An Example: Dendritic (Branching) Channels

- Problem: altered geometry reduces ecosystem function
  - Uniform hydrology reduces dynamic estuarine variability
  - Absence of land-water interface precludes energy exchange
  - Result: reduced ecosystem capacity to support native estuarine species
- Goal: mosaic of habitats
  - Establish branching channels with land-water interface in restored lands
  - Establish branching channels with land-water interface in existing Delta/Suisun waterways

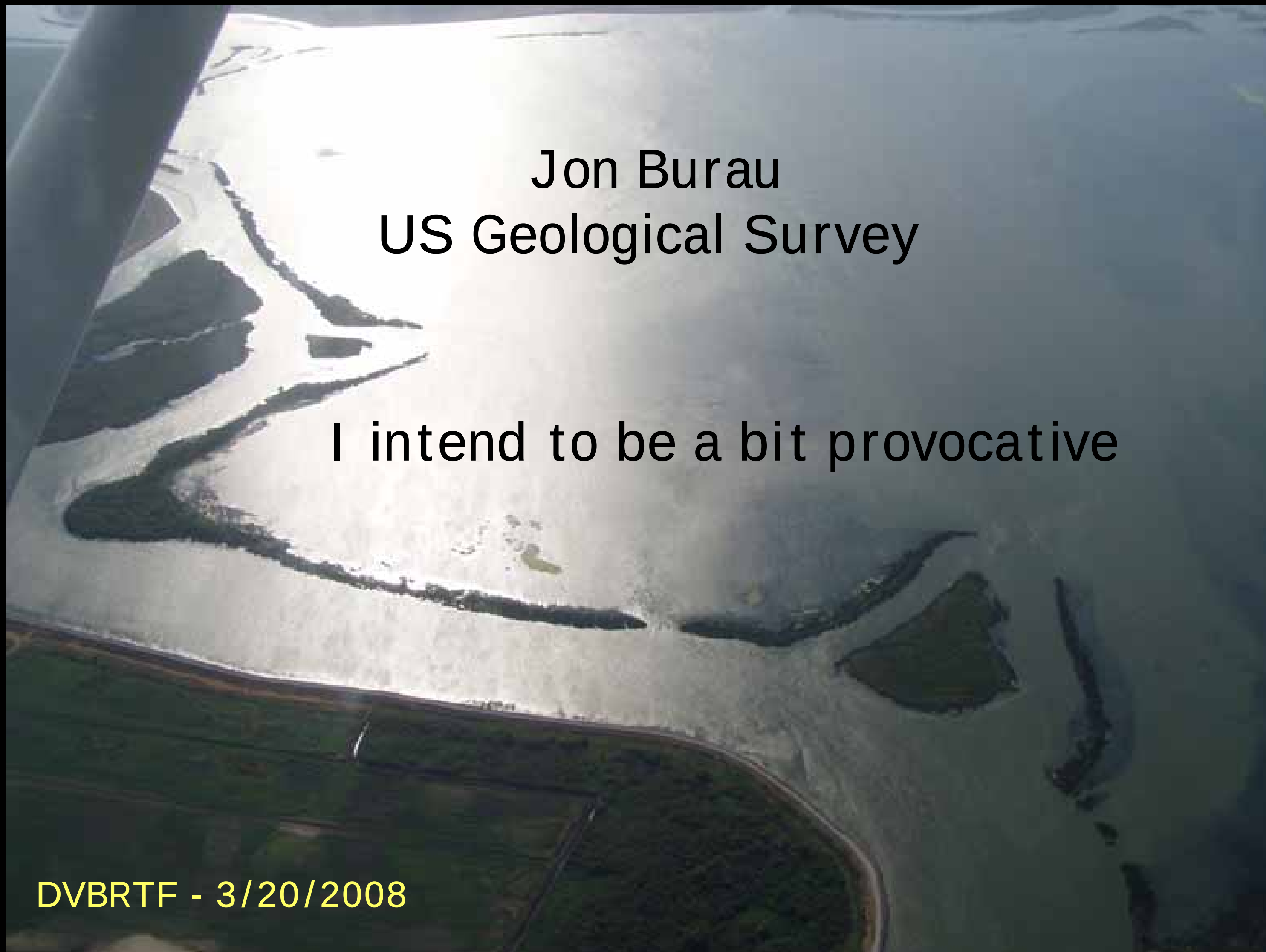
An Example: Dendritic (Branching) Channels

- Objective: branching channels (DV #PH-3) with land-water interfaces to restored tidal, floodplain and riparian ecosystems
- Target: XX acres of branching channels within and along tidal, floodplain and riparian areas, distributed throughout the Delta and Suisun
- Strategy: modify landforms behind levees and connect to tidal waters; reverse constructed waterways
- Actions: acquire property rights, secure funding, design, permit, construct, monitor, adapt

An Example: Dendritic (Branching) Channels

- Performance measures:
  - Increased residence time variability at tidal and spring-neap time scales
  - Increased connectivity between aquatic and wetland / floodplain / riparian habitats
  - Increased diatom production
  - Increased diversity of channel morphology (shoals, bars, etc.)

Estuarine Ecosystem Workgroup: Thoughts on the Land-Water interface



Jon Burau
US Geological Survey

I intend to be a bit provocative

DVBRTF - 3/20/2008

USGS

JRB

Thoughts on the Land-Water interface

Tag Team:

Burau: Examples from the Delta

The delta as a highly disturbed system

Enright: Examples from Suisun Marsh

Comparison of natural versus disturbed systems

How dendritic systems work

WORDS

Words can be a rickety means of communication

They can be misinterpreted and misleading

Words such as:

“Slough”

“River”

used in the context of the delta can be misleading

We've made two major changes to this system that have had profound effect on the ecosystem

(In Priority Order)

(1) We've made extraordinary changes in the land-water interface

(2) We've changed the way water enters, exits and moves through the delta (This is my area of expertise)

So what have we done to the land-water interface

Let's begin at the scale of the channel
and move towards the scale of the delta

Most channels in the delta are:

(1) Leveed

(2) Armored

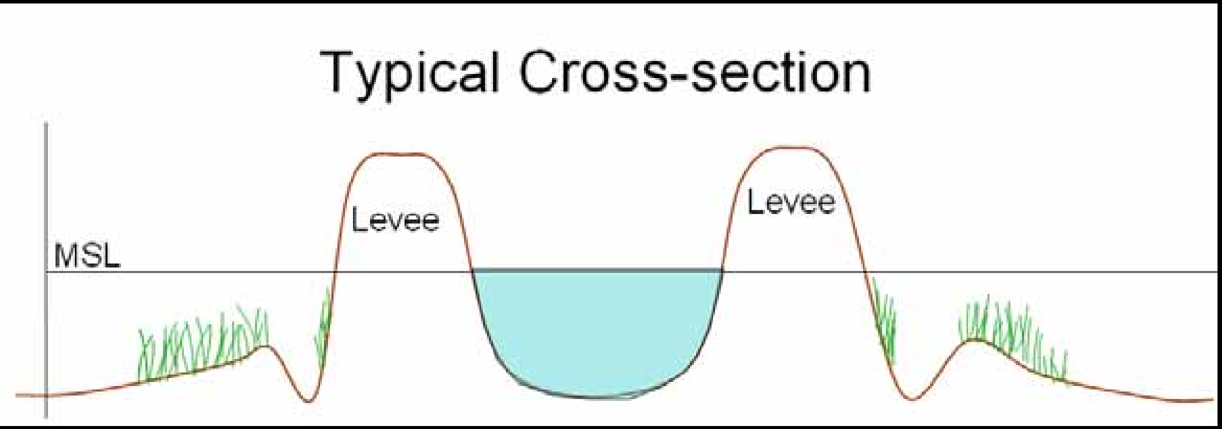
(3) Narrow

Levees

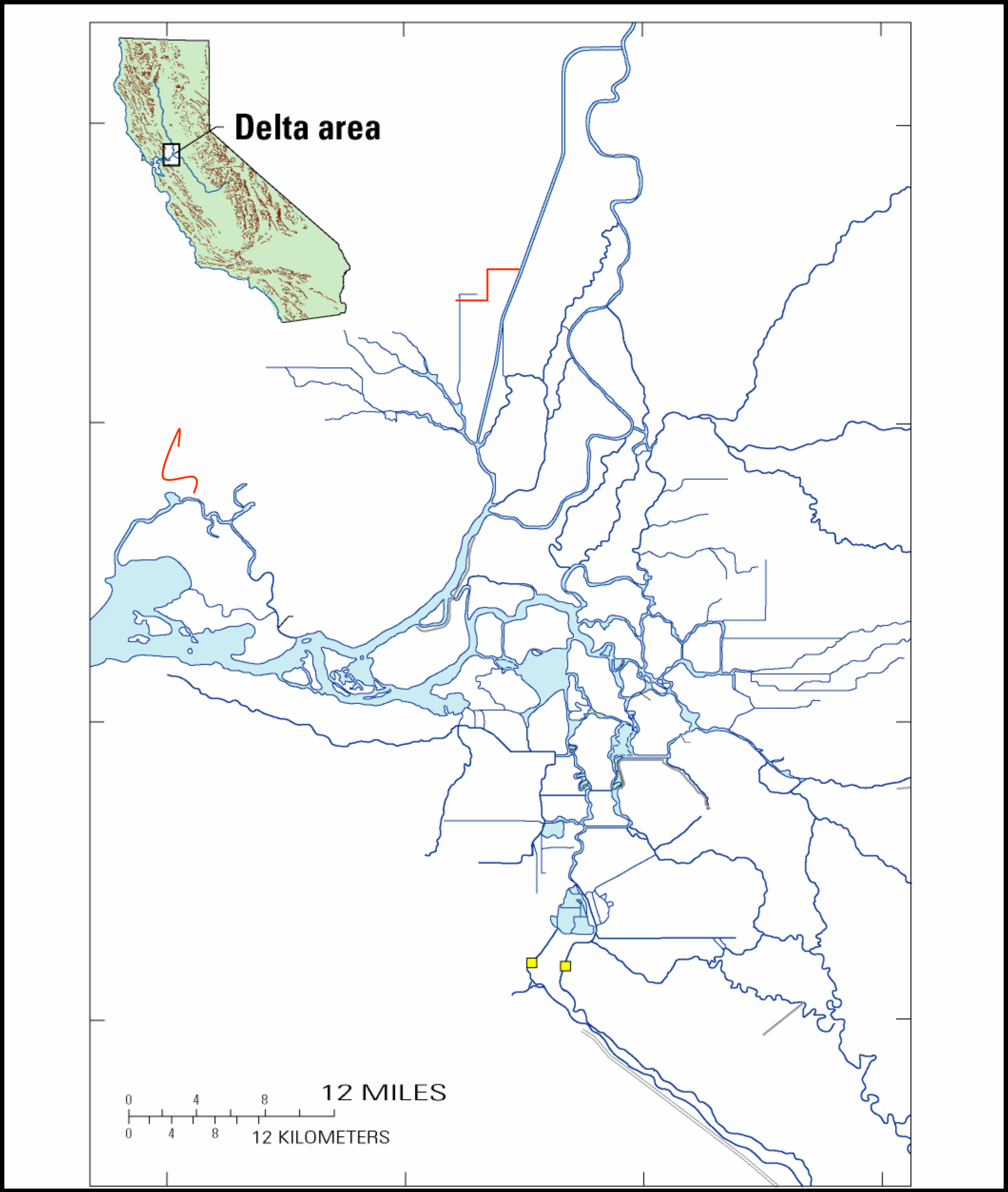
Consequences

(1) No connection with adjacent land

(2) Sides are steep (no plant growth)



Most channels in the delta are Leveed



Rare site in the delta - 1

North of Libery I.

Rare site in the delta - 2

North of Libery I.

Armored Levees - I

Cache Sl.

Armored Levees - I

Jersey Pt.

Conclusion:

For the most part:
The delta has a rock-water interface

Narrow

Q: Why were the channels made narrow?

A: To keep them deep and sediment deposition free

Initially this was done to remove hydraulic mining debris from the system

Consequences of "narrow"

(1) The channels are much deeper than they were historically

(2) The tides likely propagate much farther into the system

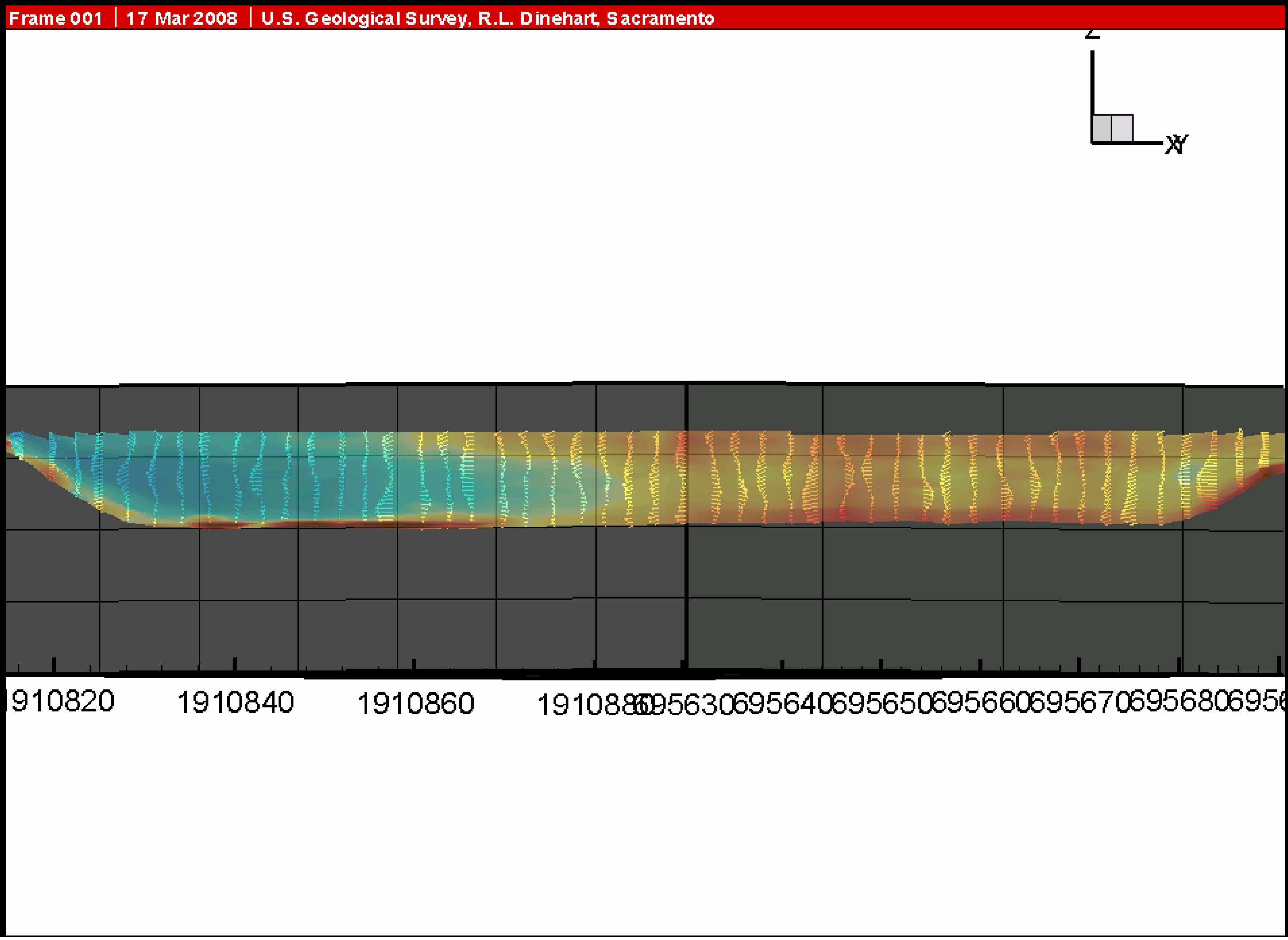
(3) The tidal currents are much stronger farther into the system

