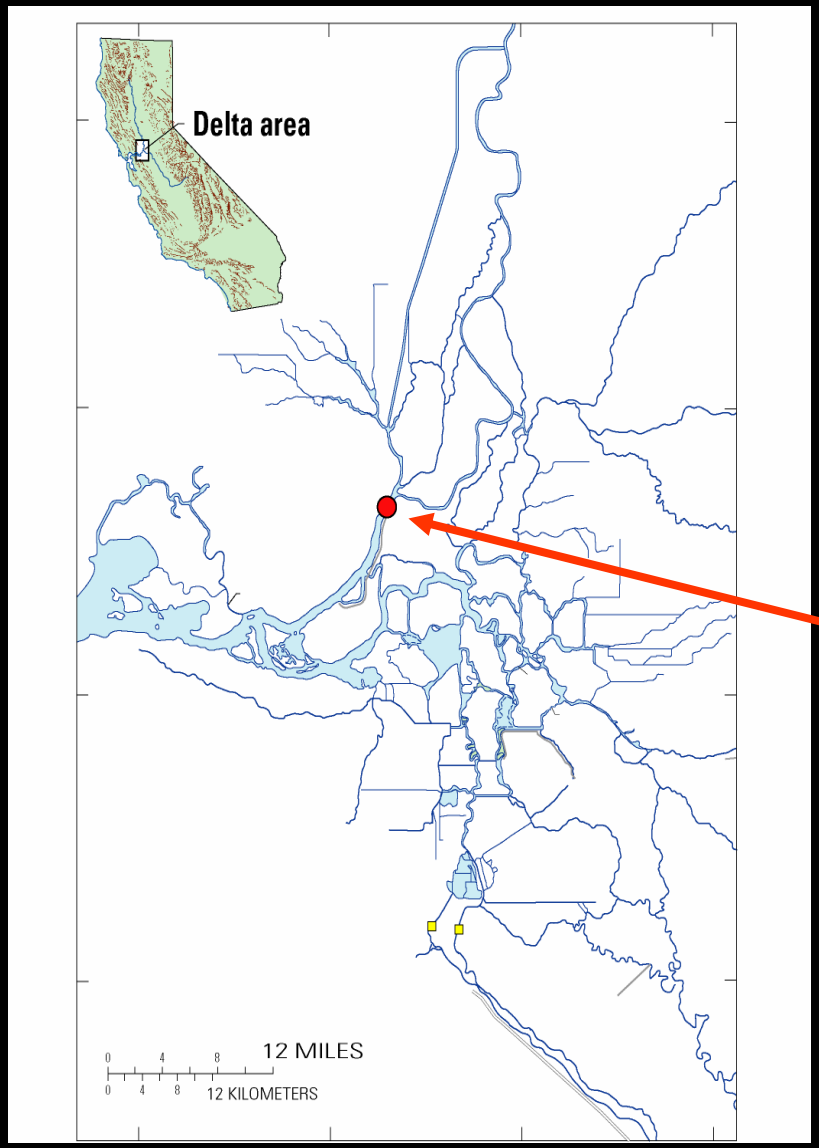
Discuss Geometric impacts on transport at two scales:
(1) Channel (local) scales, (2) Regional scale

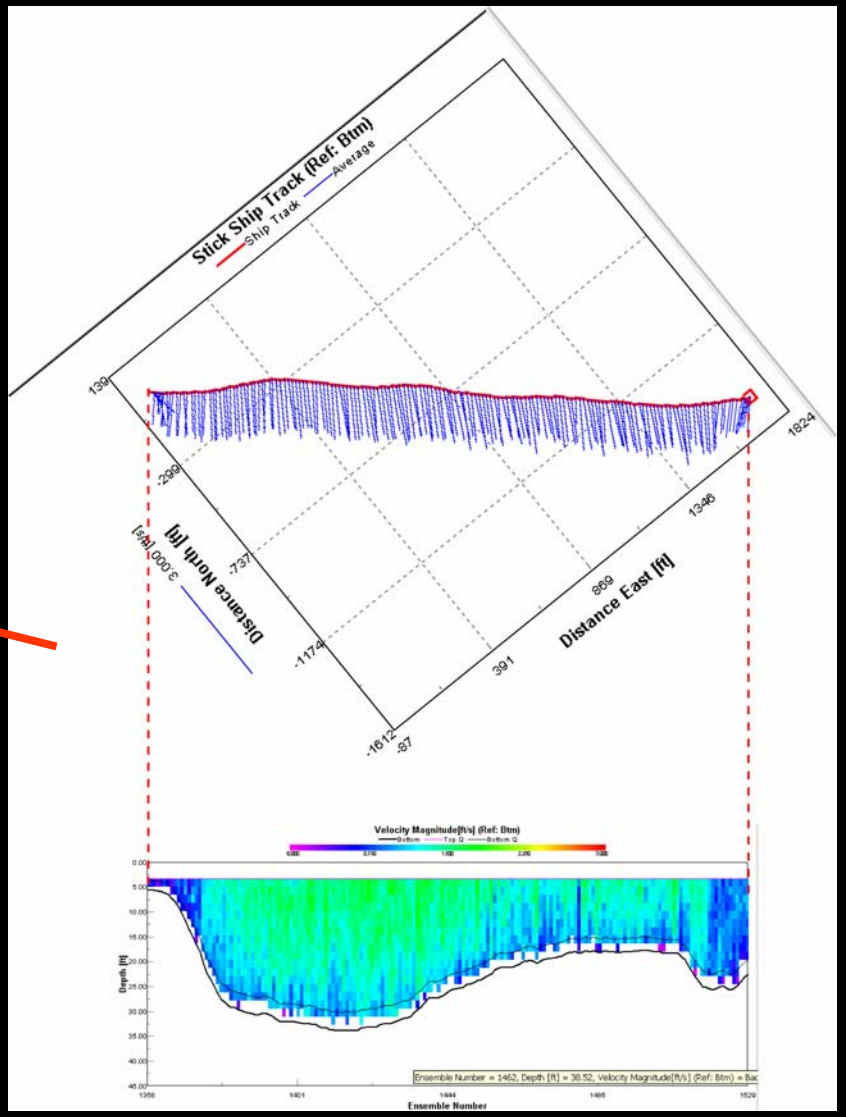
Geometry at local scales

North Delta Bathymetry has very little within-channel variability



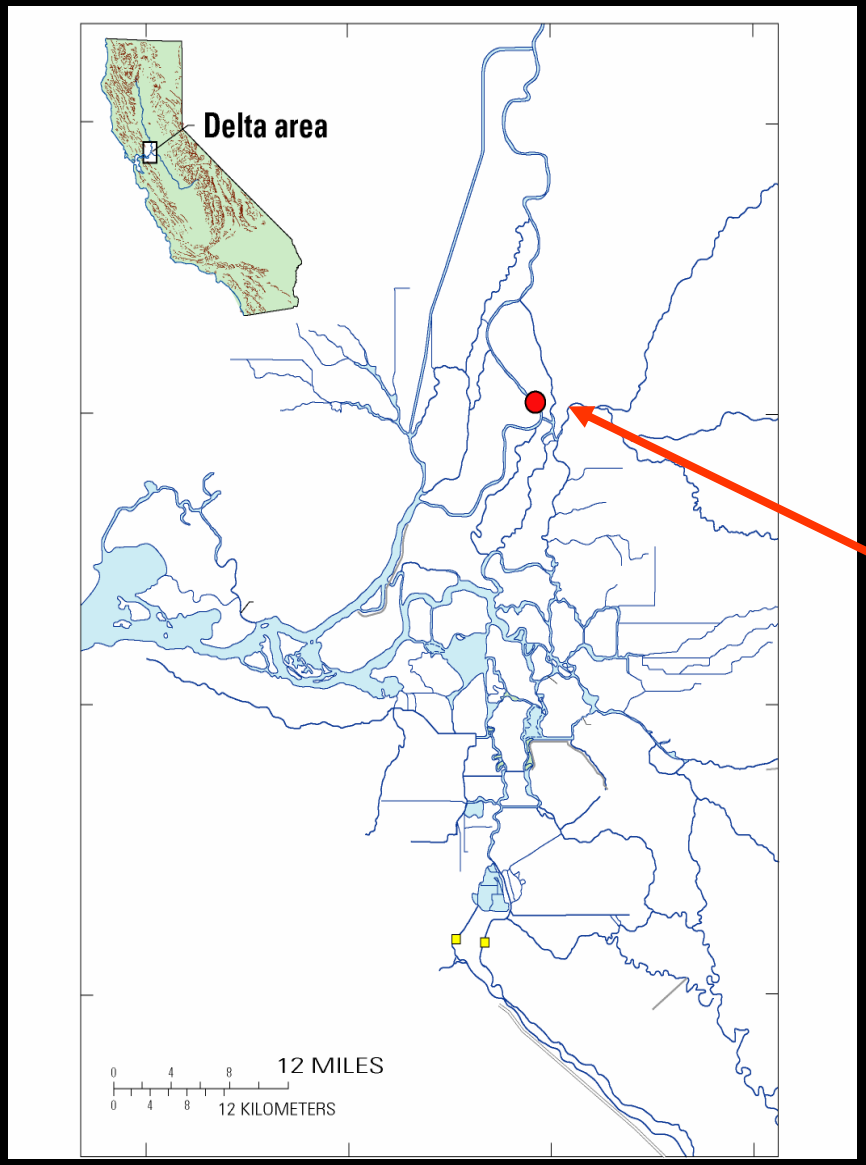
Cross Sectional Current variability
Rio Vista