(4) Sediment that enters the rivers is rapidly moved through the system

(5) channels are prismatic – no bathymetric variability

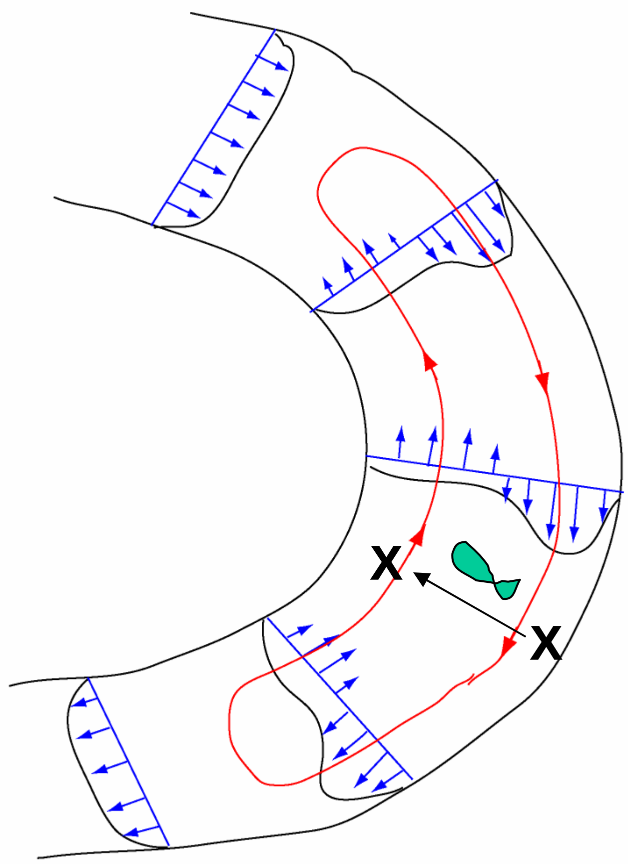
Typical delta cross section

Prismatic Channel: Steep sides – rock
Flat bottom

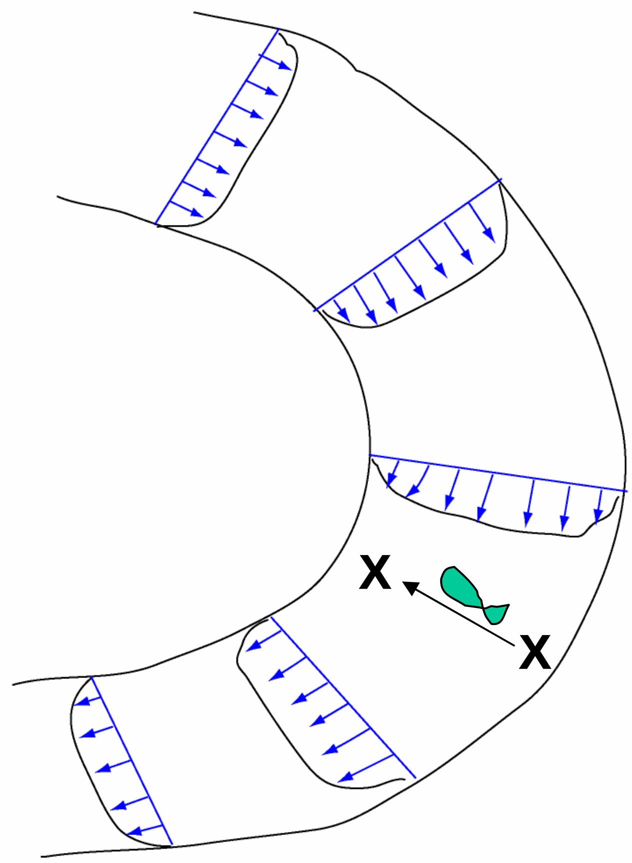


Velocity Structure

Unconfined channel vs confined channel

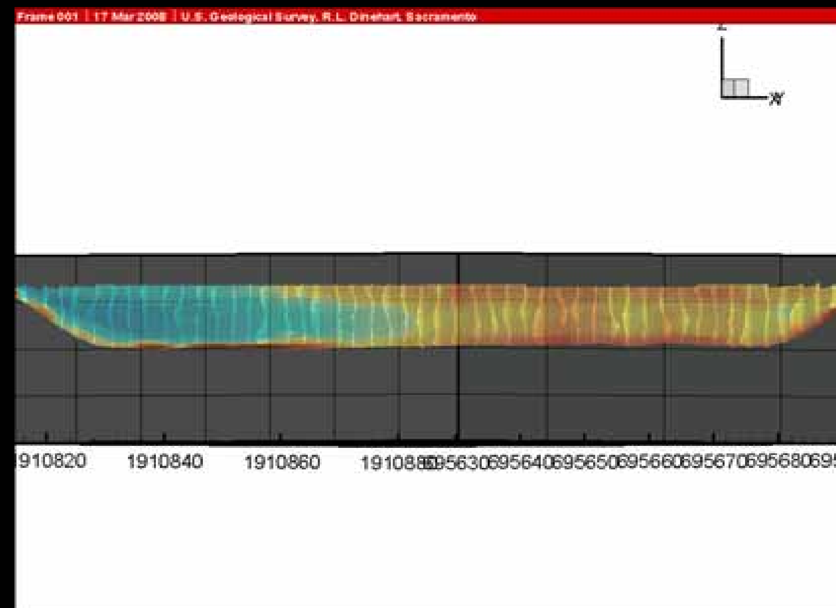


Natural Channel
Bathymetry variability -> Velocity structure



Armored Channel
Lack of bathymetry variability -> weak velocity structure

The channels in the delta are not natural river channels



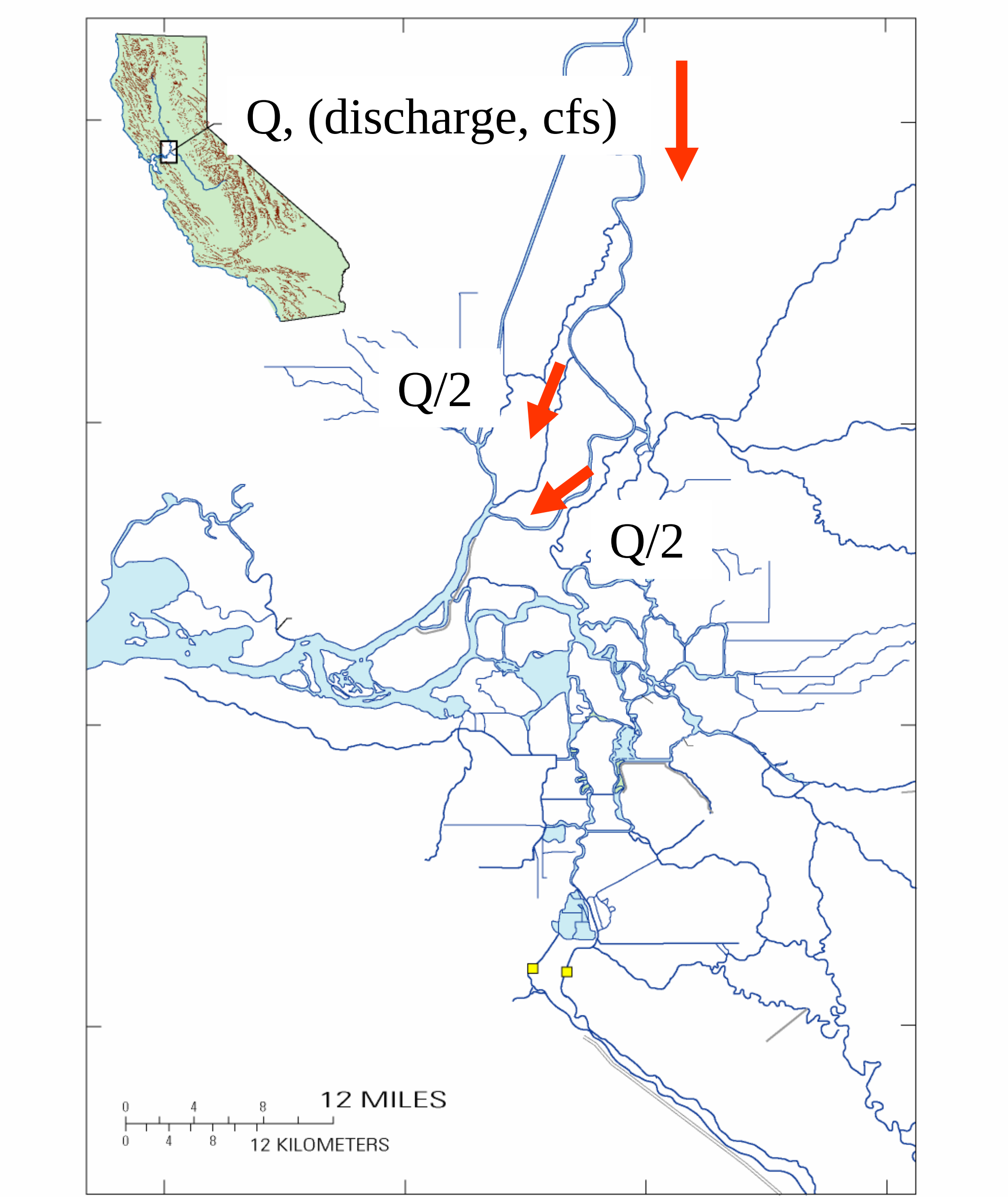
They are more closely related to man-made canals

Where is the habitat?

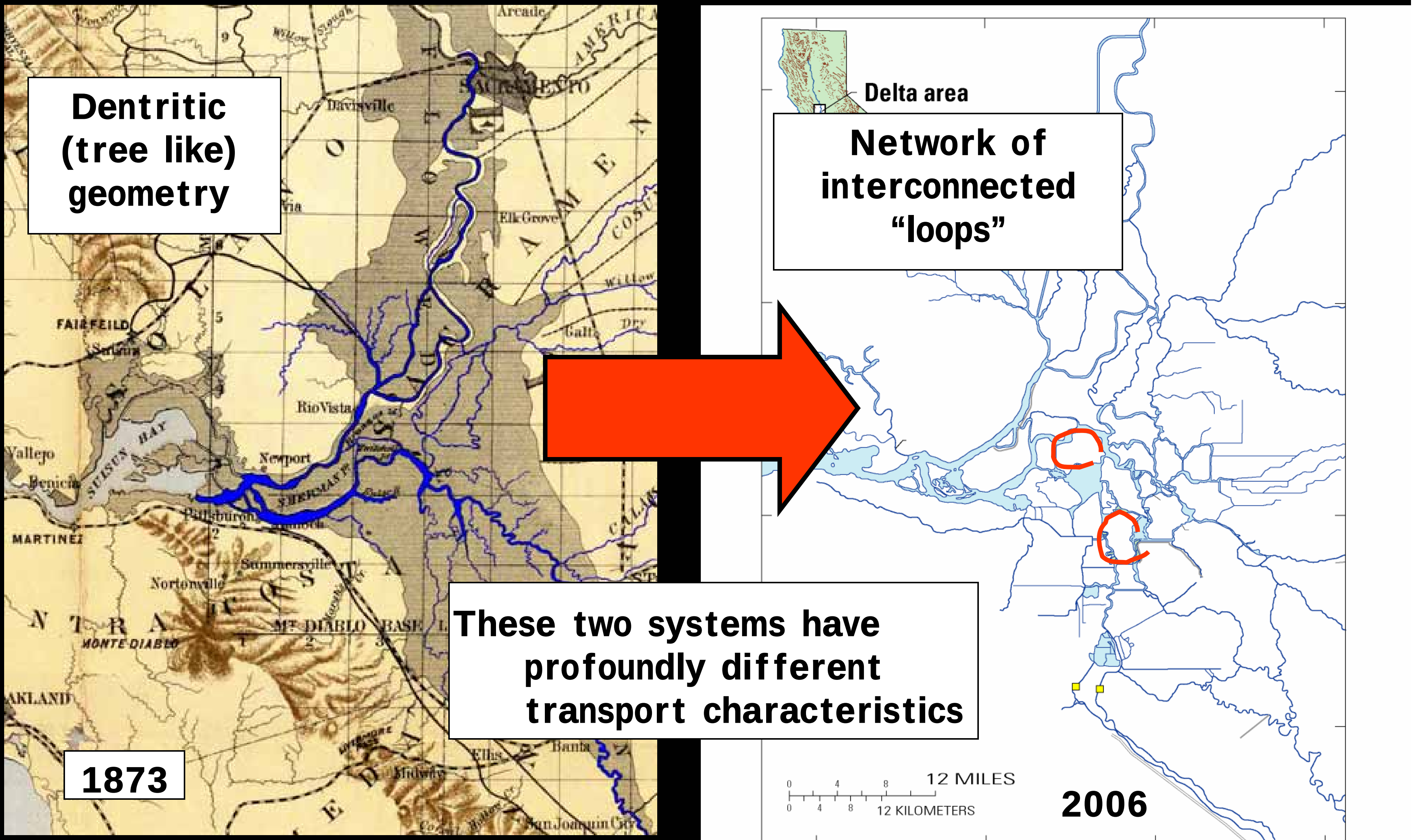
What other words are misleading ?

Sutter and Steamboat Slough

These are not sloughs - they are serious conveyance canals



Changes we've made at the scale of the Delta (segway to Chris)



Conclusions - I

The delta is primarily:

An interconnected web of prismatic and rock-lined water conveyance and flood control canals

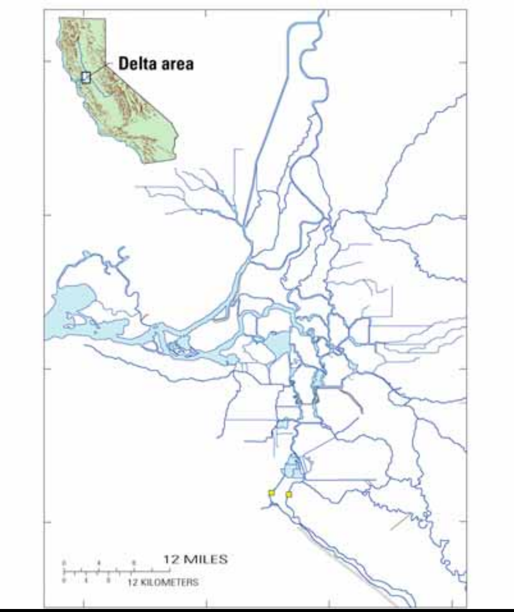
that is trying to function as an ecosystem.

Conclusions - II

We don’t expect man-made canals to provide ecosystem services

All American Canal (USBR)

Why do we expect it from the delta?



Primary message:

Geometry has an incredible influence on transport

Secondary message:

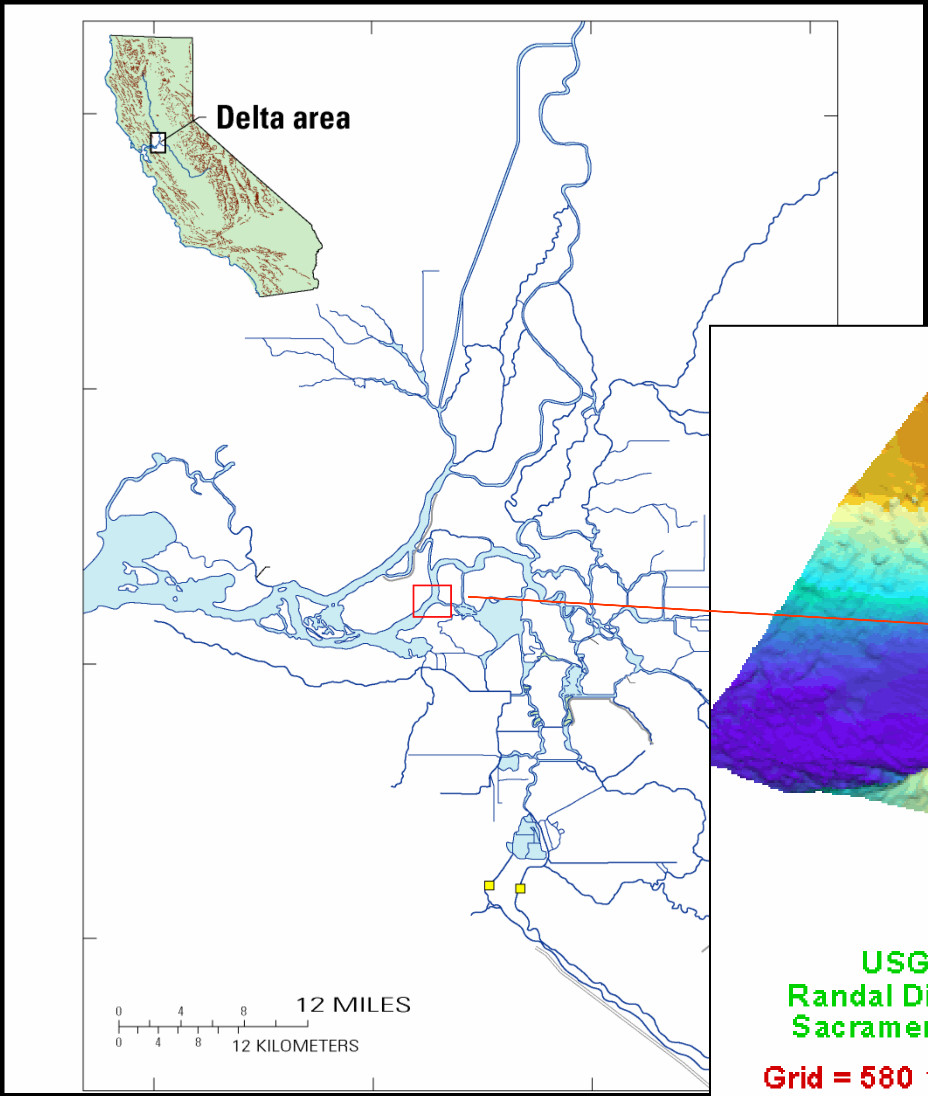
Delta's geometry (at local and regional scales) creates homogeneous pelagic habitats

Discuss Geometric impacts on transport at two scales:

(1) Channel (local) scales, (2) Regional scale

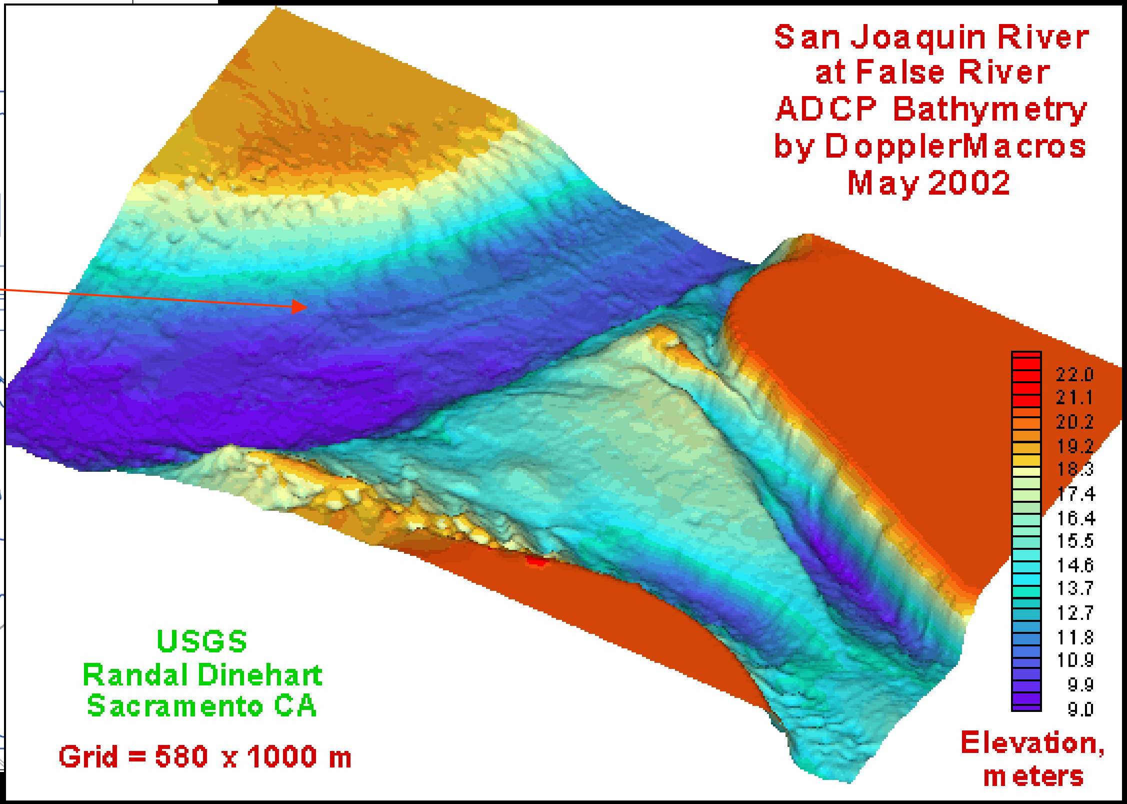
What do I mean by Geometry?