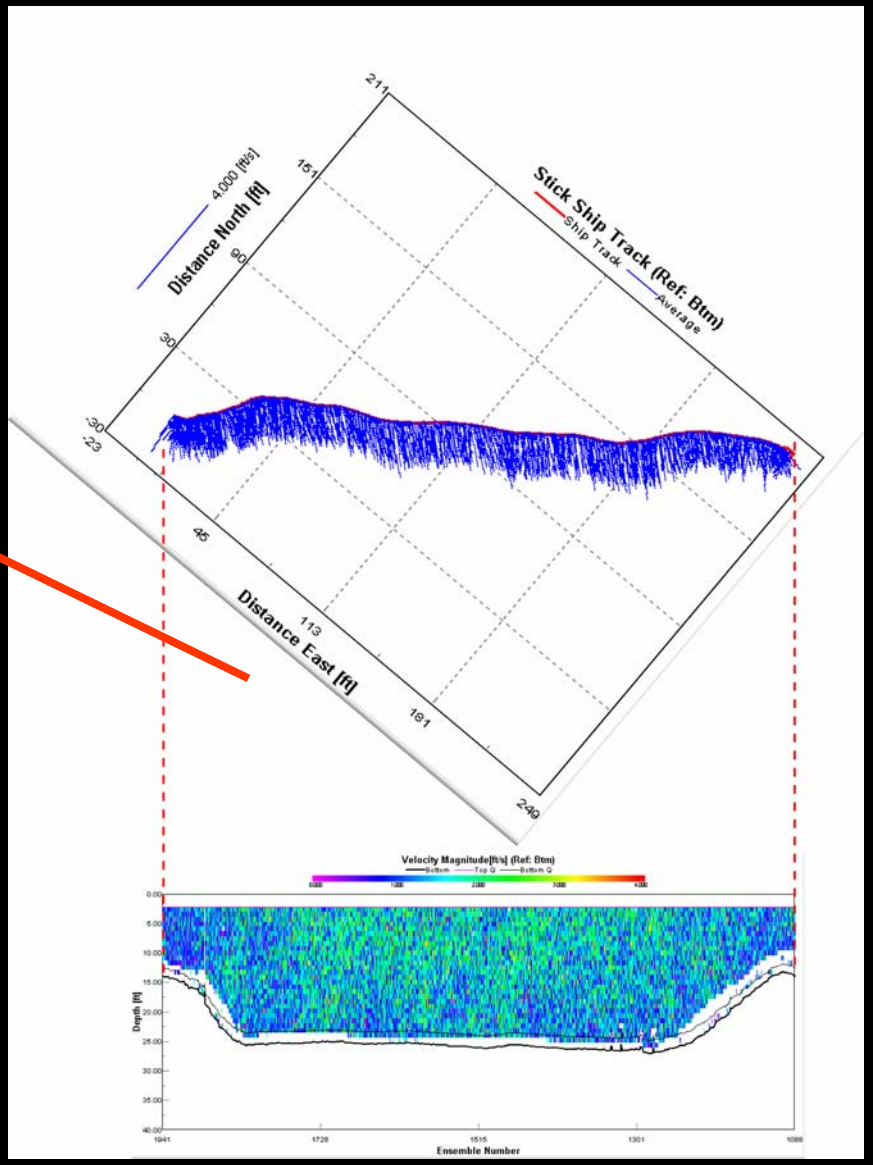




Cross Sectional Current variability

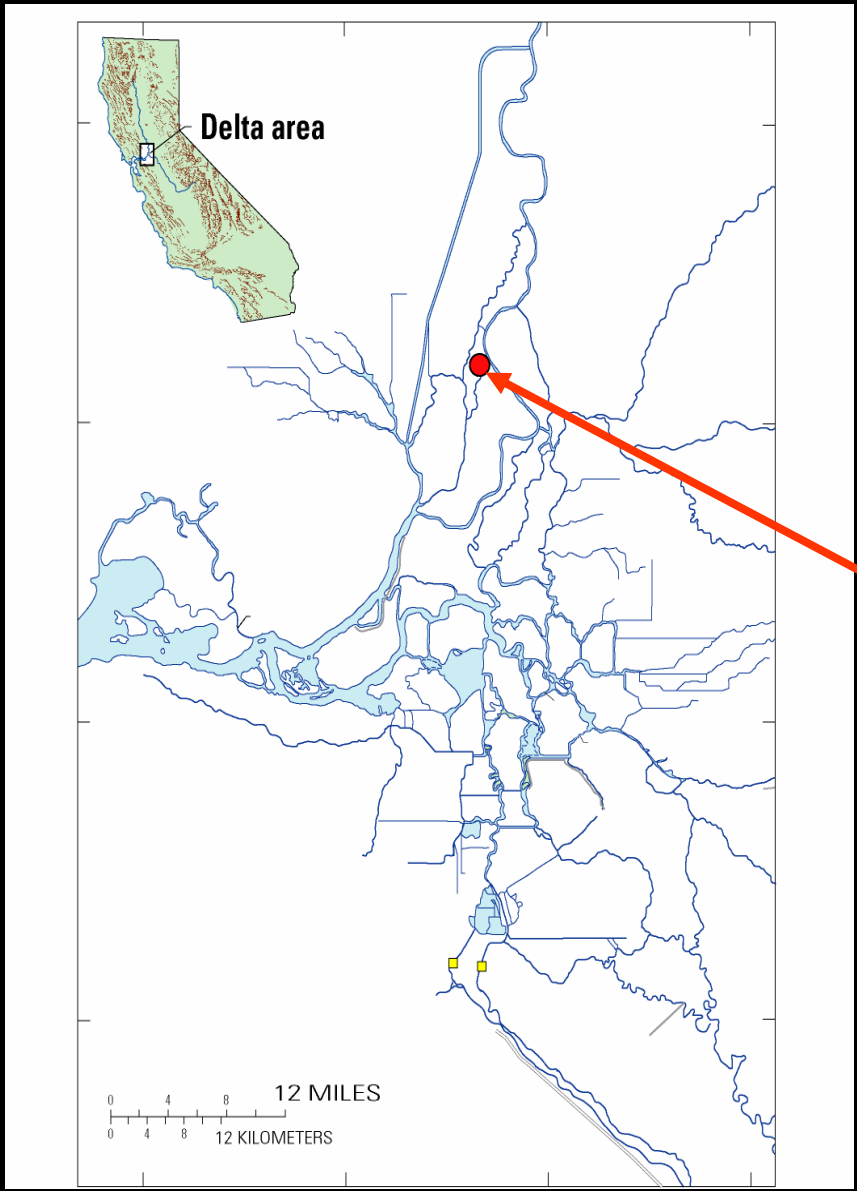
Sacramento River Below Walnut Grove

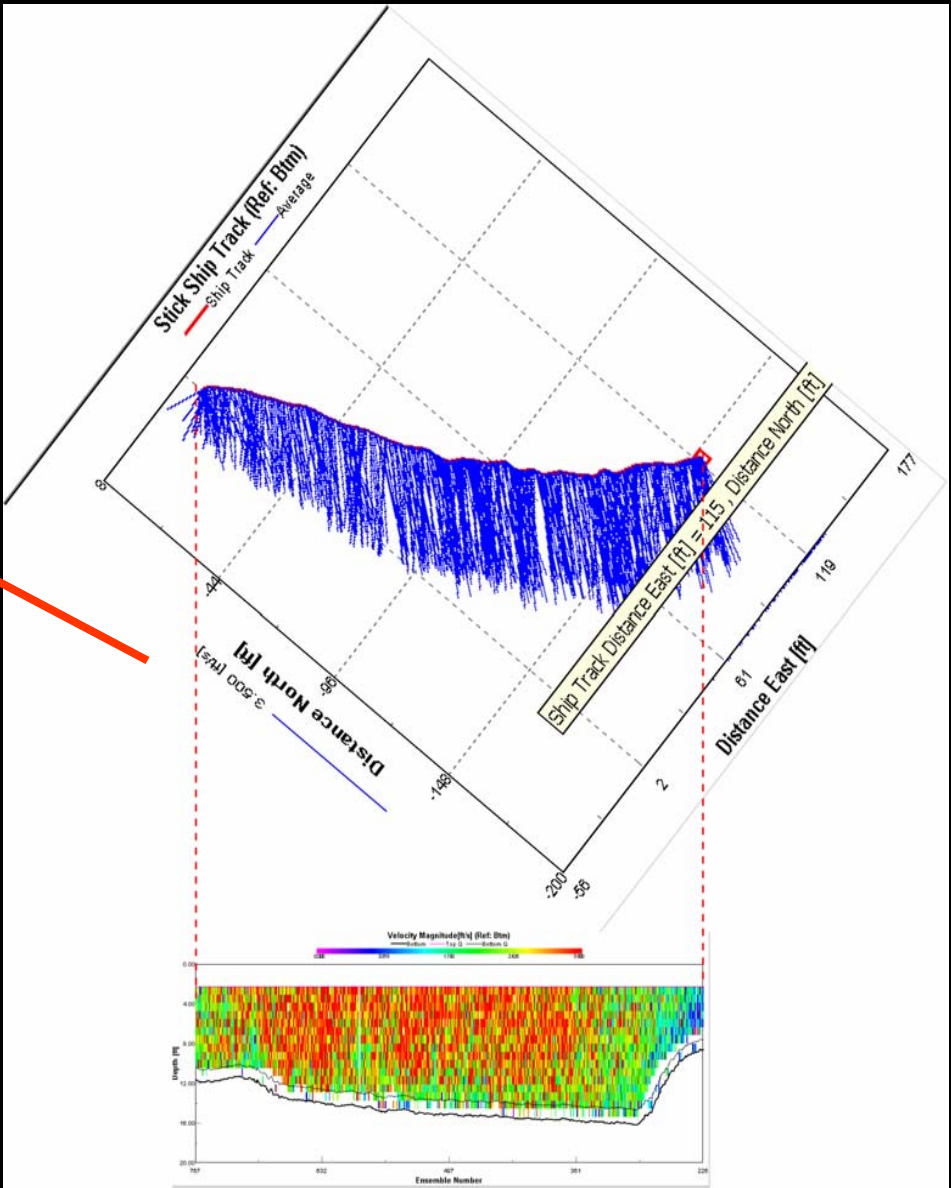




Cross Sectional Current variability

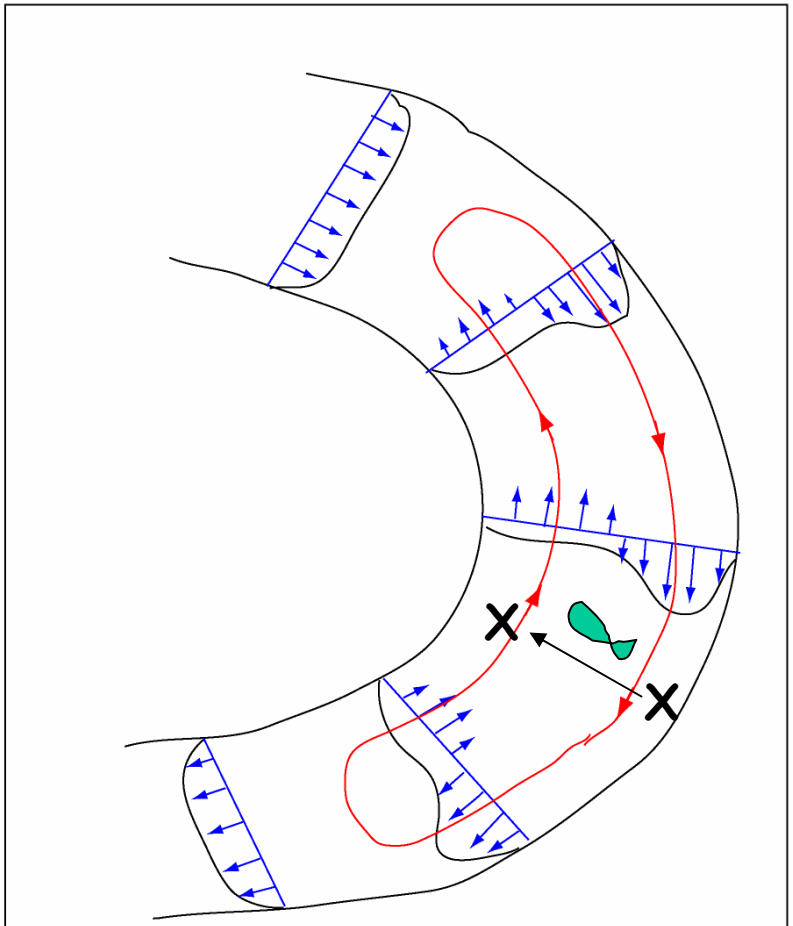
Steamboat Slough



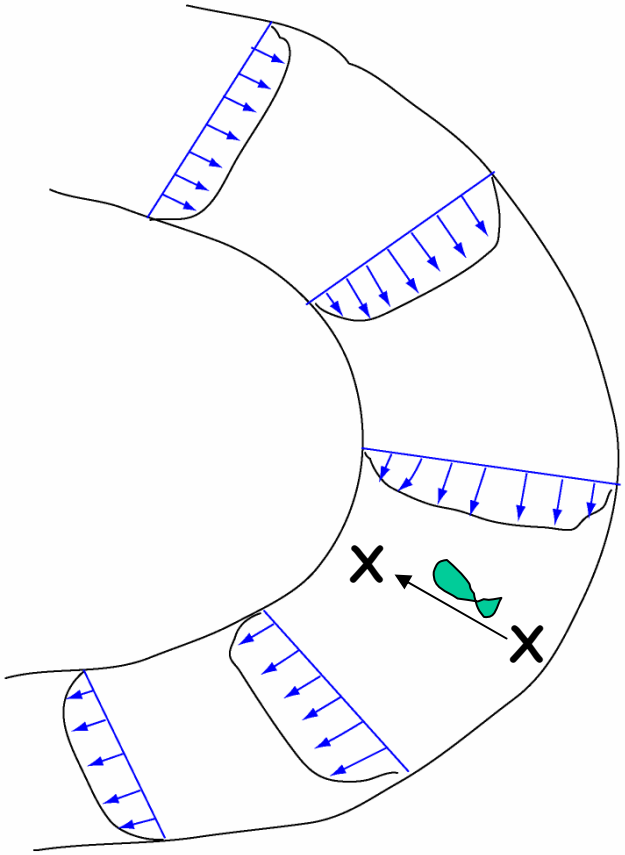


Velocity Structure

Unconfined channel vs confined channel



Natural Channel
Bathymetry variability -> Velocity structure



Armored Channel
Lack of bathymetry variability -> weak velocity structure

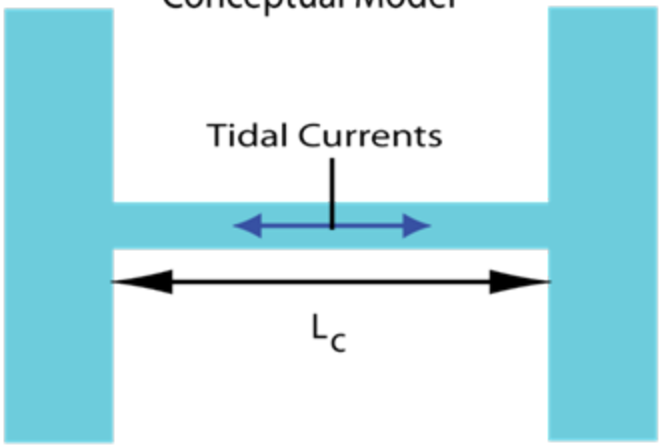
Armored Channels create pelagic environments lacking in hydraulic diversity

Most channels in Delta geomorphologically somewhere between natural river and concrete lined canal

Geometry at network scales

Network Dispersion

Conceptual Model



If $\gamma = \frac{L_u}{L_c} > 1$: system is dispersive

If $\gamma = \frac{L_u}{L_c} < 1$: system is advection dominated

L_c = Channel Length

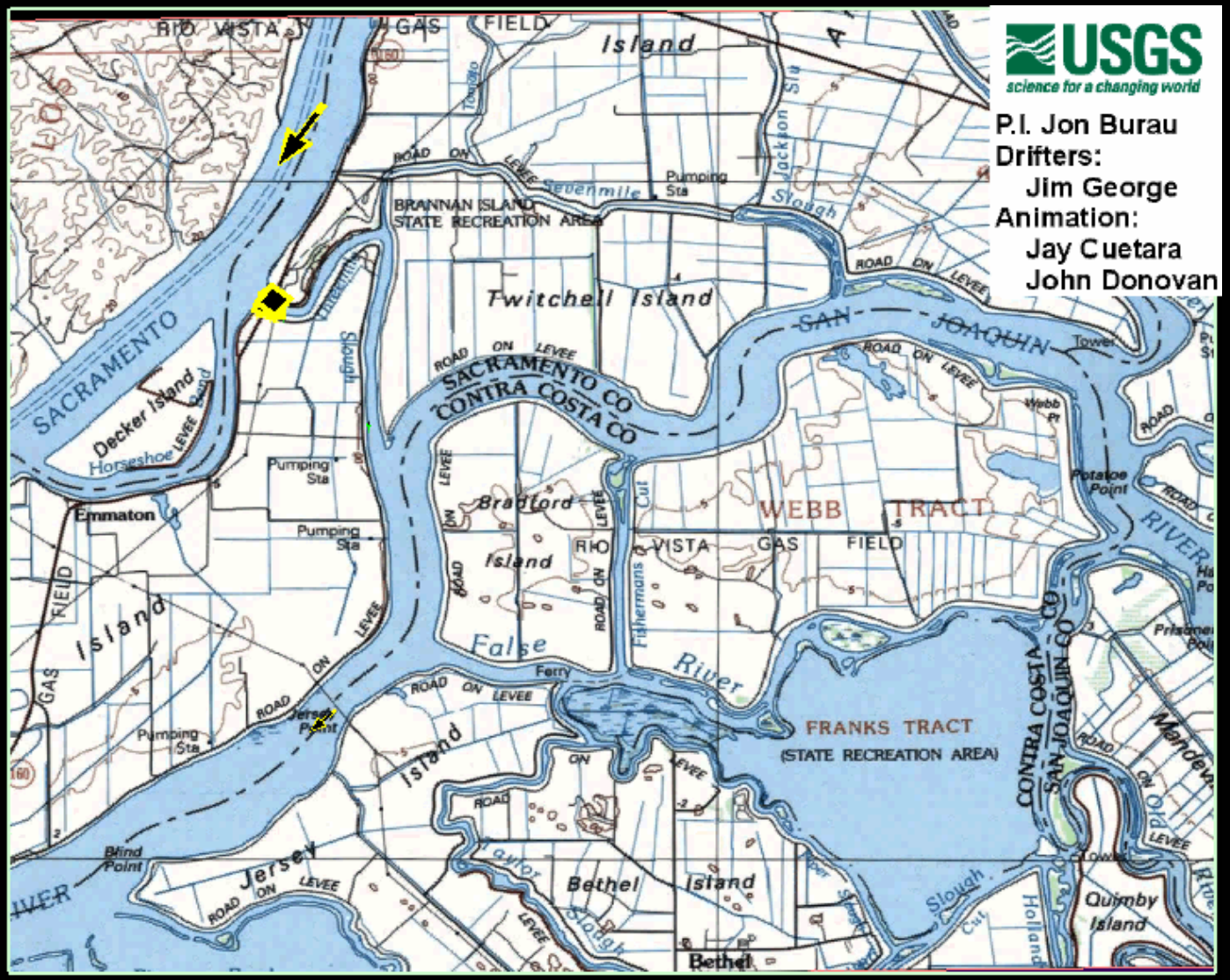
L_u = Tidal excursion

$$L_u \sim \frac{U*P}{\pi}$$

U = Tidal current amplitude

P = Tidal Period (12.42 hrs)