Horizontal Plan Form

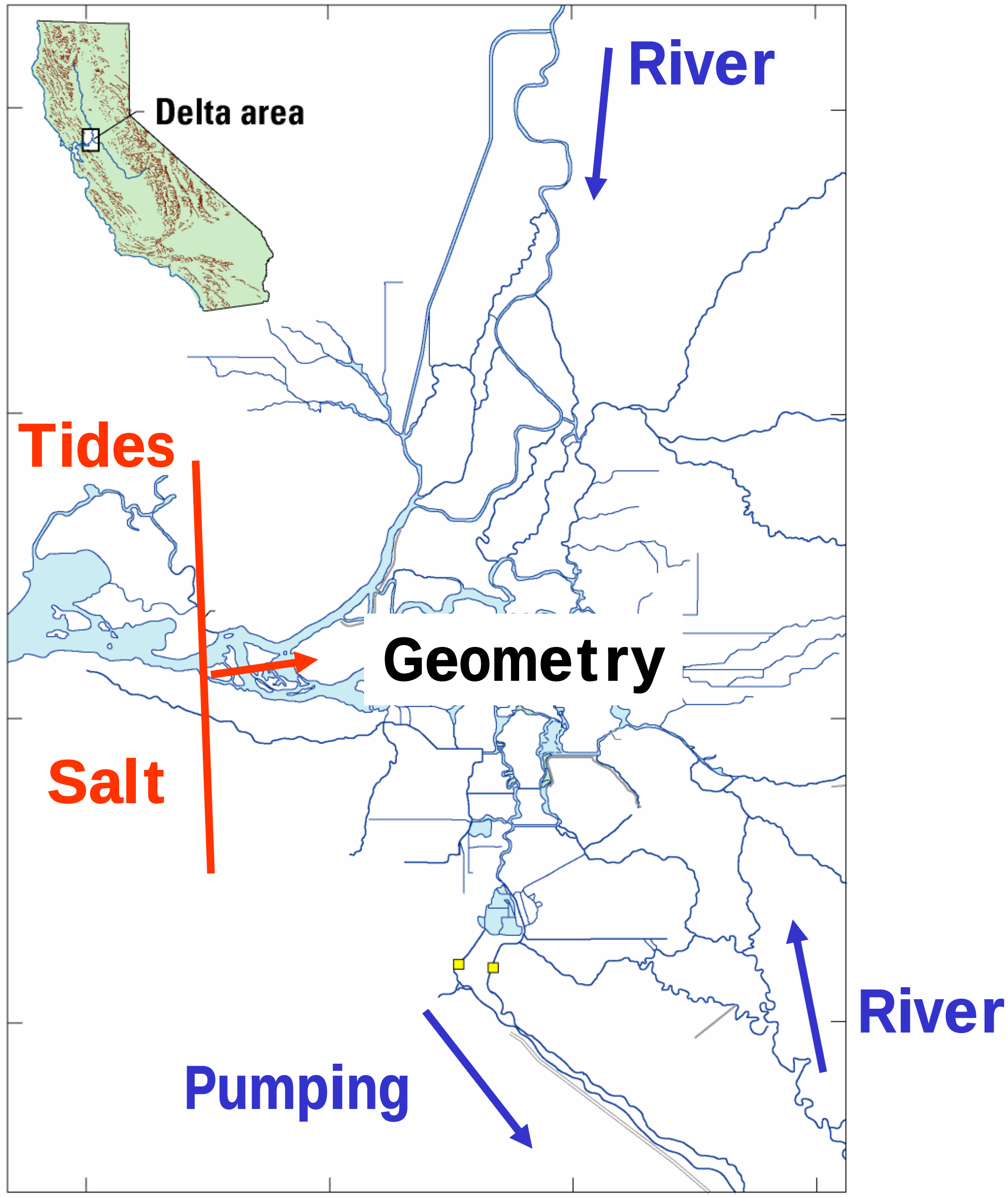


Bathymetry

(bottom topography)



Forcing



What do I mean by transport

The movement of “stuff” around the delta

Stuff can be (anything in the water column):

Salinity

Phyto- zoo-plankton

DOC

sediment

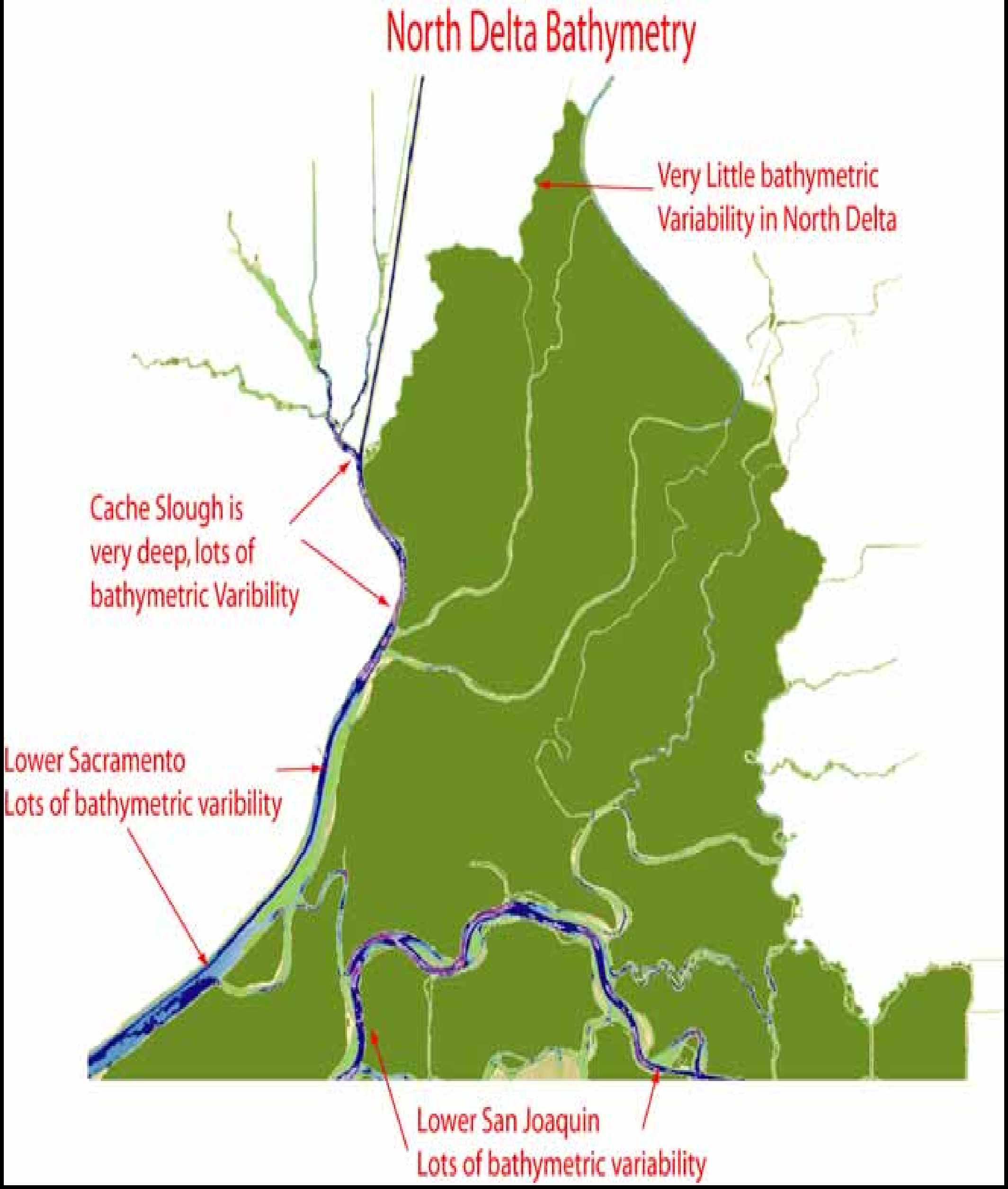
Toxics

Non-motile, feeble swimming fish

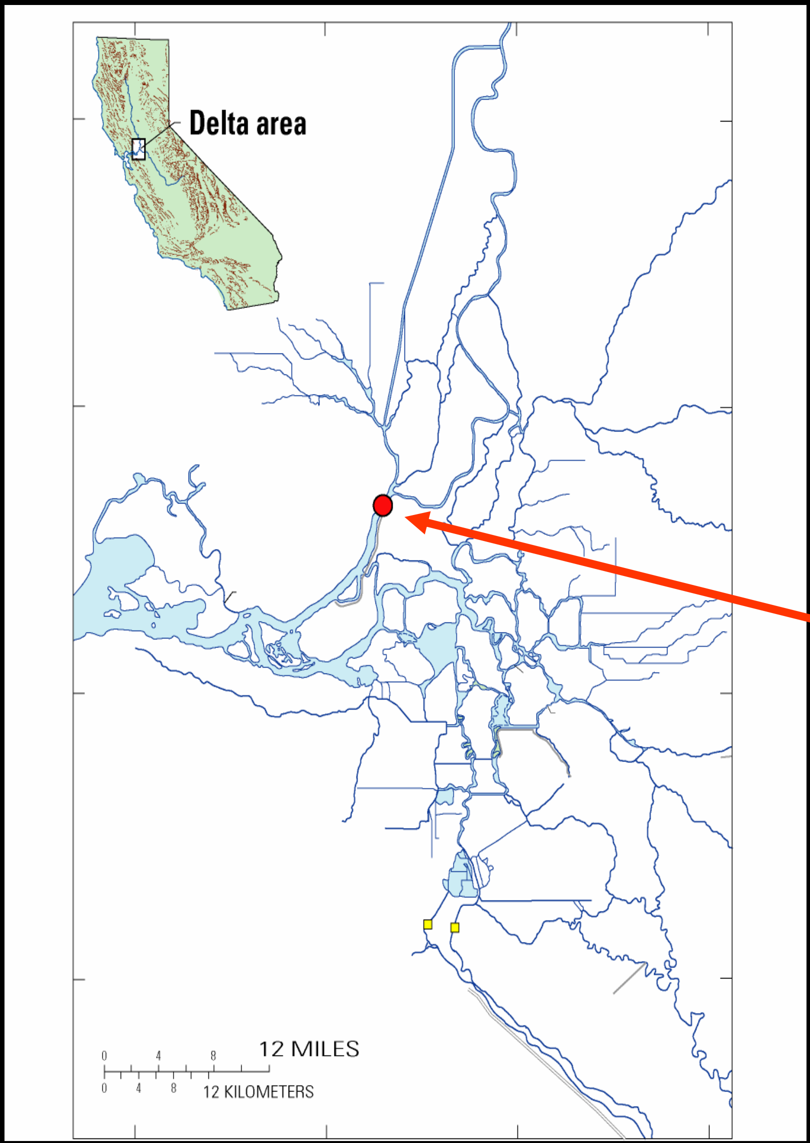
Etc.

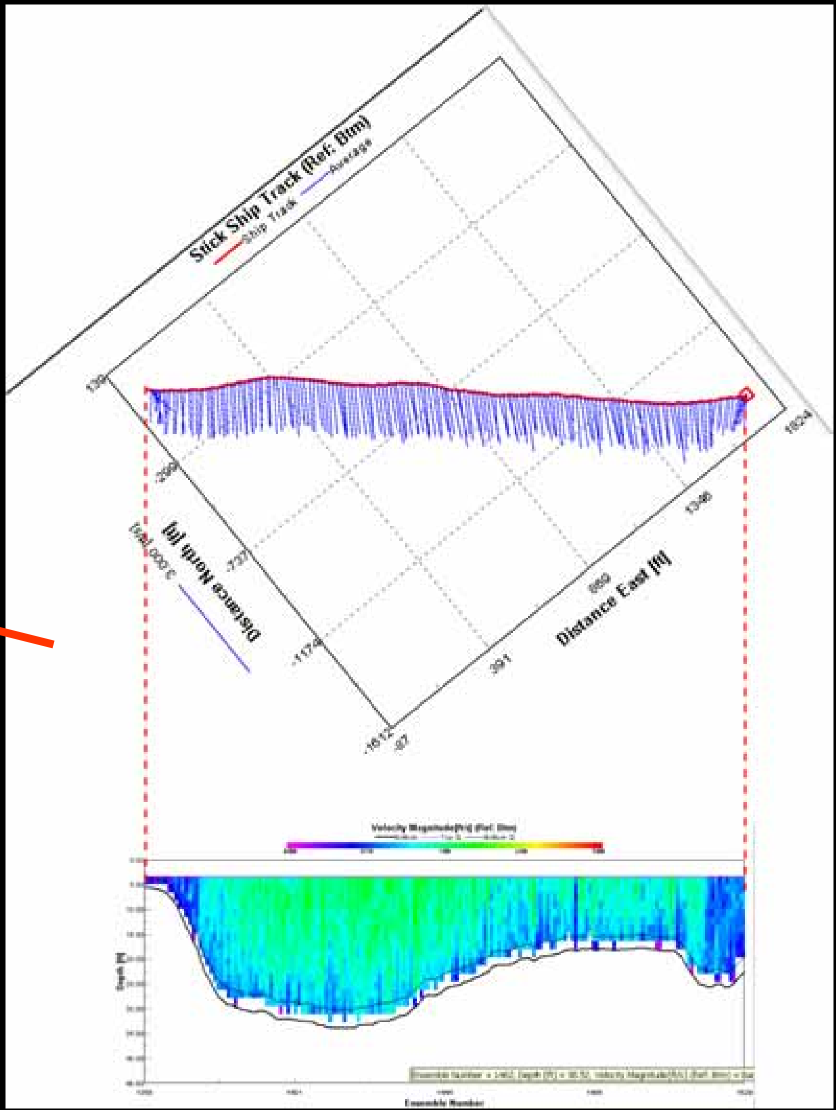
Geometry at local scales

North Delta Bathymetry has very little within-channel variability



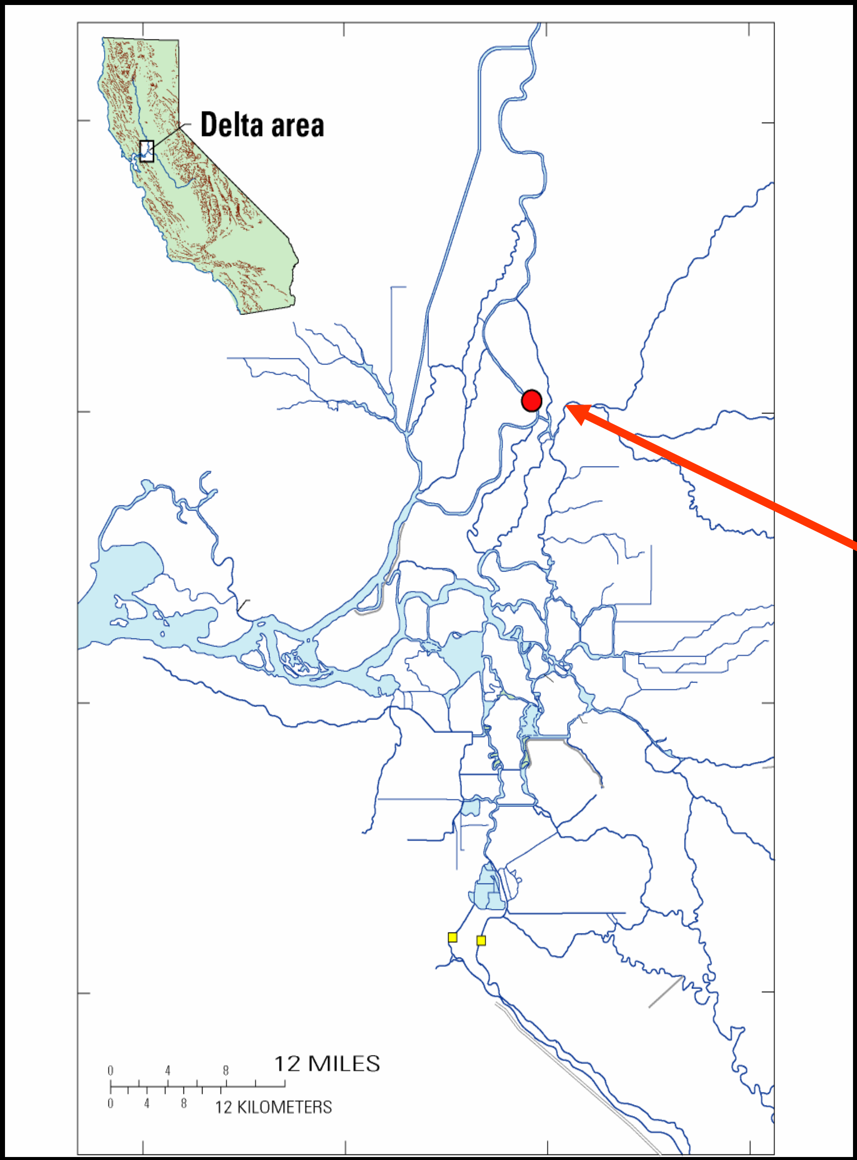
Cross Sectional Current variability
Rio Vista