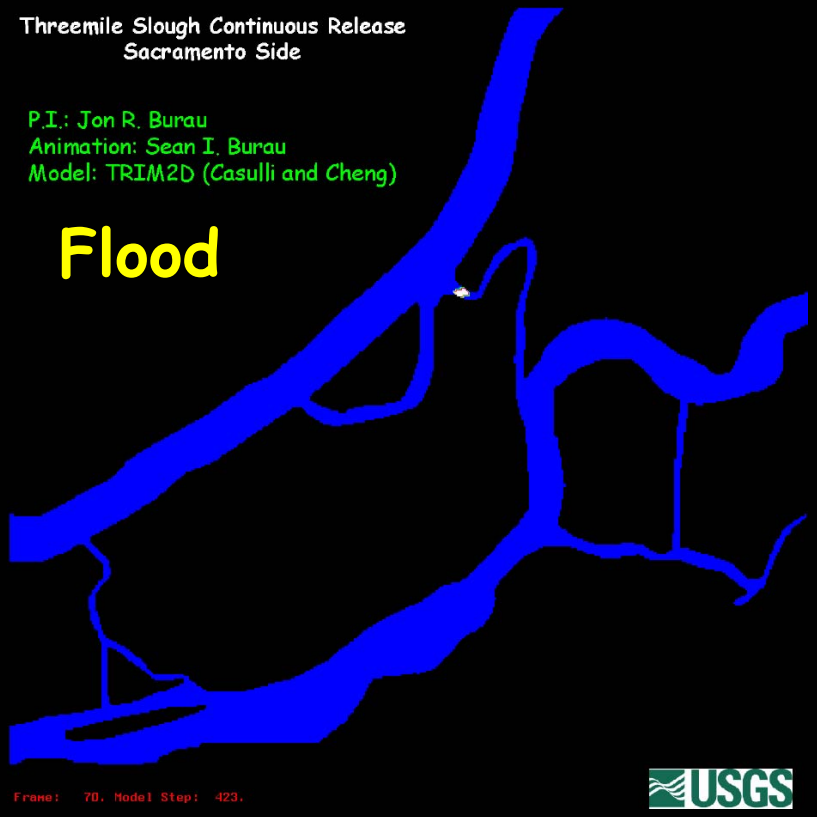
False River Drifter example
(tidal ex. >> channel length



Feb. 19, 2003 at 01:07 PM

Threemile Slough example

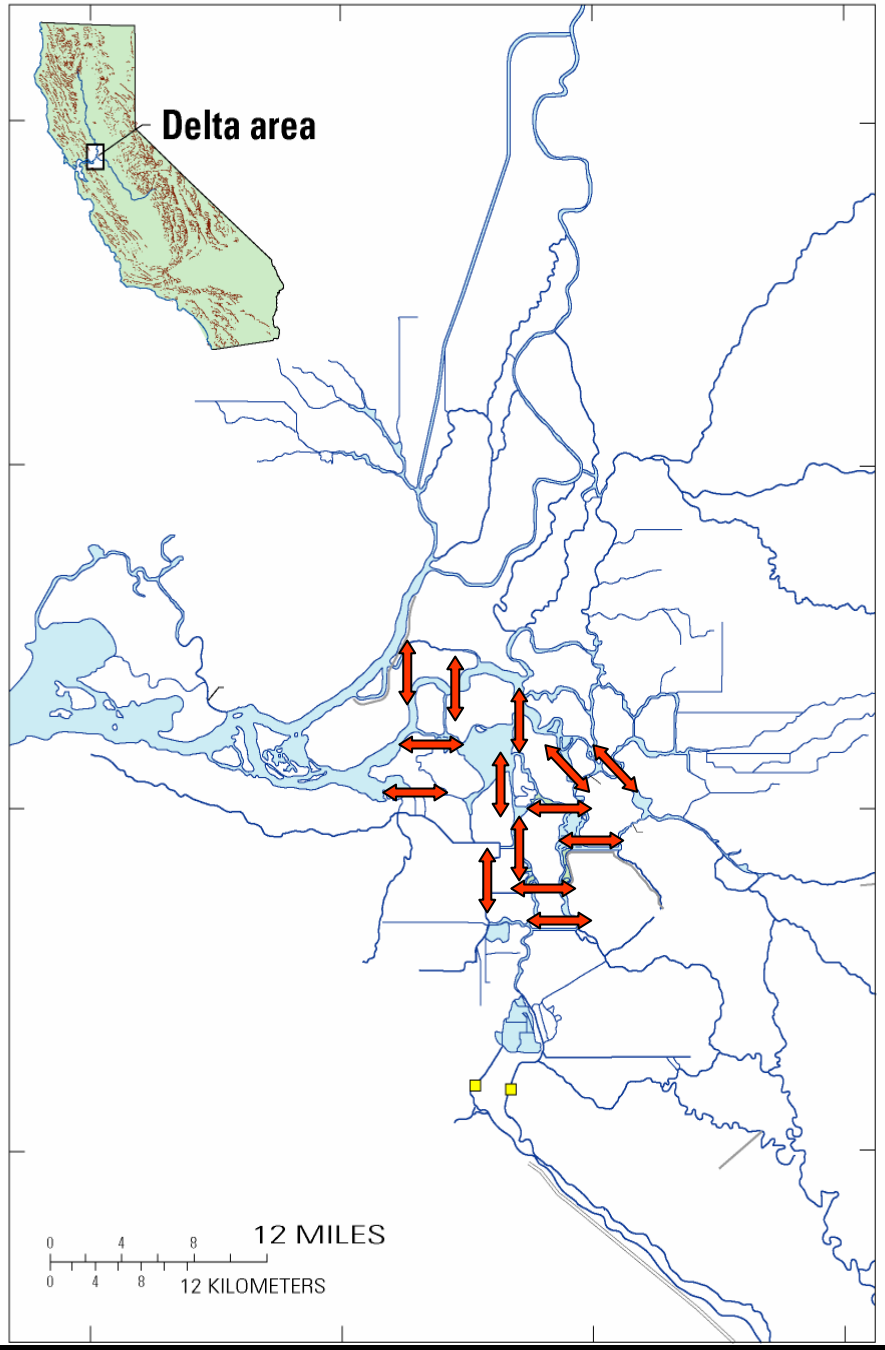
(tidal excursion >> channel length)