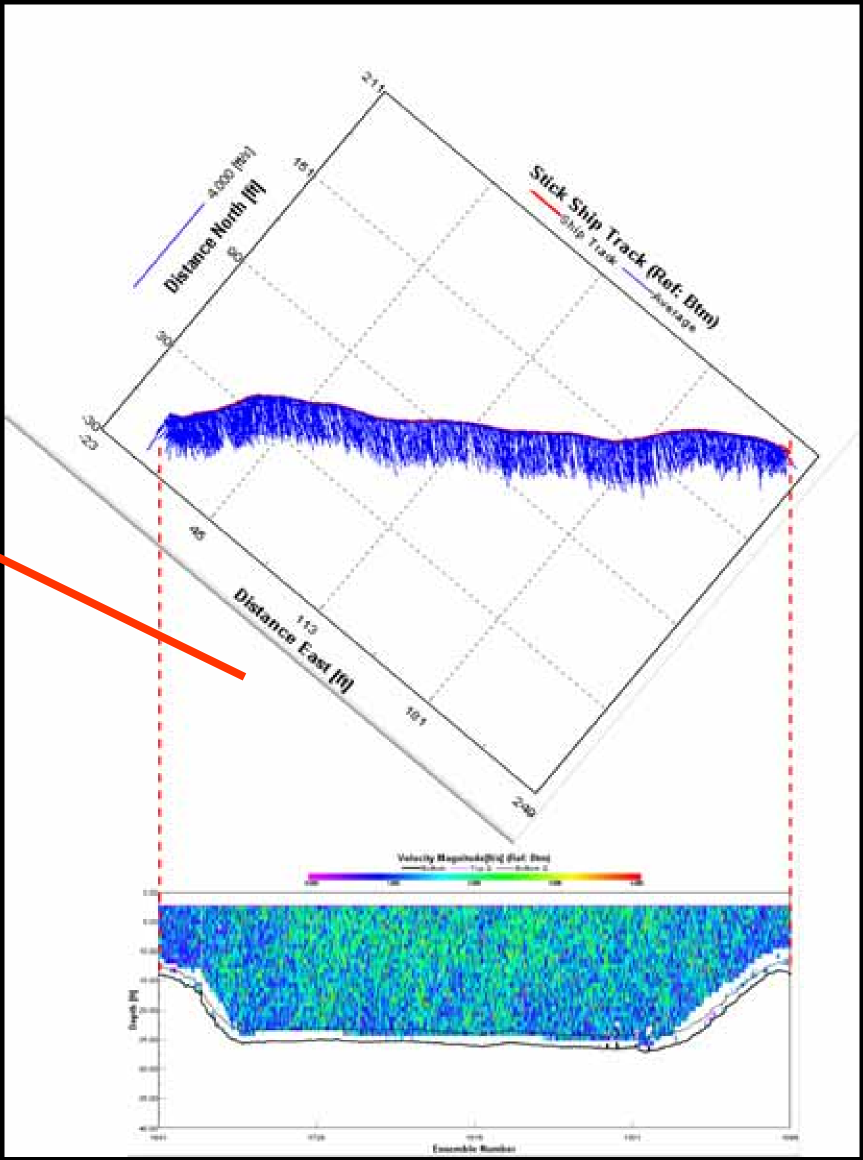




Cross Sectional Current variability

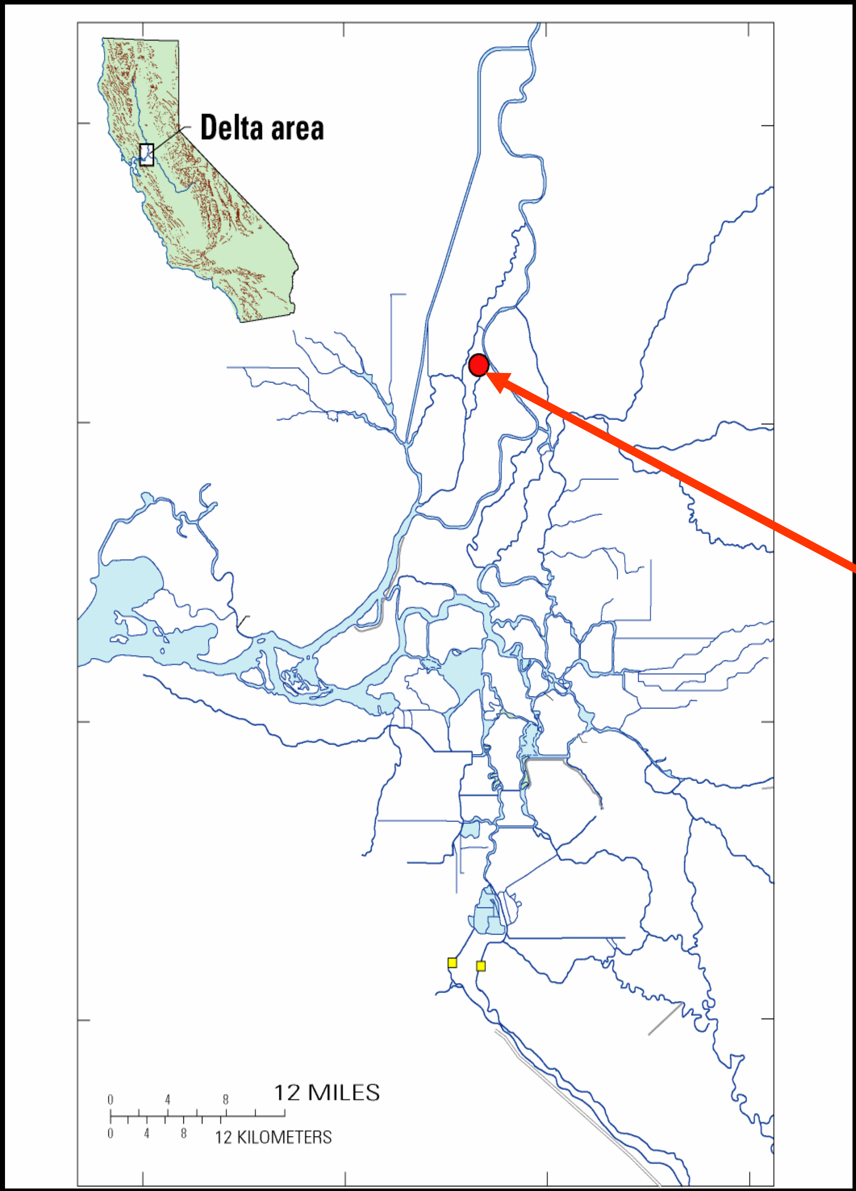
Sacramento River Below Walnut Grove

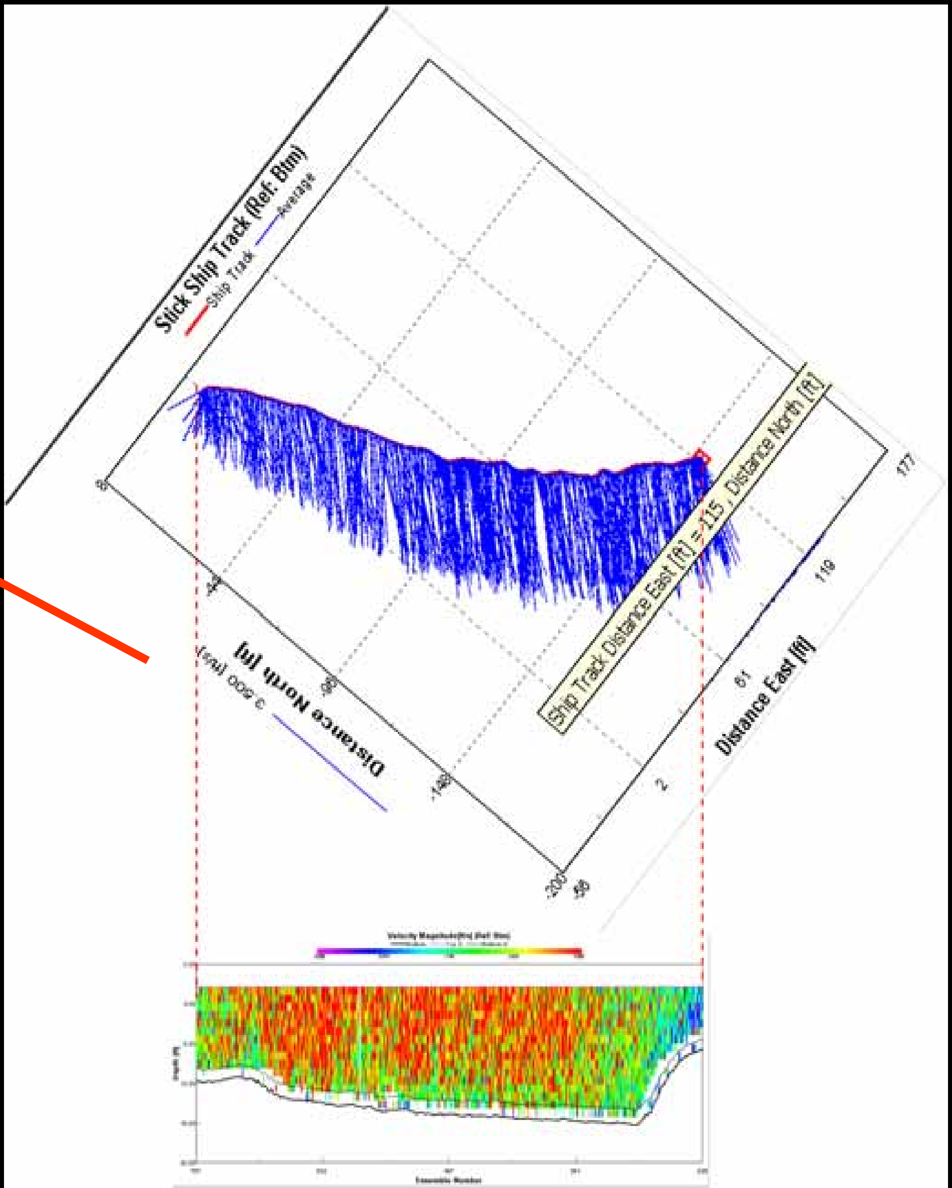




Cross Sectional Current variability

Steamboat Slough





Armored Channels create pelagic environments lacking in hydraulic diversity

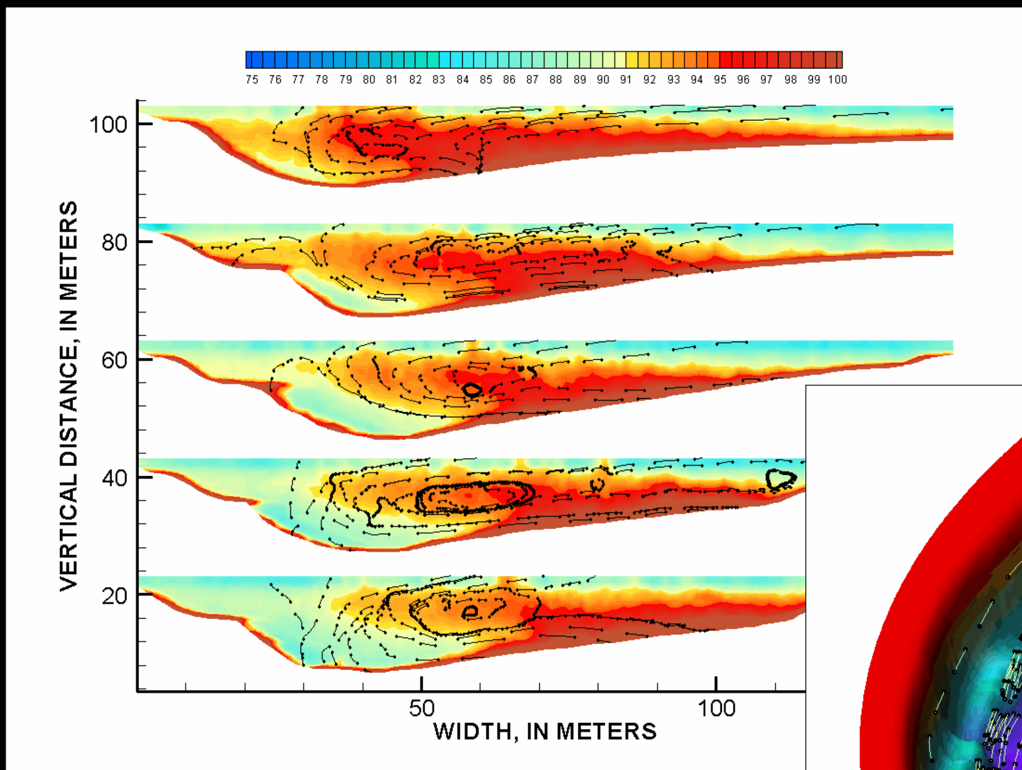
North delta channels somewhere between natural river and concrete lined canal

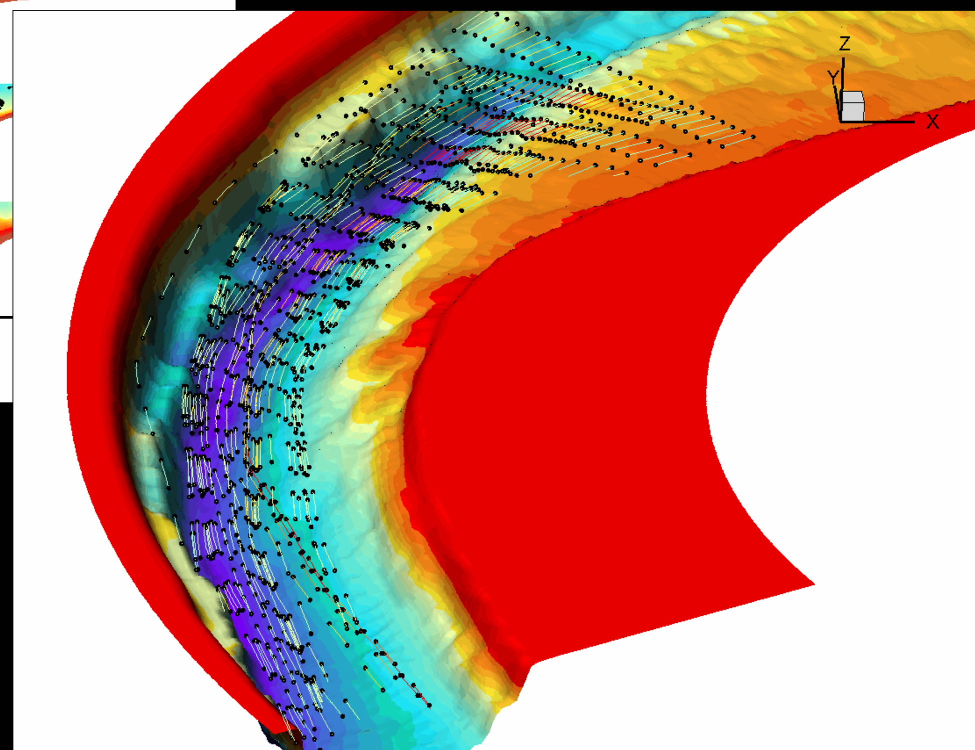
Even though there is a lack of bathymetric/hydrodynamic diversity In the north delta channels

What velocity structure exists in bends and in junctions is important

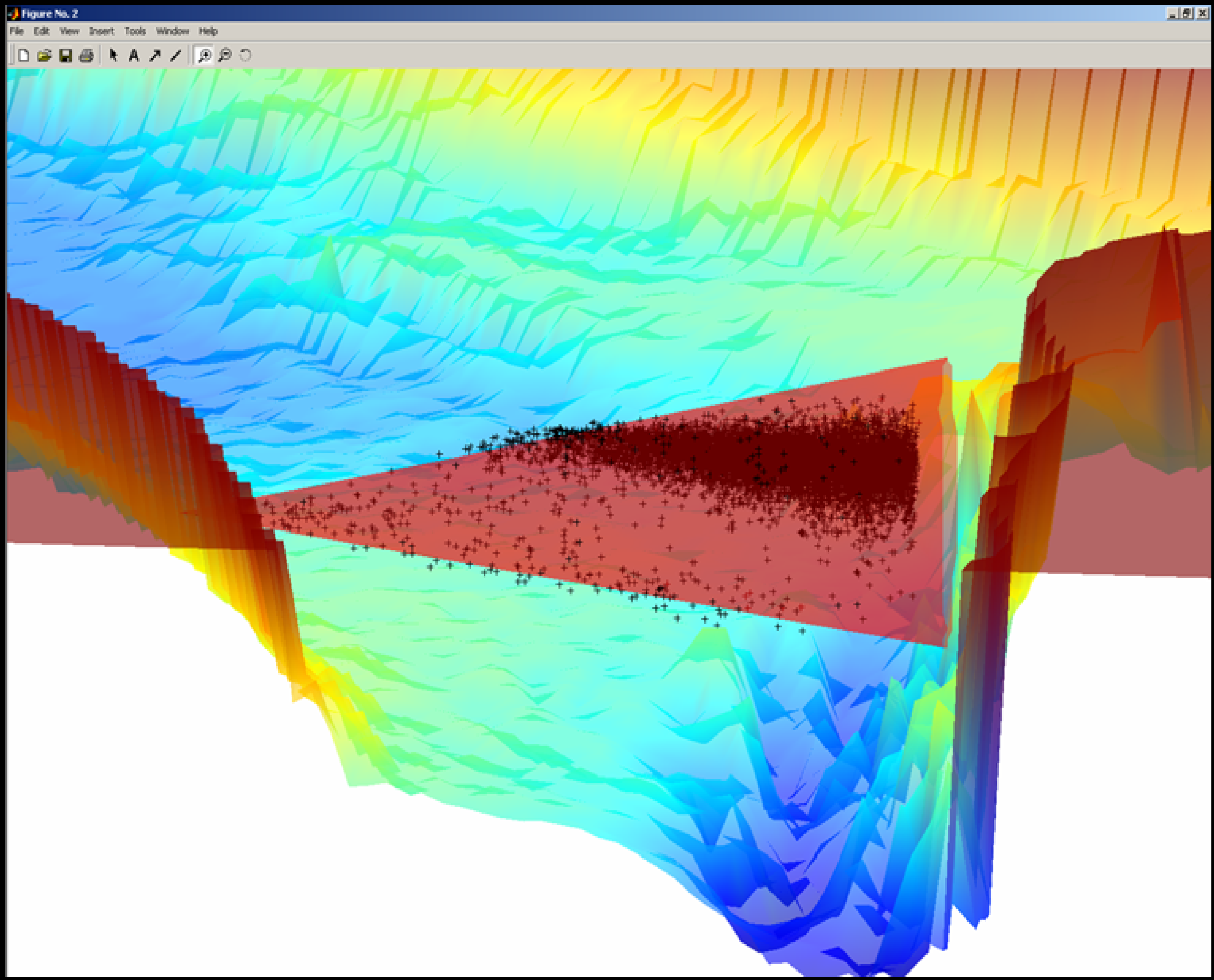
For example

Secondary circulation in bends:

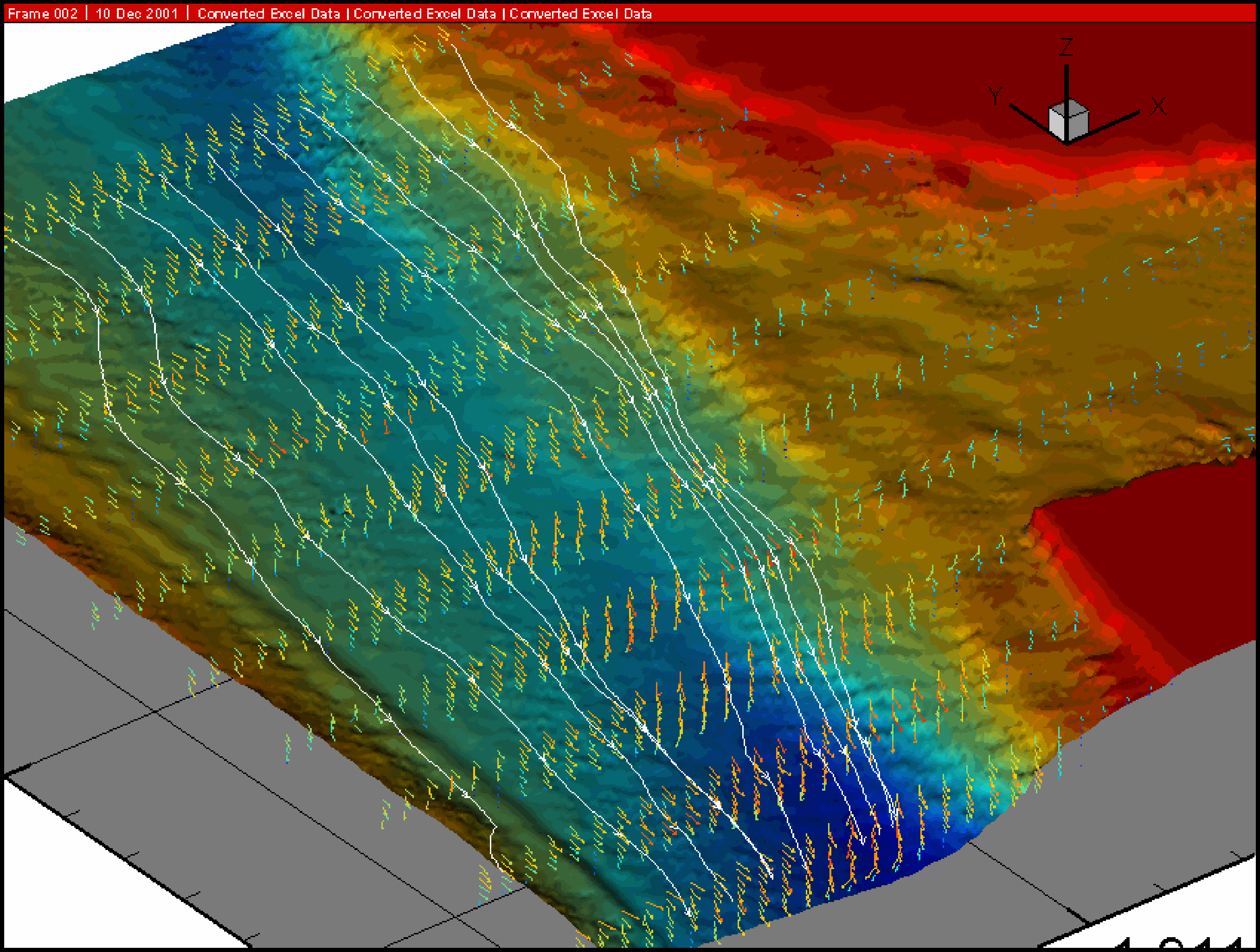




Concentrating juvenile salmon on the outside of bends



Secondary circulation in bends coupled with Dynamic flow patterns in junctions determines where salmon "go" within the north Delta network