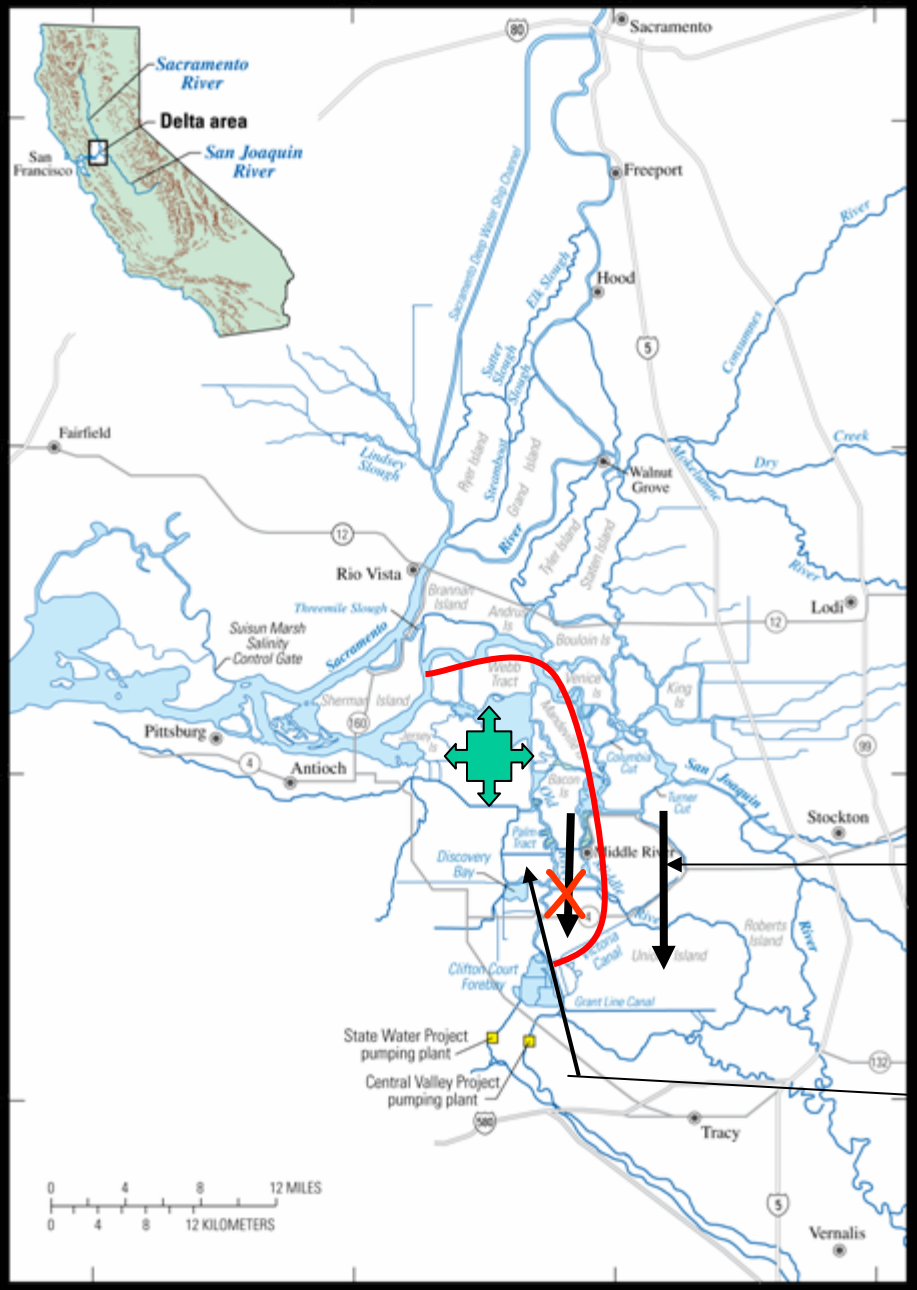


Central Delta is an
Homogenized environment

Dispersive mixing occurs when:
tidal excursions
Longer than channel lengths

This occurs in virtually
Every channel in the central Delta





Break up the "loops"

"Eco Crescent"

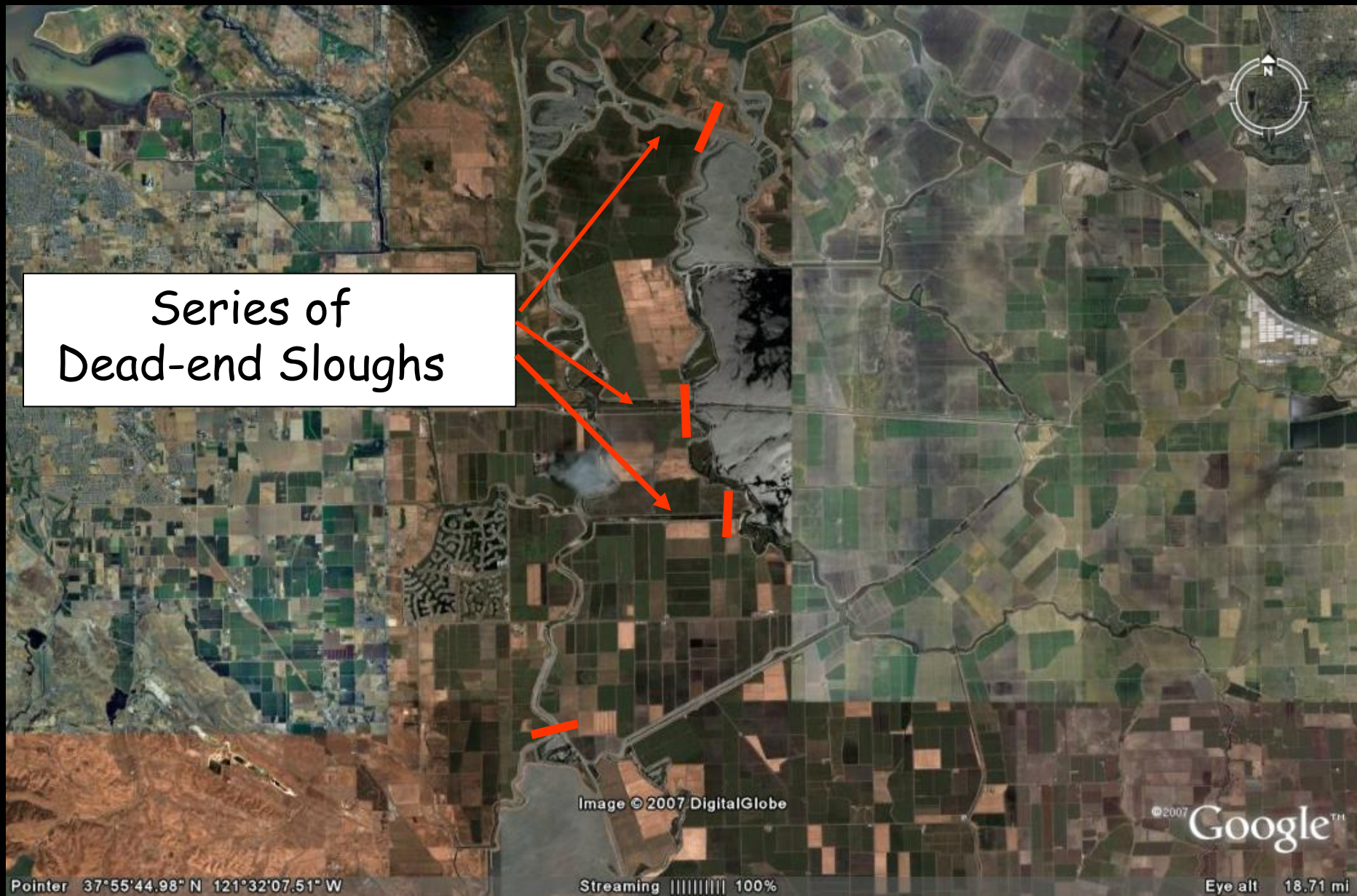
Central Delta managed for ecosystem services

Water Supply

Long residence time

Residence time diversity

"Eco Crescent"