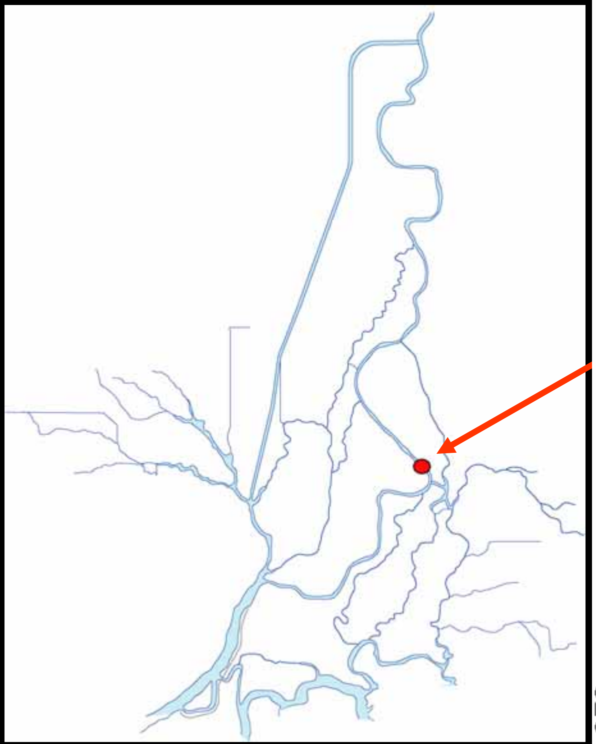


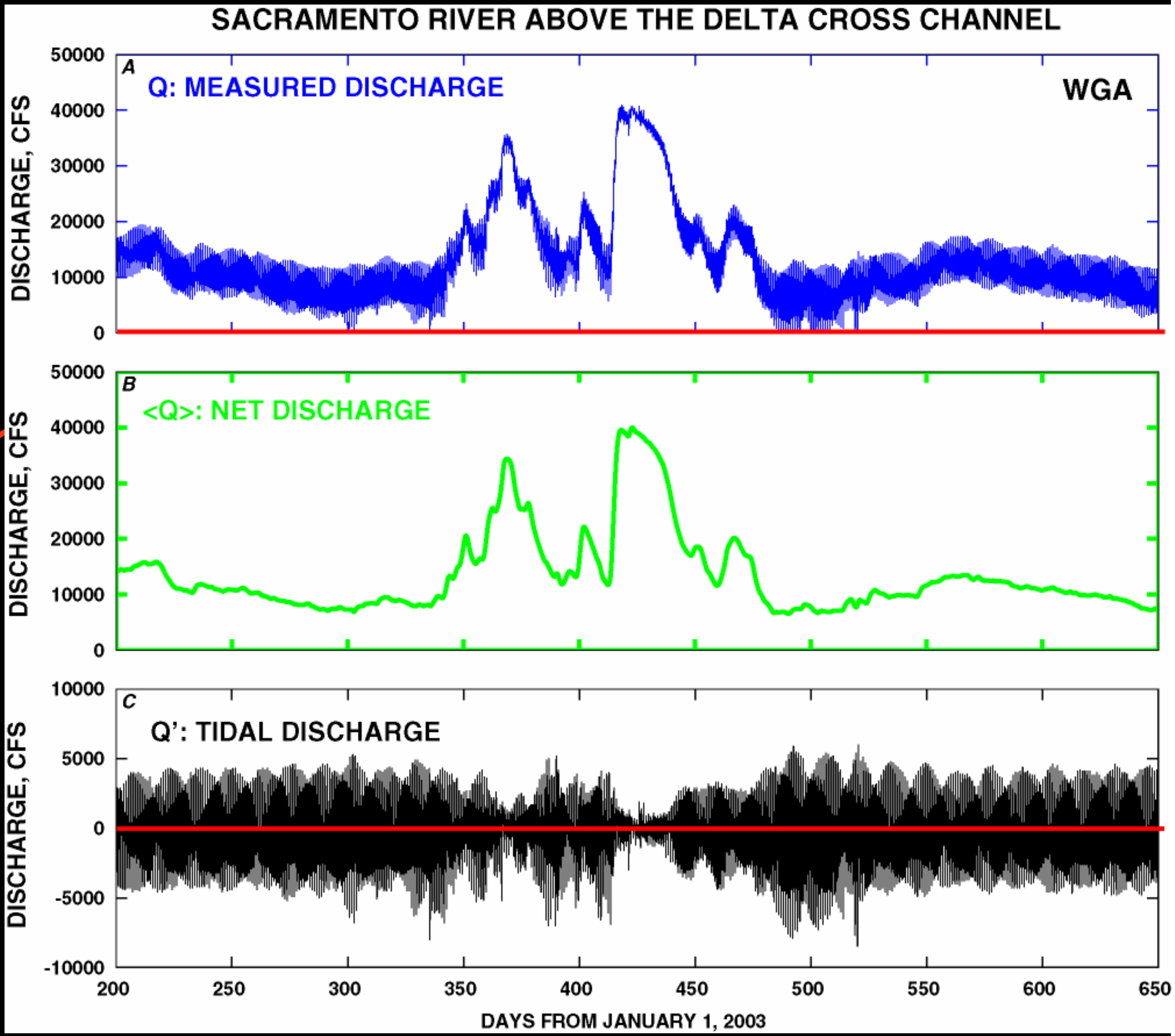
Conclusion:

Geometry controls the velocity structure within channels and junctions

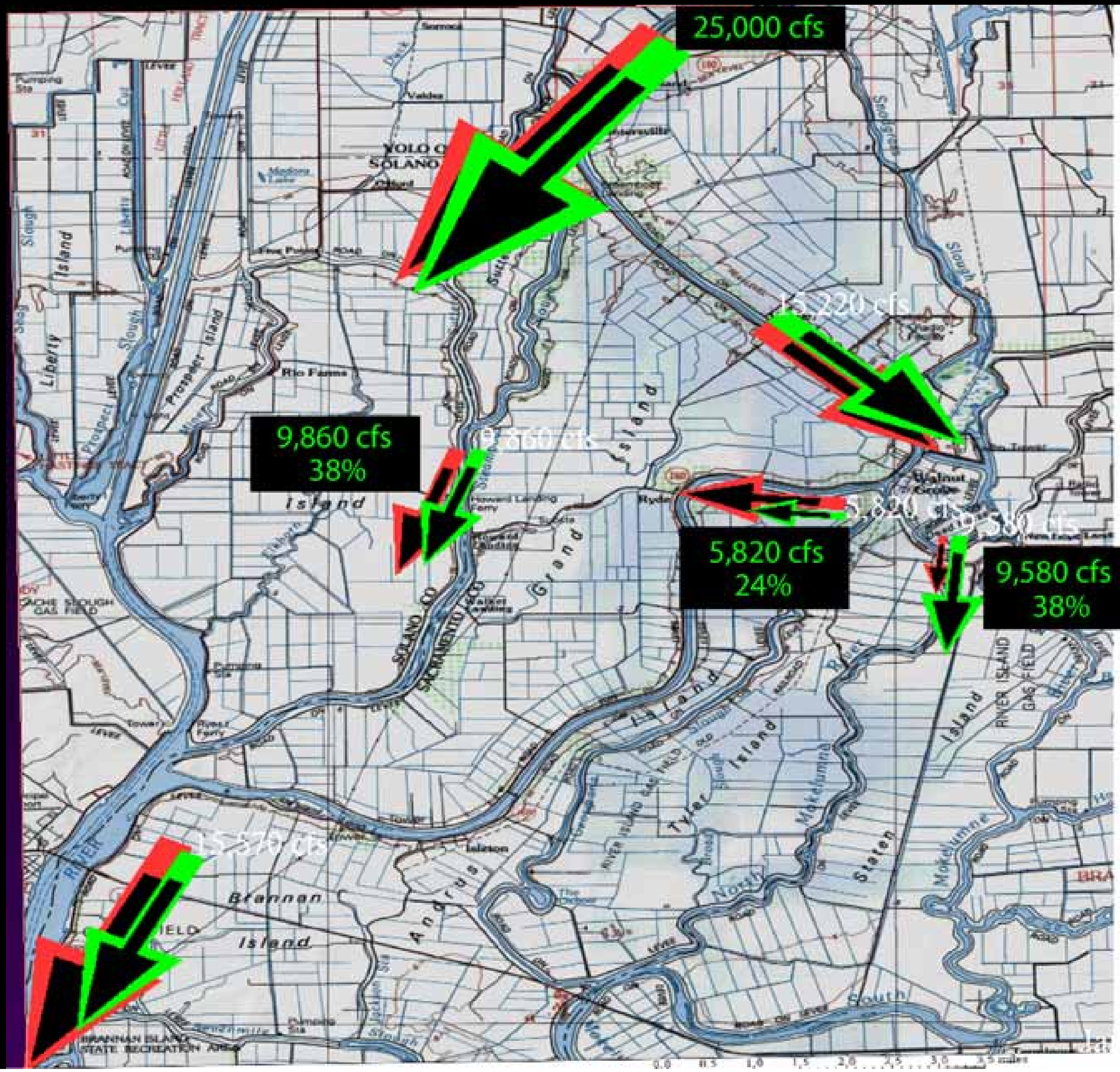
What about the discharge within a channel?

Decomposing the measured discharge into net And tidal components





Distribution of net flows in the North Delta at Sacramento River flow of 25,000 cfs

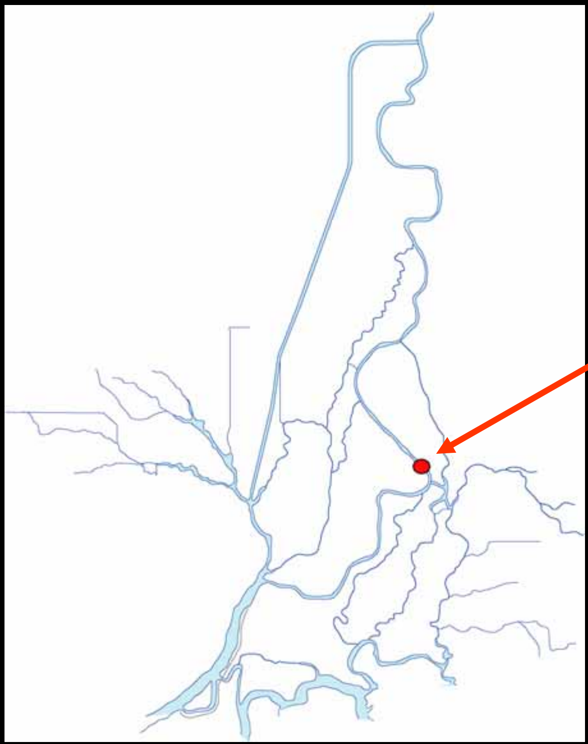


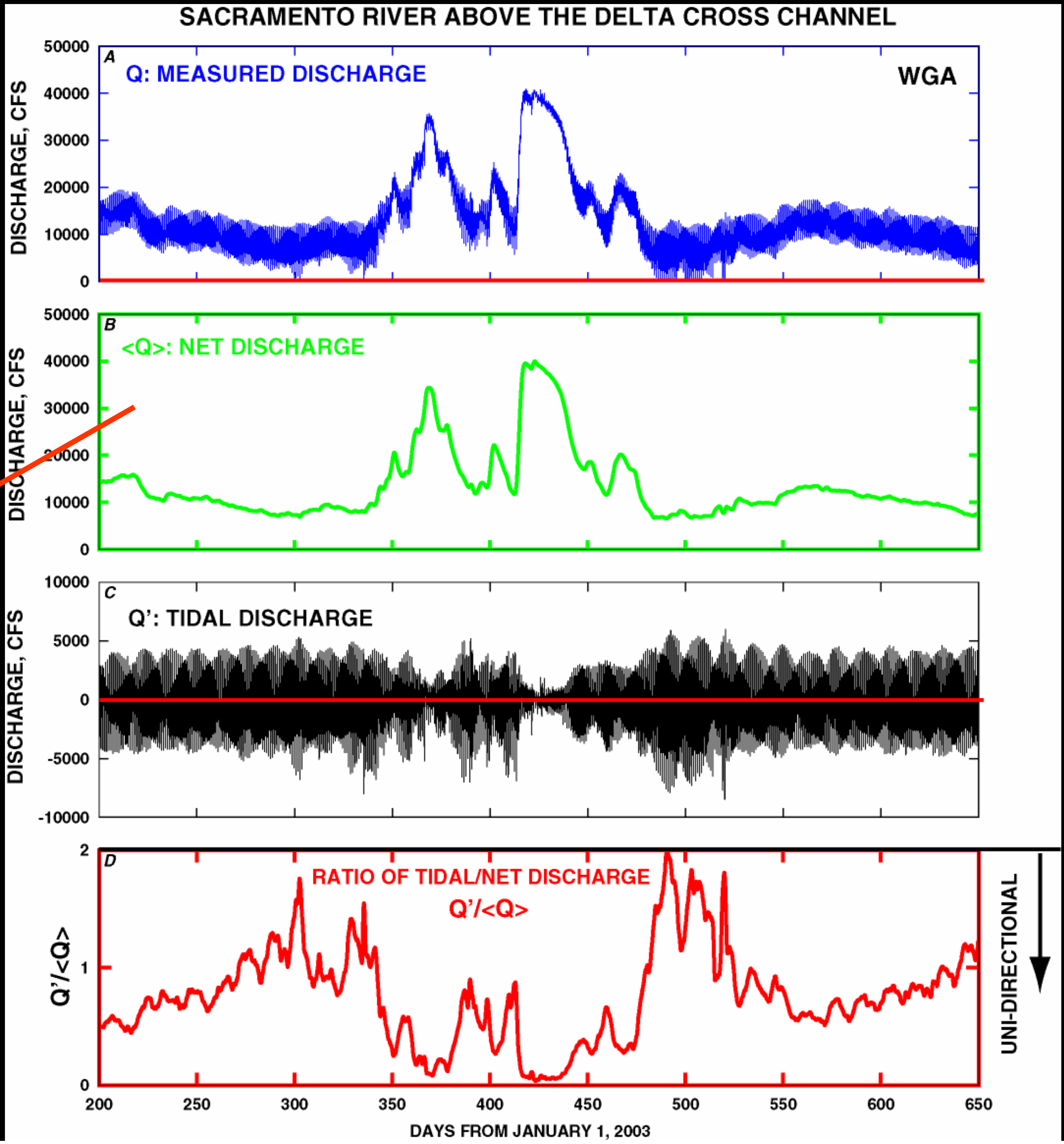
Head difference

If Steamboat slough bigger – a much larger Percentage would go down steamboat slough because it is shorter

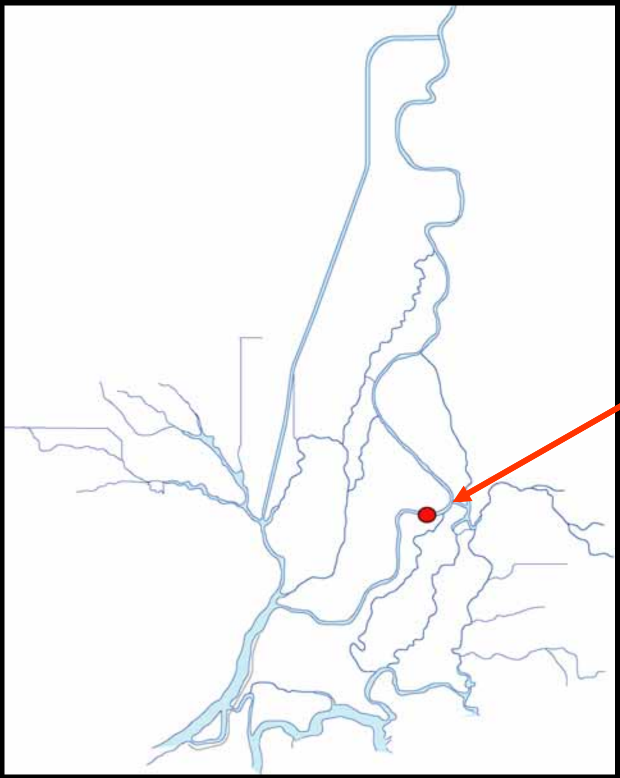
Geometry controls the distribution among north Delta channels