Evolution back to natural (historical) geometric form

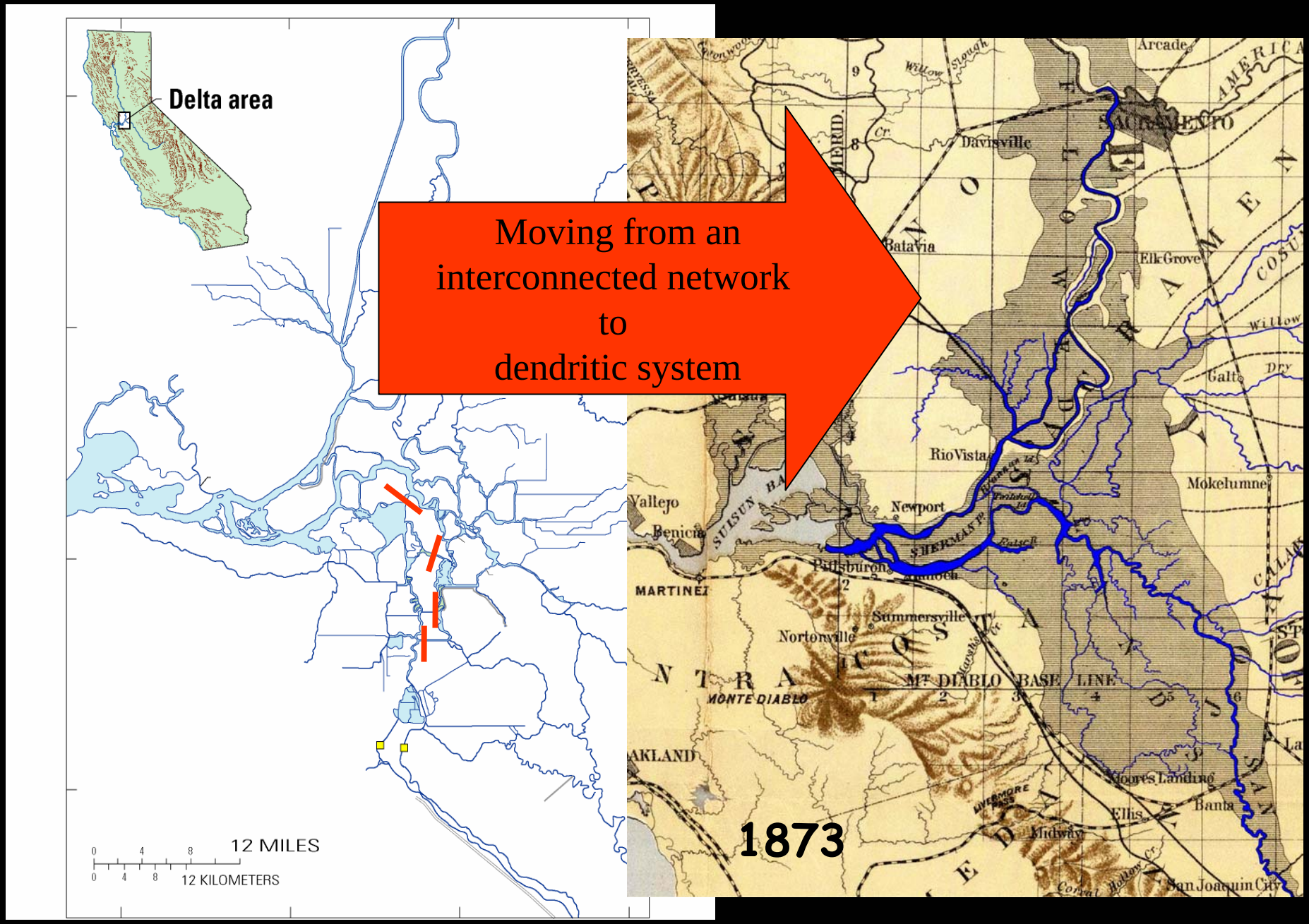
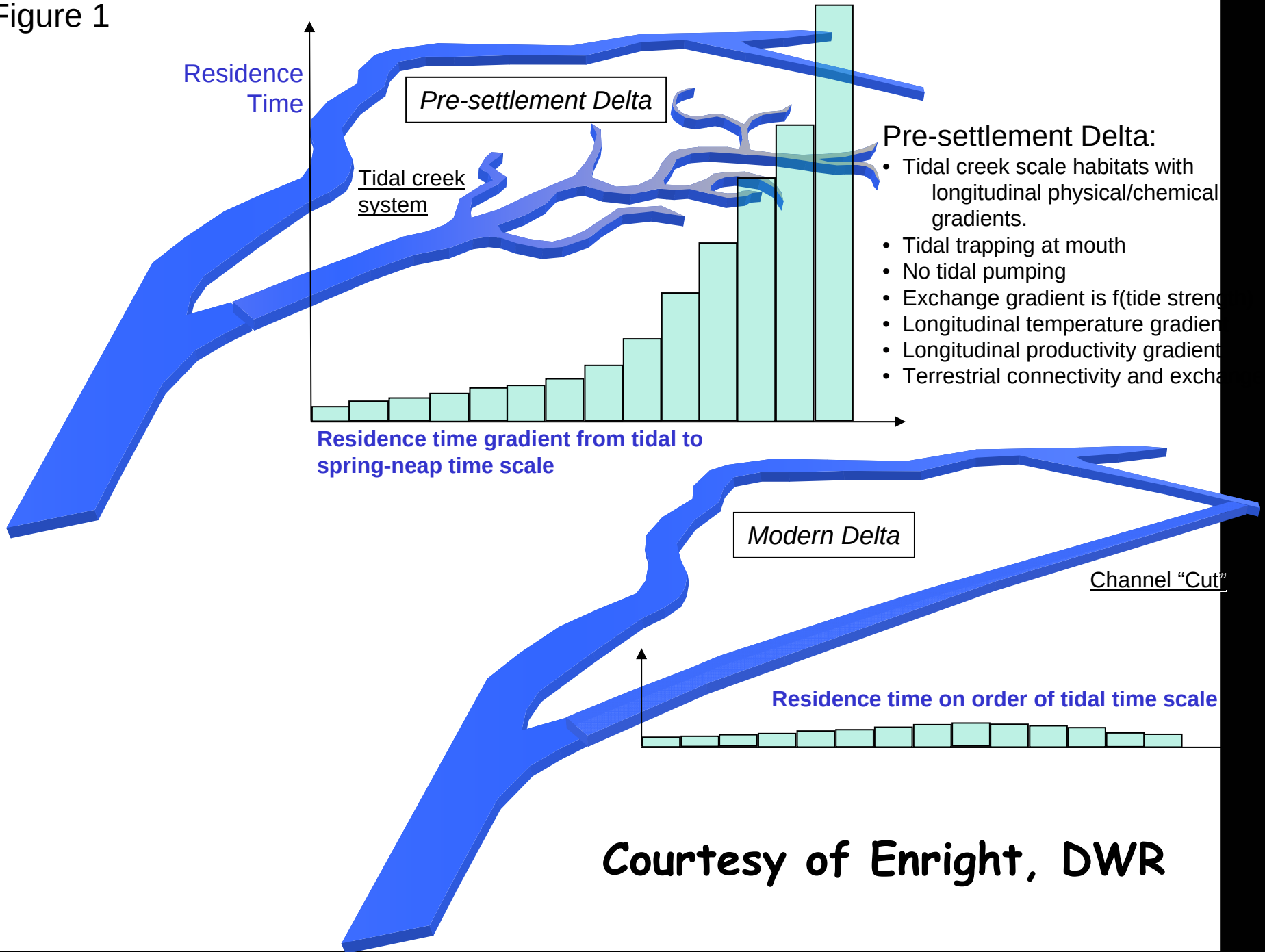
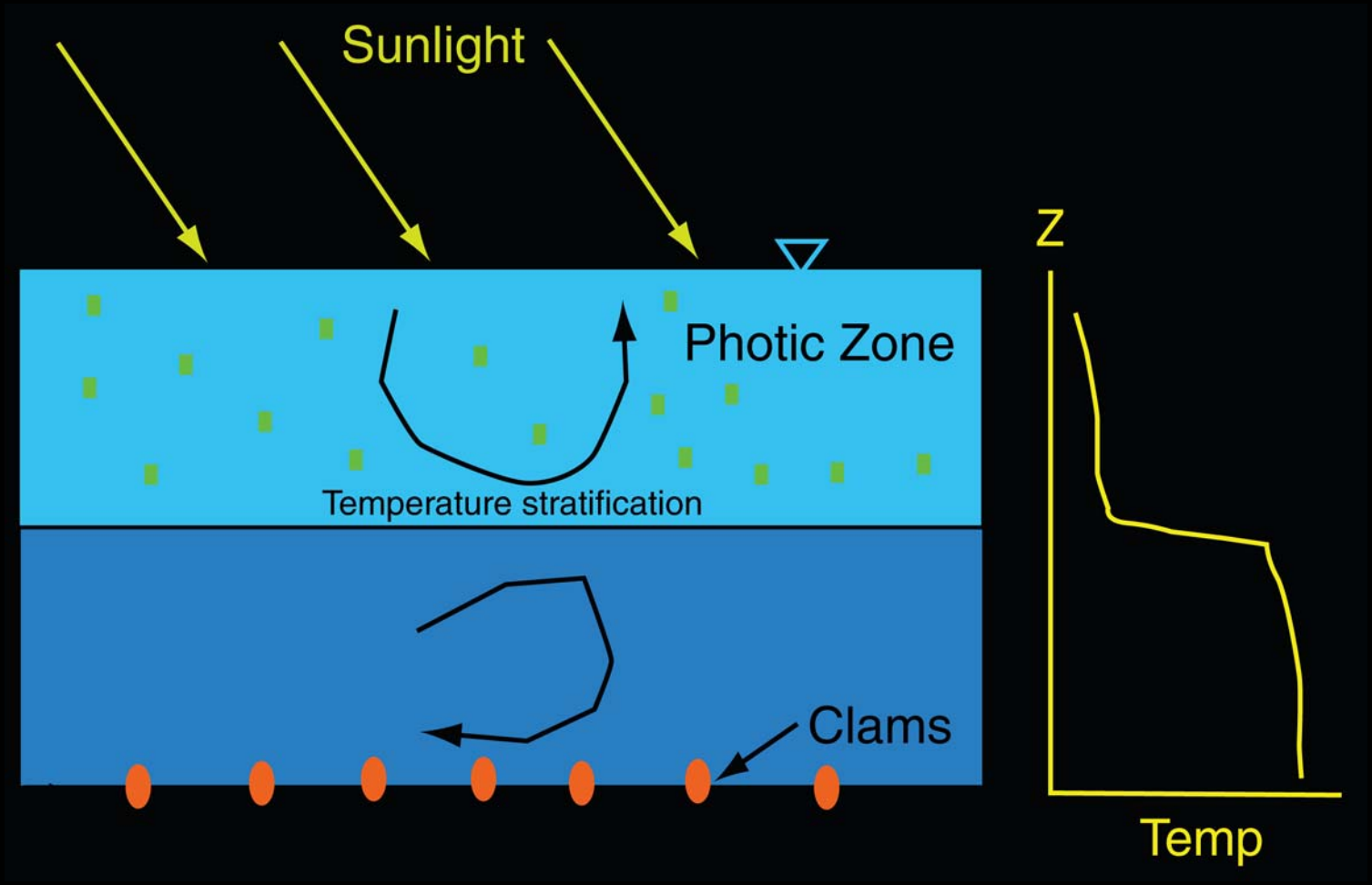