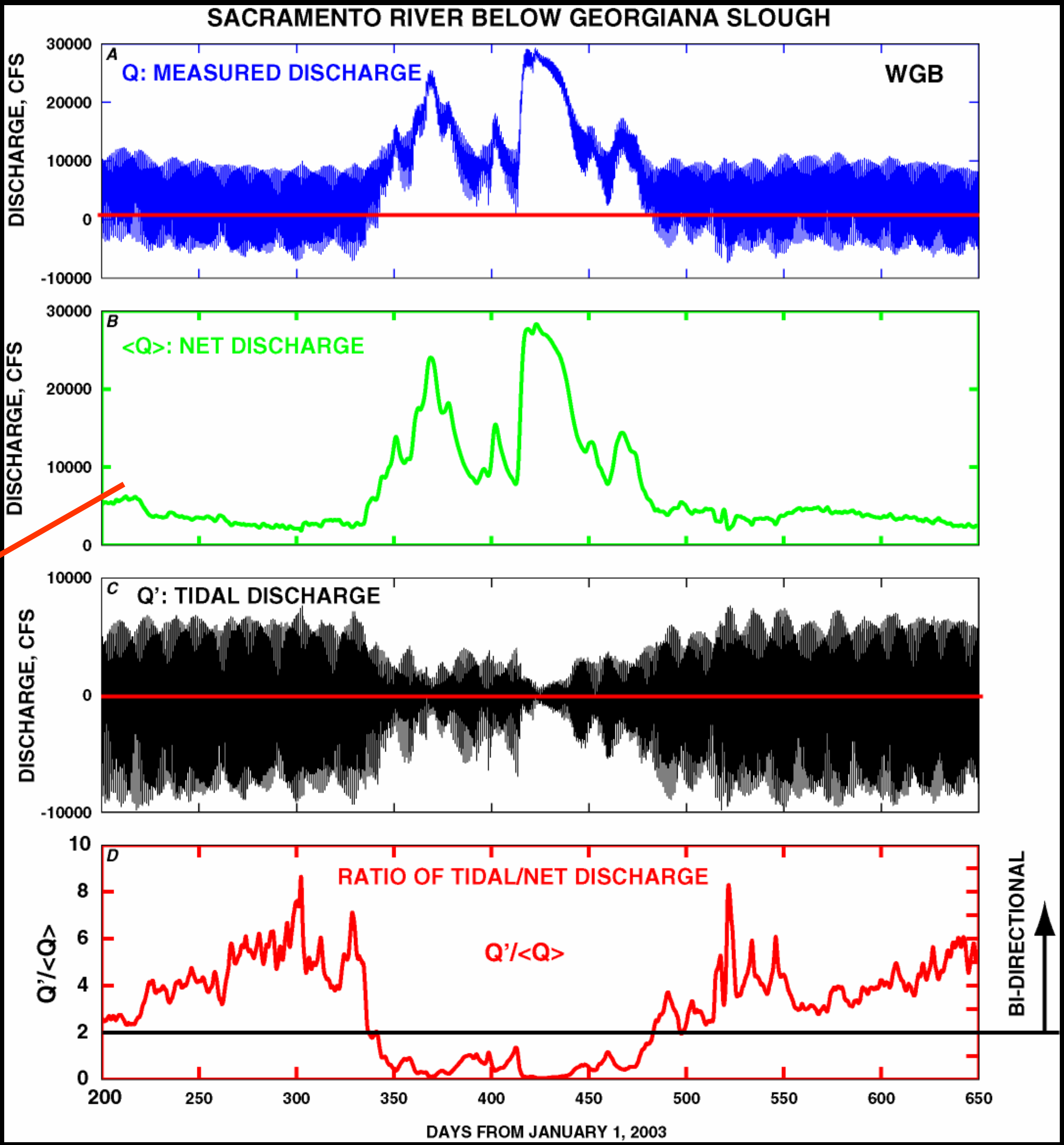
Decomposing the measured discharge into net And tidal components





Discharge decomposition 1.5 mi lower in the system





Regional map of Q'/<Q>

Show where net flows are important

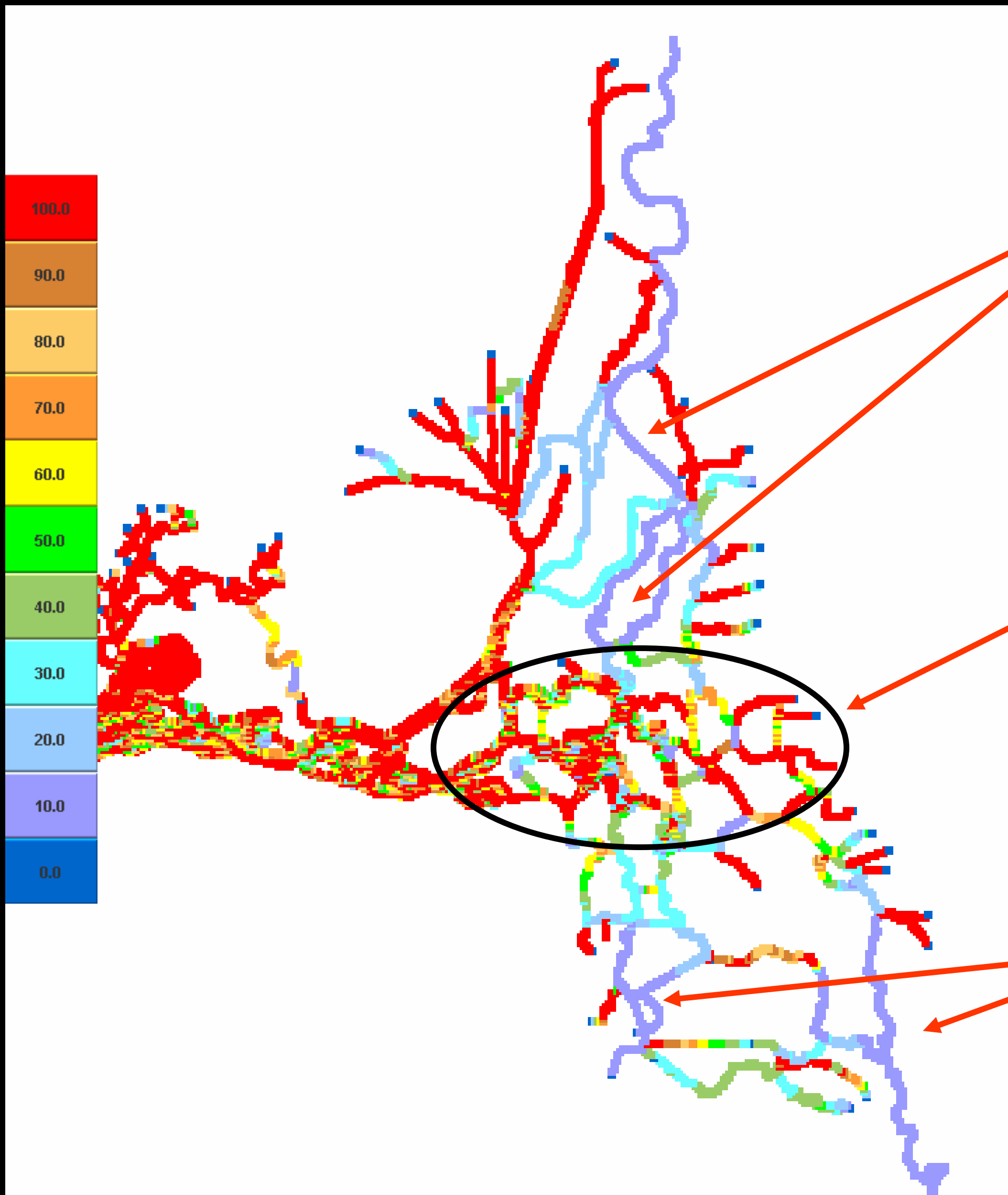
Influence of Sac Rivers

Influence of SJ River

Influence of pumps

Influence of tides in central delta
This is why the water project operators struggle to meet
Salinity standards in the central delta
– influence of net flows relative to tides is weak

Map of Q'/<Q> Sac R. Flow ~8,000 cfs

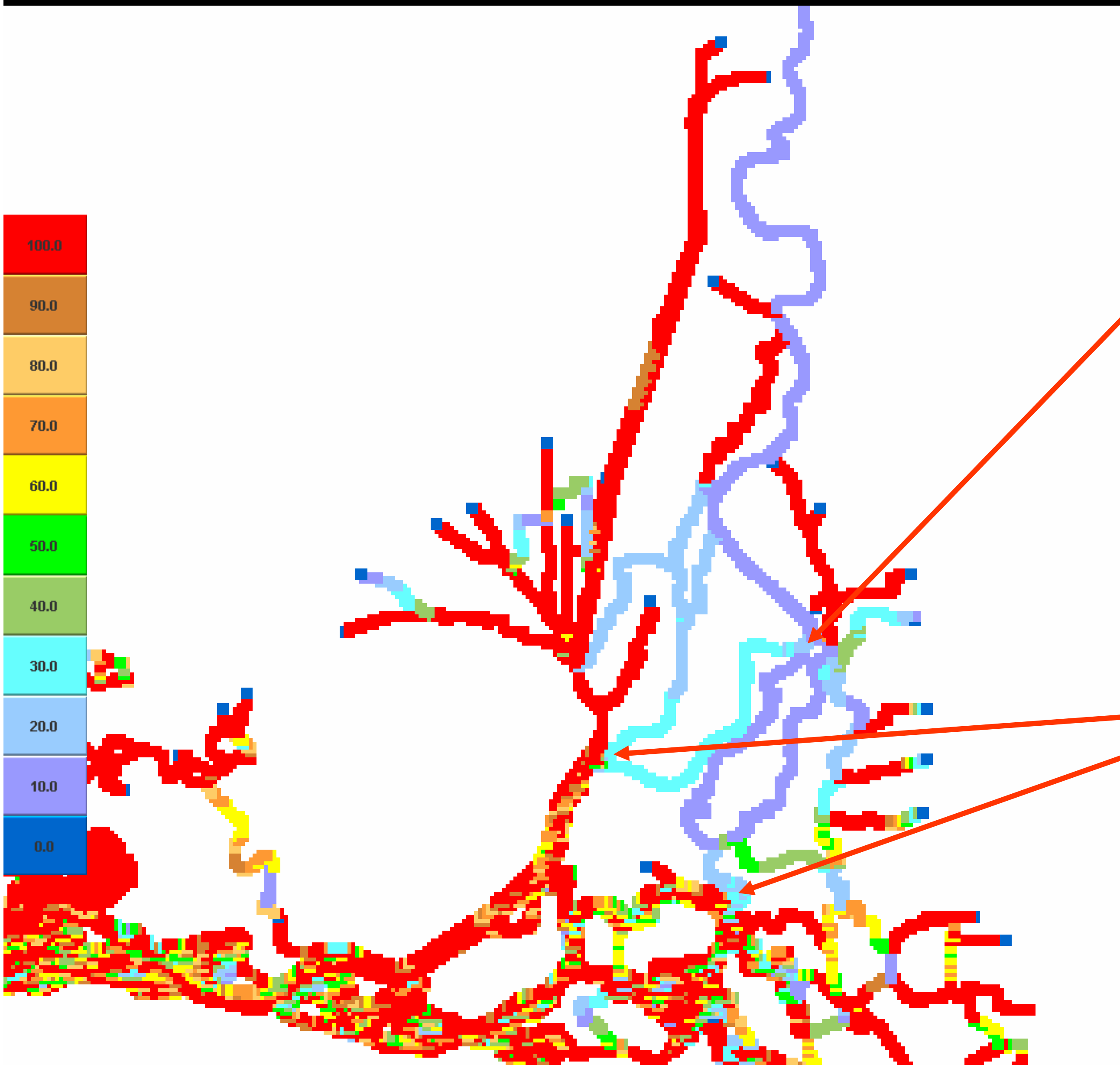


Blue areas:
Net flow influenced

Red area:
Tidally influenced

Blue areas:
Net flow influenced

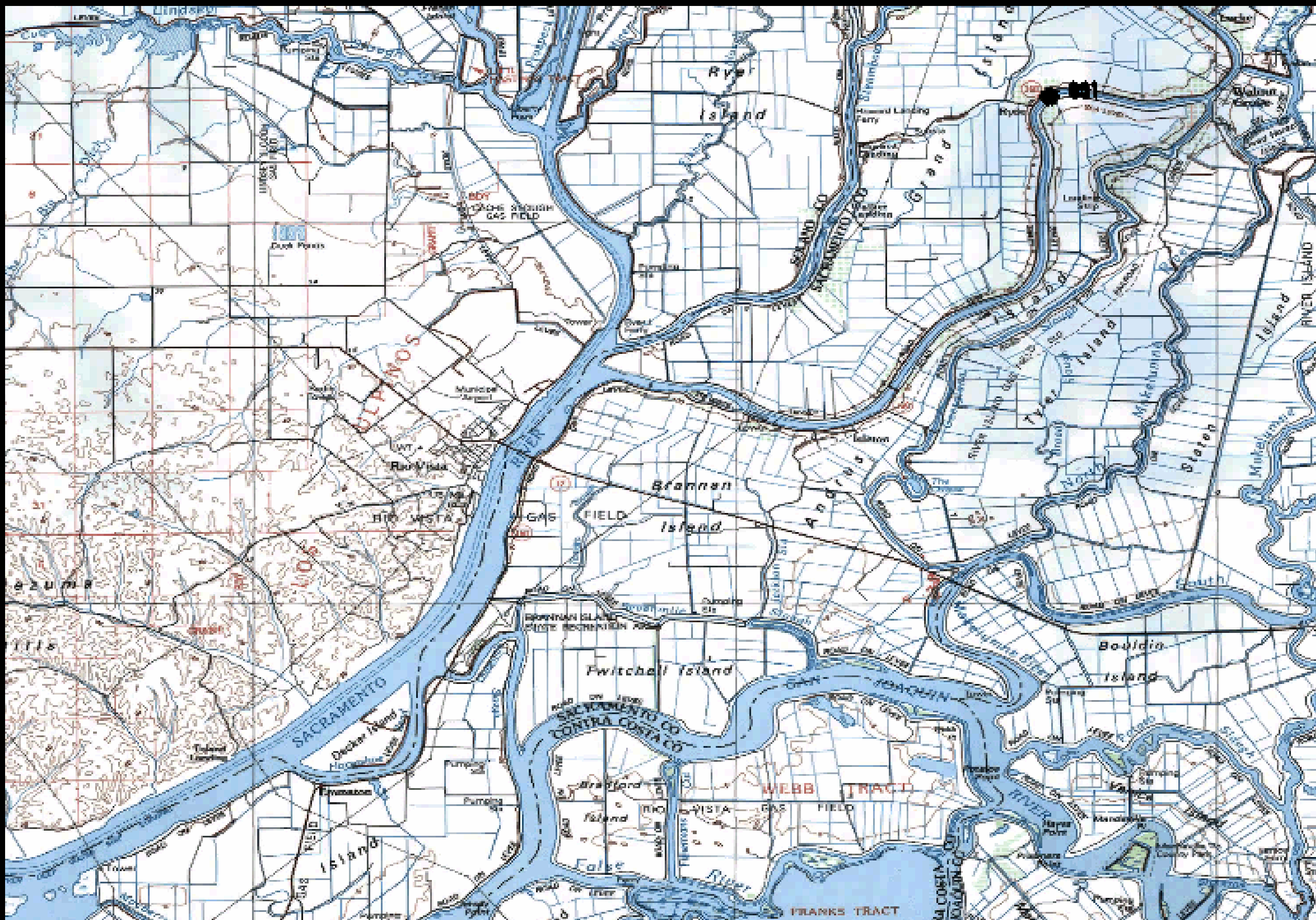
Map of Q'/<Q> Sac R. Flow ~8,000 cfs



Q'/<Q> ~ 2

Bi-directional flow

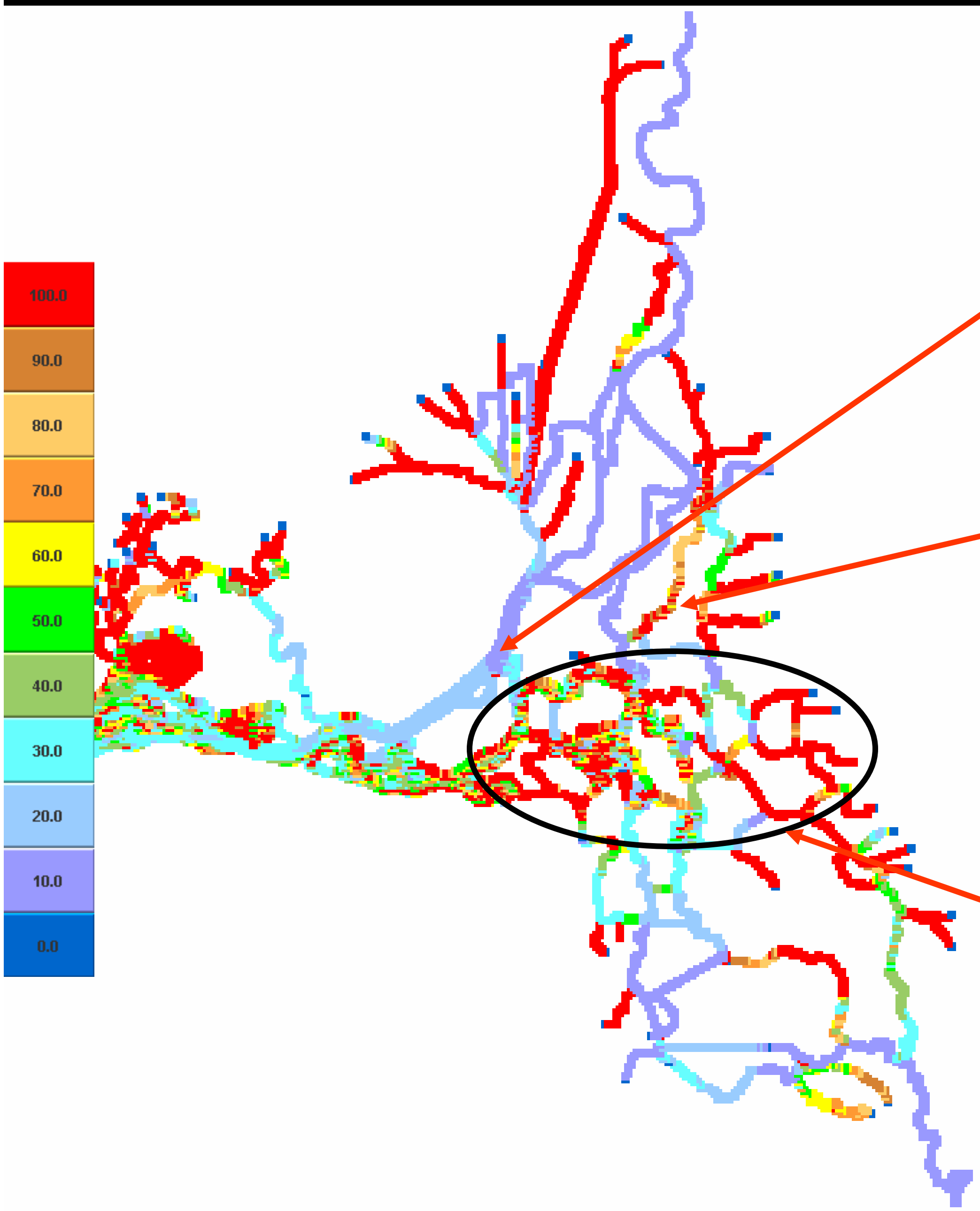
Step-function Change in Q'/<Q>



Jan. 18, 2000 at 03:00 PM PST

Jan. 25, 2000 at 01:00 PM PST

Map of Q'/<Q> Sac R. Flow ~65,000 cfs



Expansion of blue areas:
Net flow influenced

Mokelumne
becomes tidal
with DCC gates closed

Central Delta is remains
tidally influenced
even at high flow

Dispersive mixing is important where:

Bi-directional Flow Occurs

AND

Channel is WIDE and includes bathymetric features

Lateral variability in currents: Shear flow dispersion

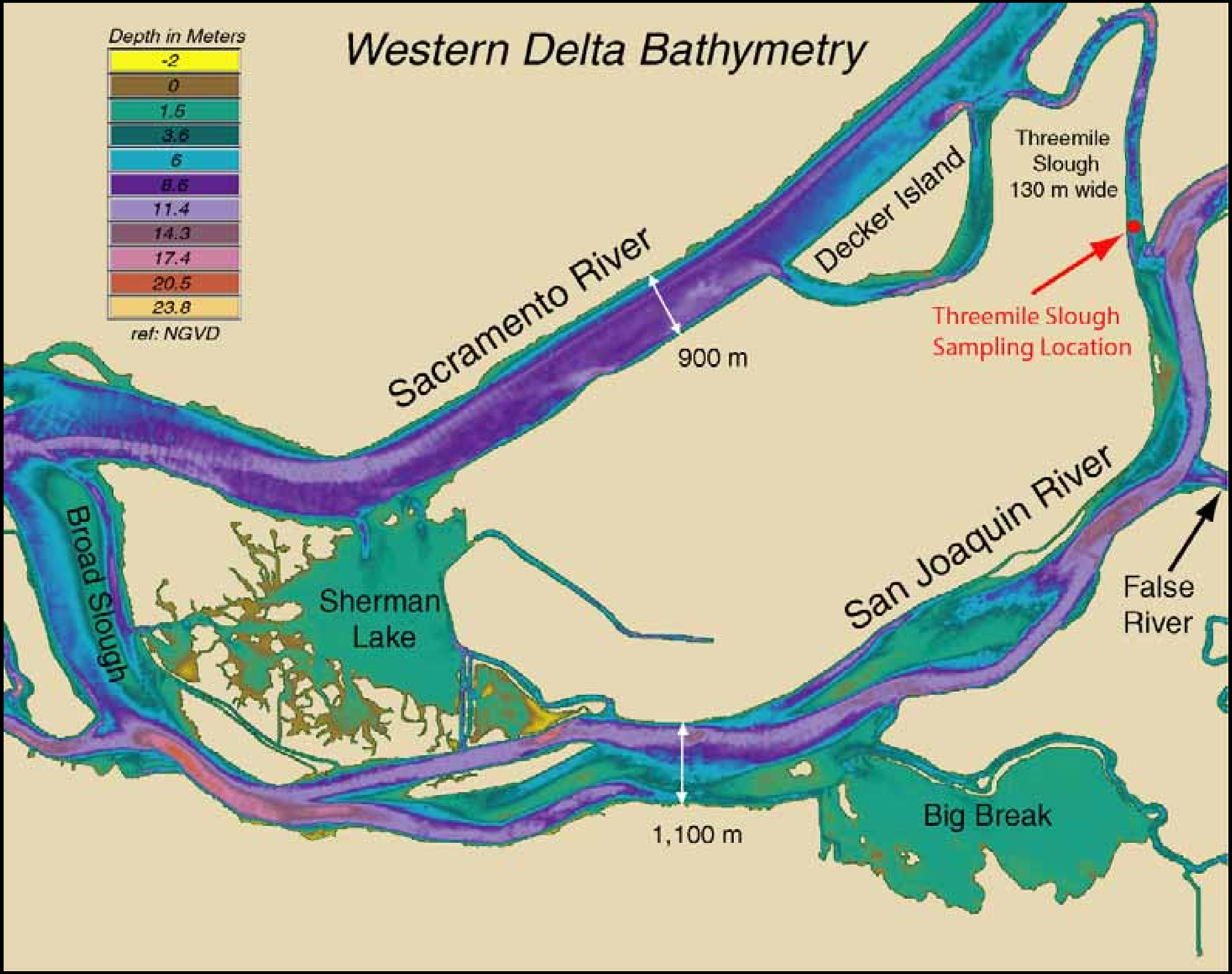
Western Delta

OR

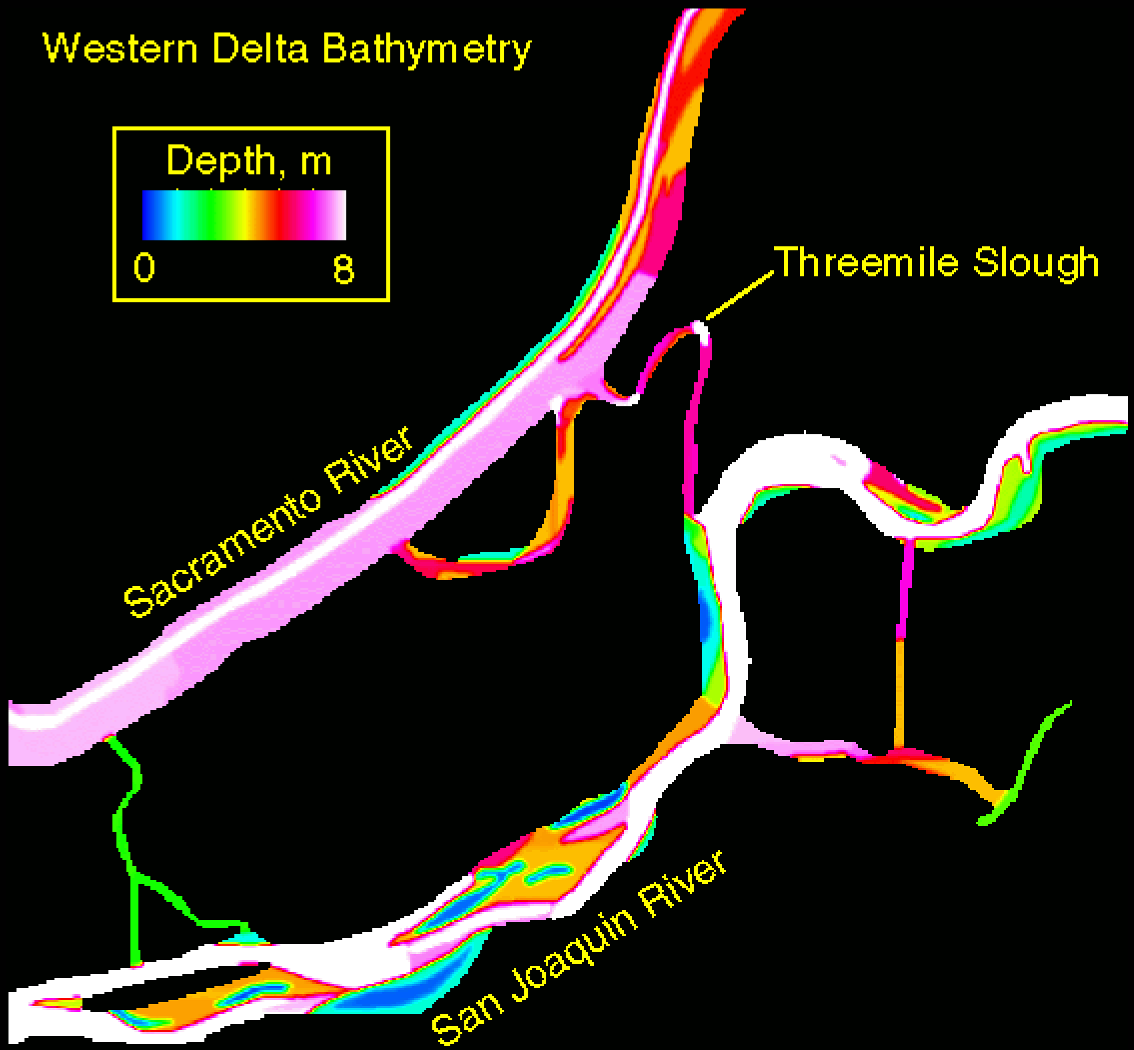
Tidal excursion >> channel length

Central and Southern Delta

Lateral Bathymetric Variability in Western Delta



Bathymetric Variability in Western Delta

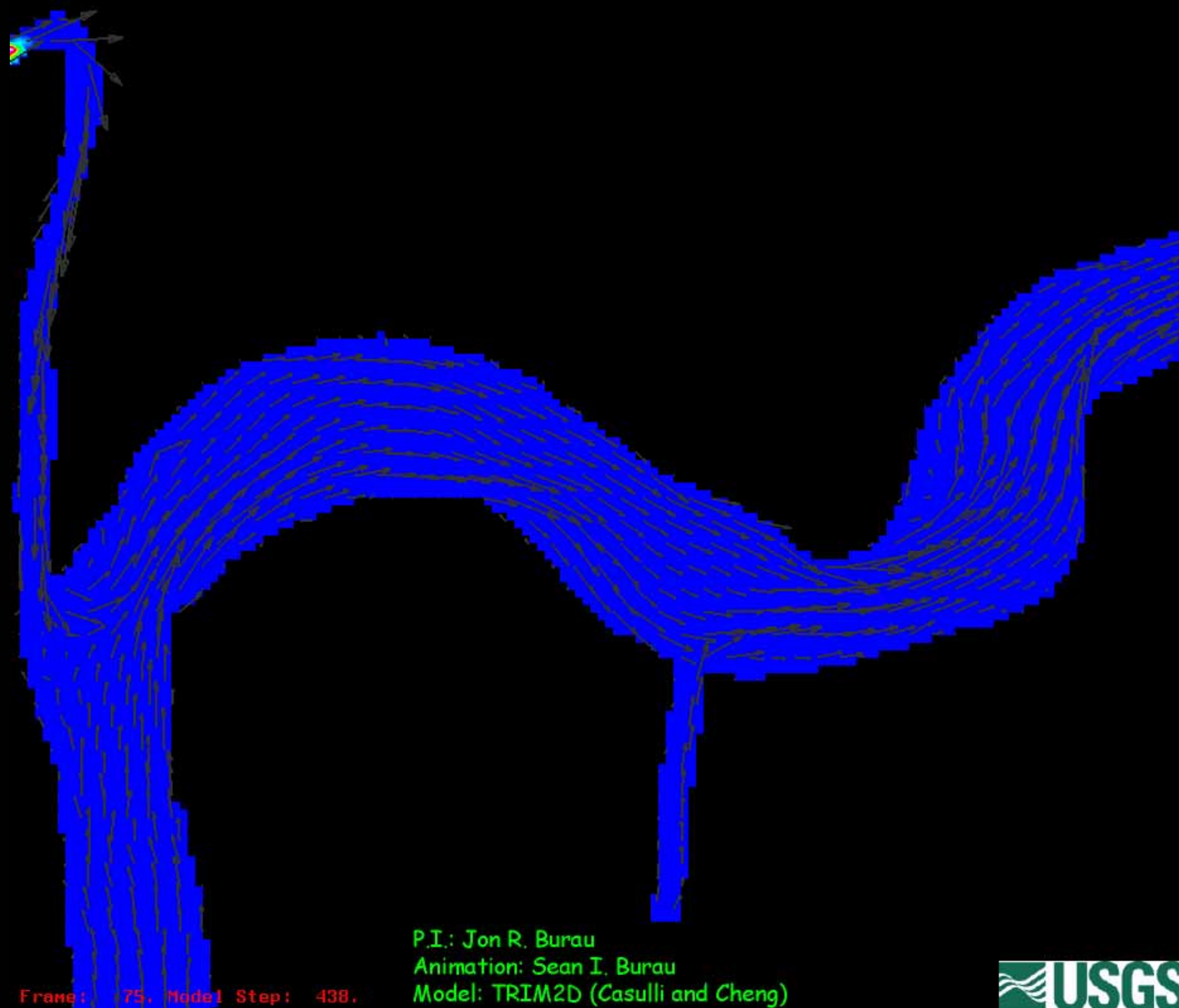


Which leads to

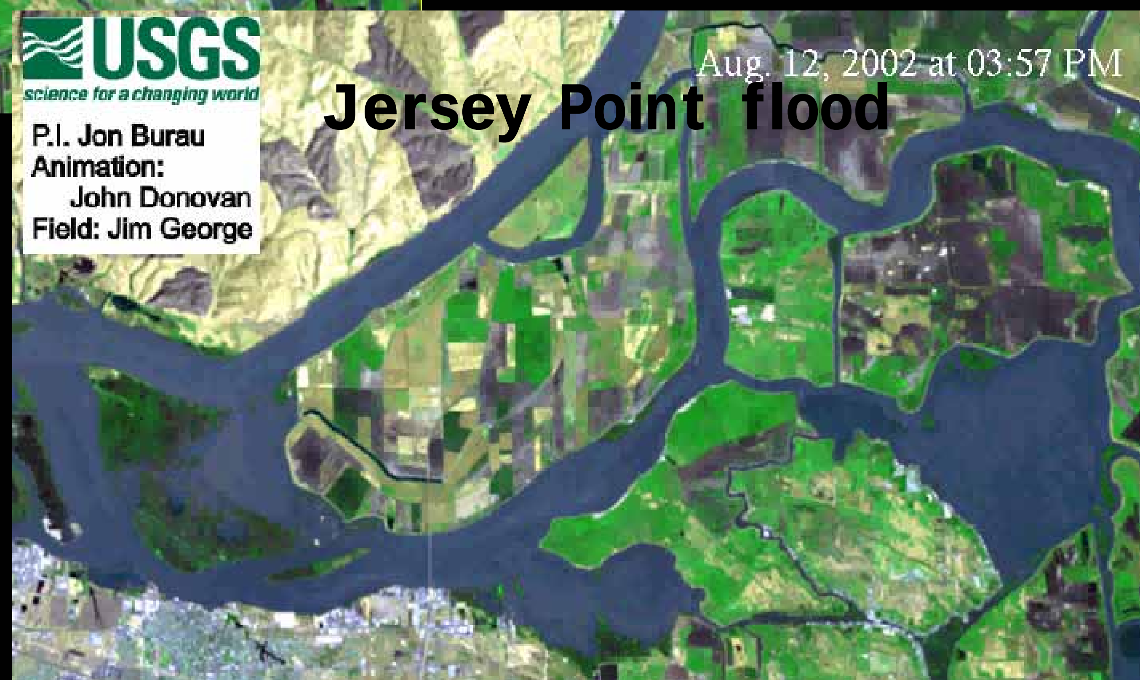
Lateral variability in the current structures