Figure 1



Courtesy of Enright, DWR

Decoupling of the water column



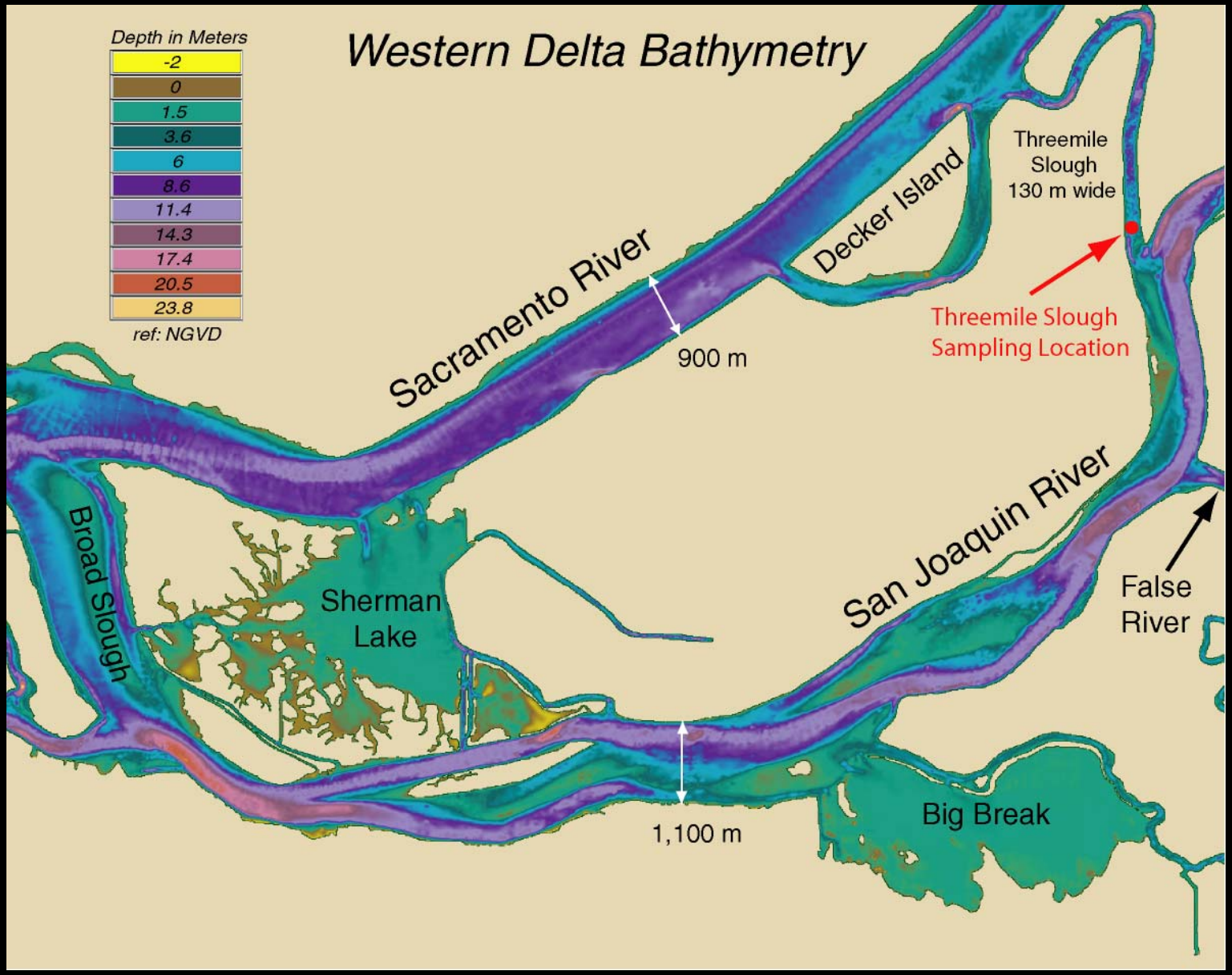
Conclude

Current Delta geometry promotes homogeneity and is lacking in proximate residence time gradients

Current Delta geometry is inconsistent with "variable delta"

Connected but distinct habitats characterized by a diversity of residence times doesn't exist in the Delta

Lateral Bathymetric Variability in Western Delta



Lateral variability in the current structures

Dispersive Mixing

Threemile Slough Dye Release

P.I.: Jon R. Burau
Animation: Sean I. Burau
Model: TRIM2D (Casulli and Cheng)

USGS

Dispersive mixing is important where:

Bi-directional Flow Occurs

AND

Channel is WIDE and includes bathymetric features

Lateral variability in currents: Shear flow dispersion

Western Delta

OR

Tidal excursion >> channel length

Central and Southern Delta