Dispersive Mixing

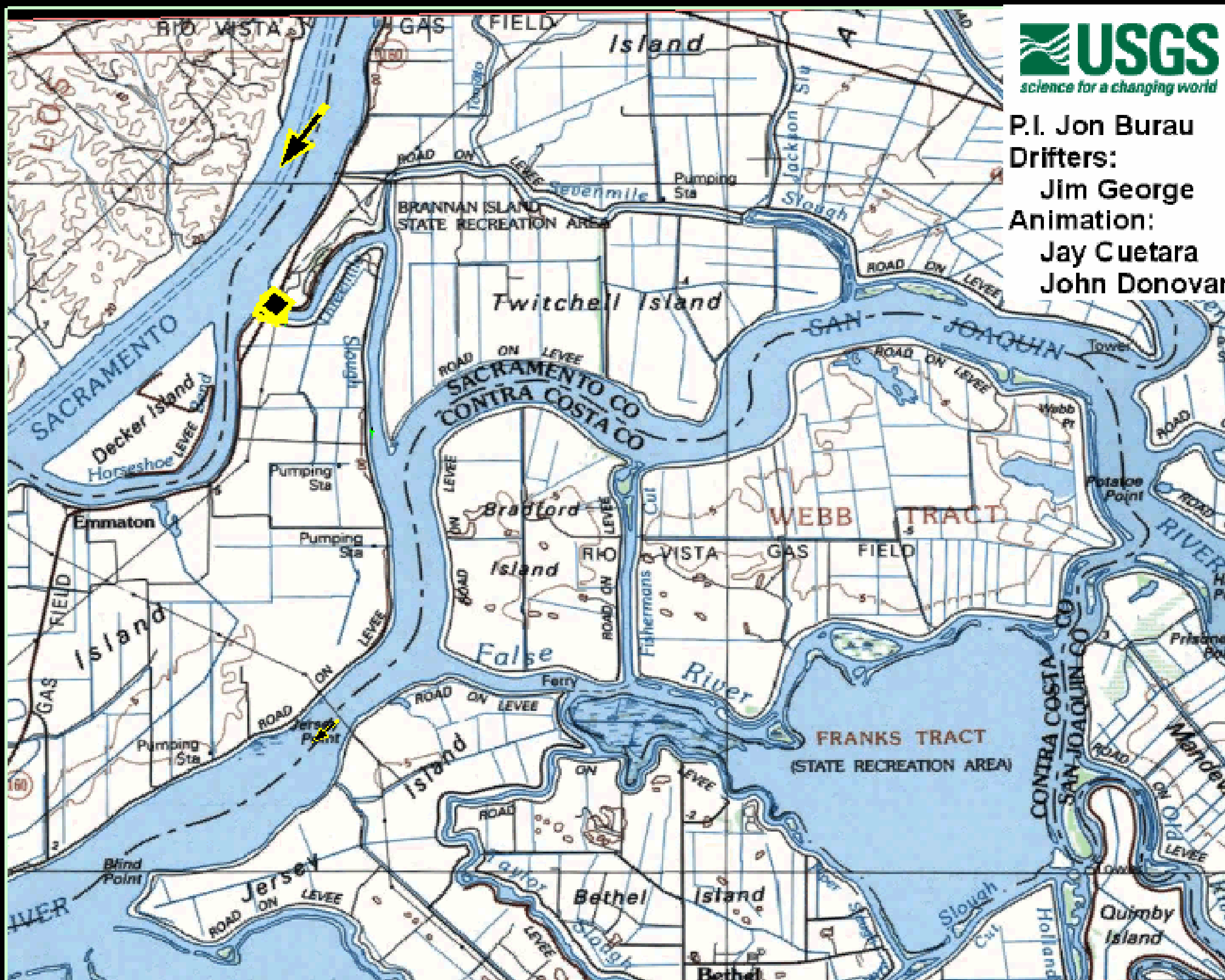
Threemile Slough Dye Release



Tidal excursion



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



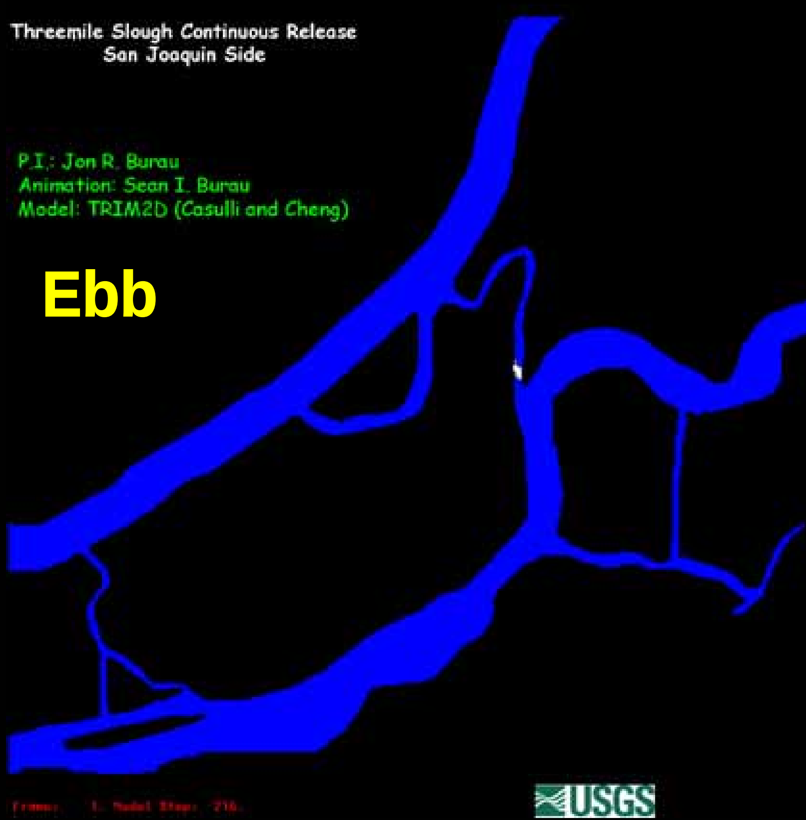
USGS
science for a changing world

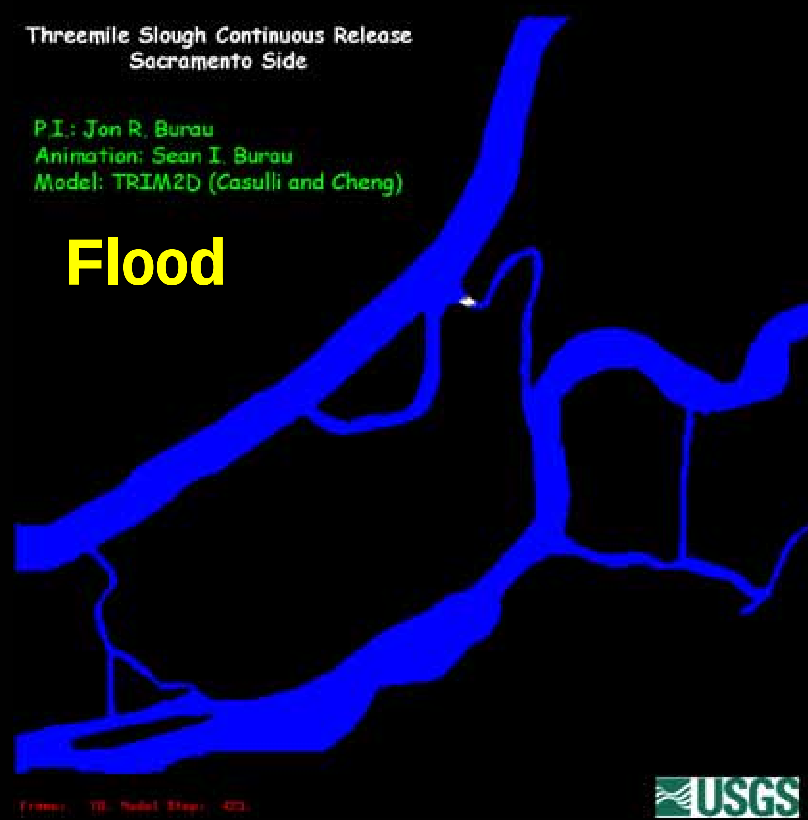
P.I. Jon Burau
Drifters:
Jim George
Animation:
Jay Cuetara
John Donovan

Feb. 19, 2003 at 01:07 PM

Threemile Slough example

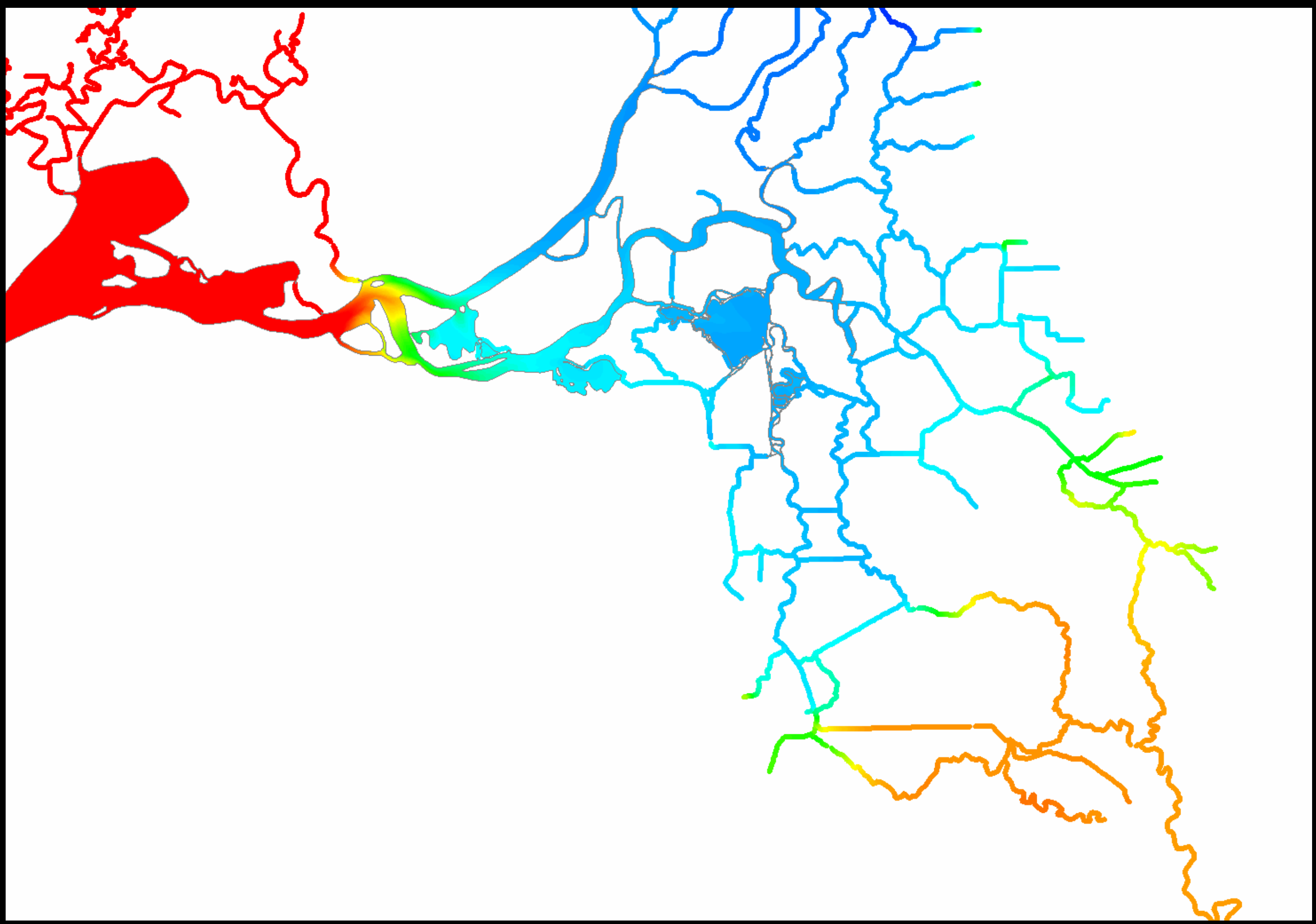
(tidal excursion >> channel length



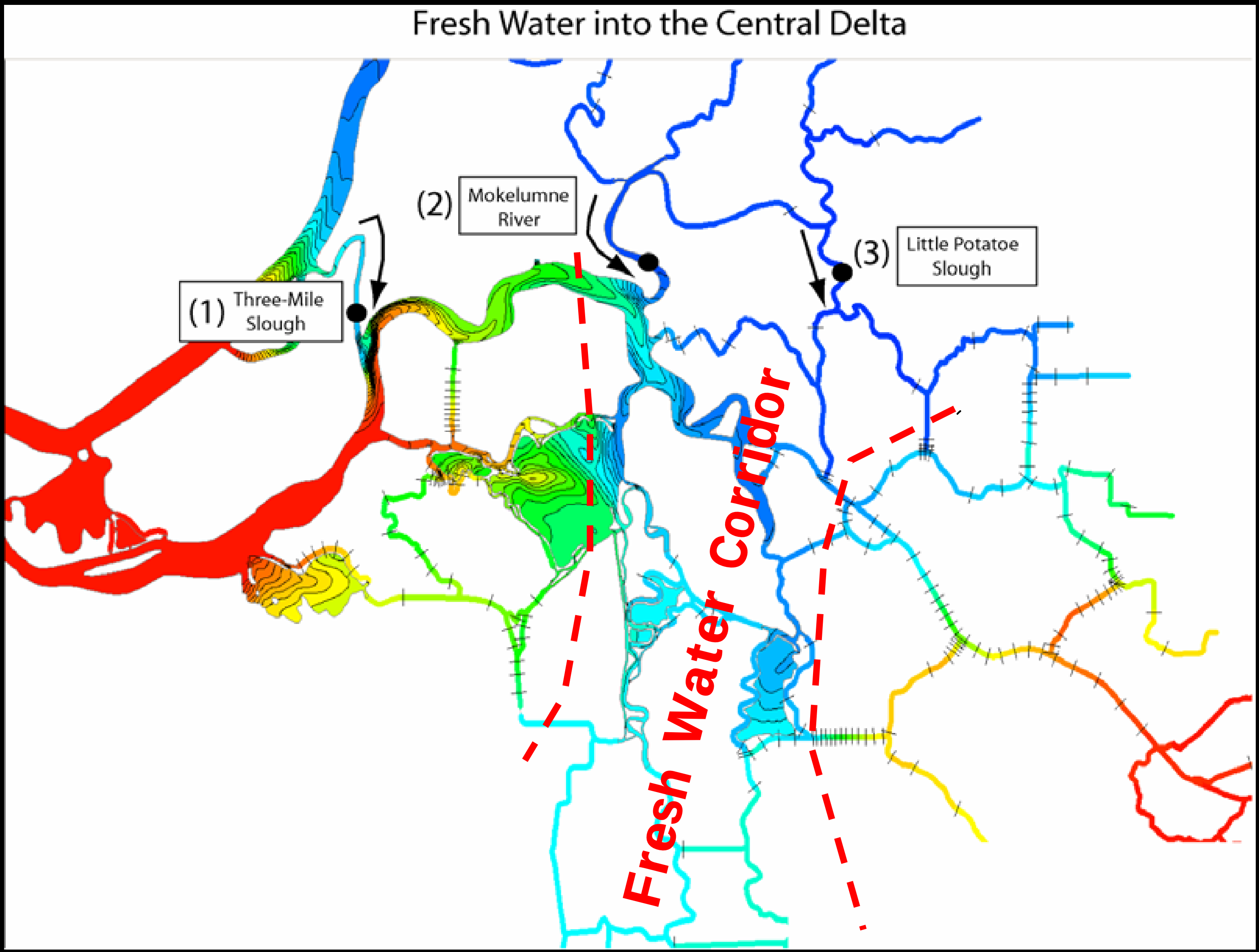


False River dye example
(lots of mixing along dye path)

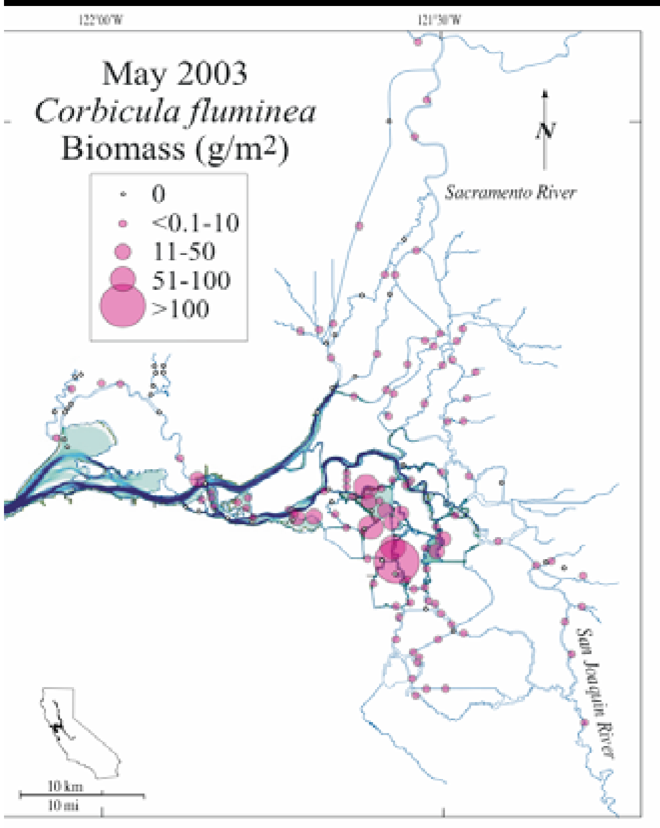
Dispersive transport means that salinity intrudes into the Delta from the bay despite a net flow that is out (so called carriage water)

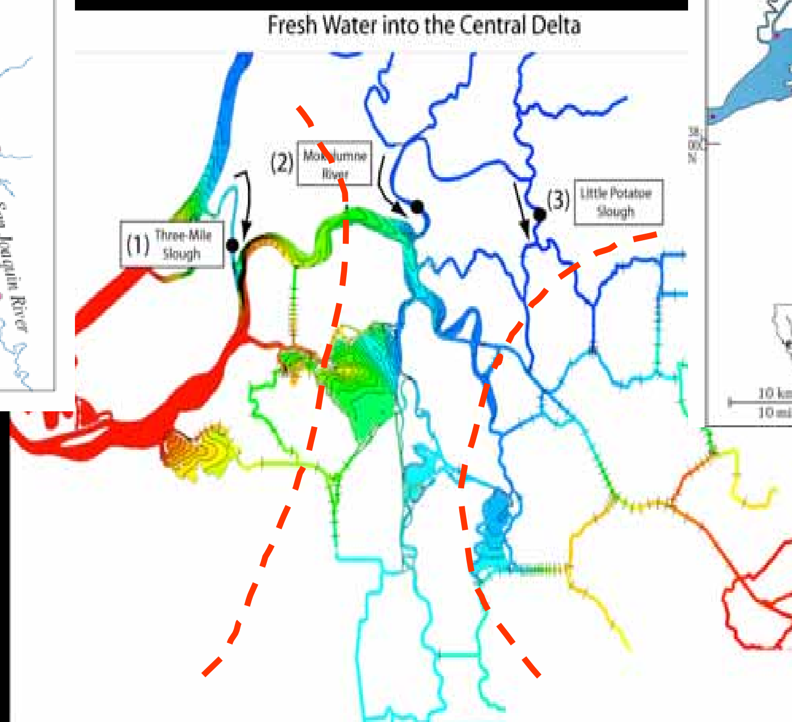


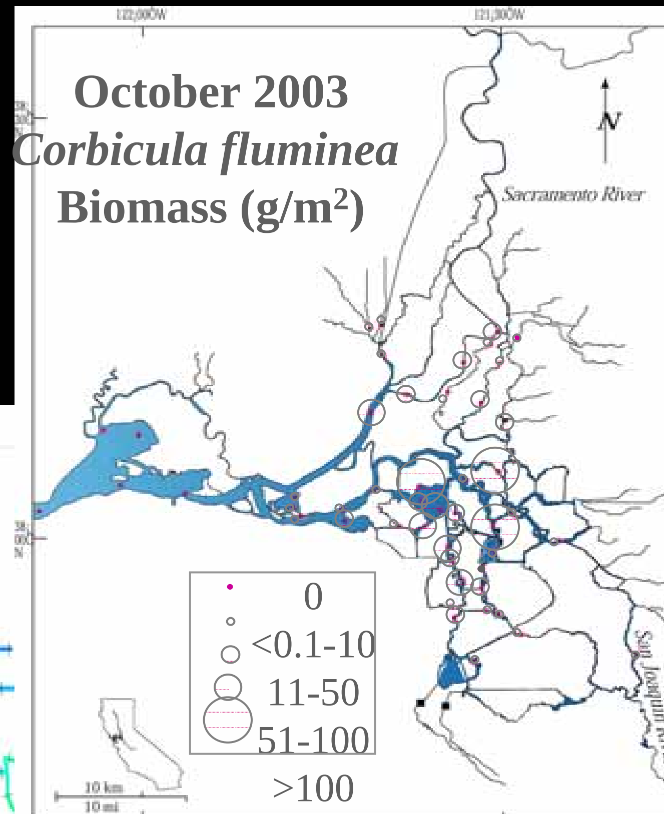
"Fresh Water Corridor"



Corbicula appear to thrive in the freshwater corridor – fast food??

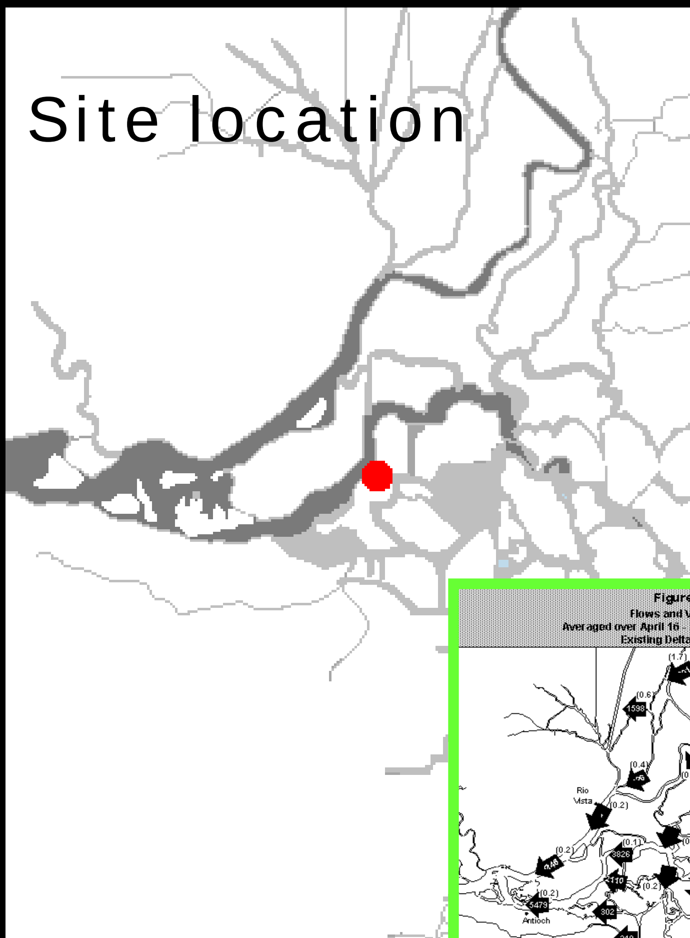


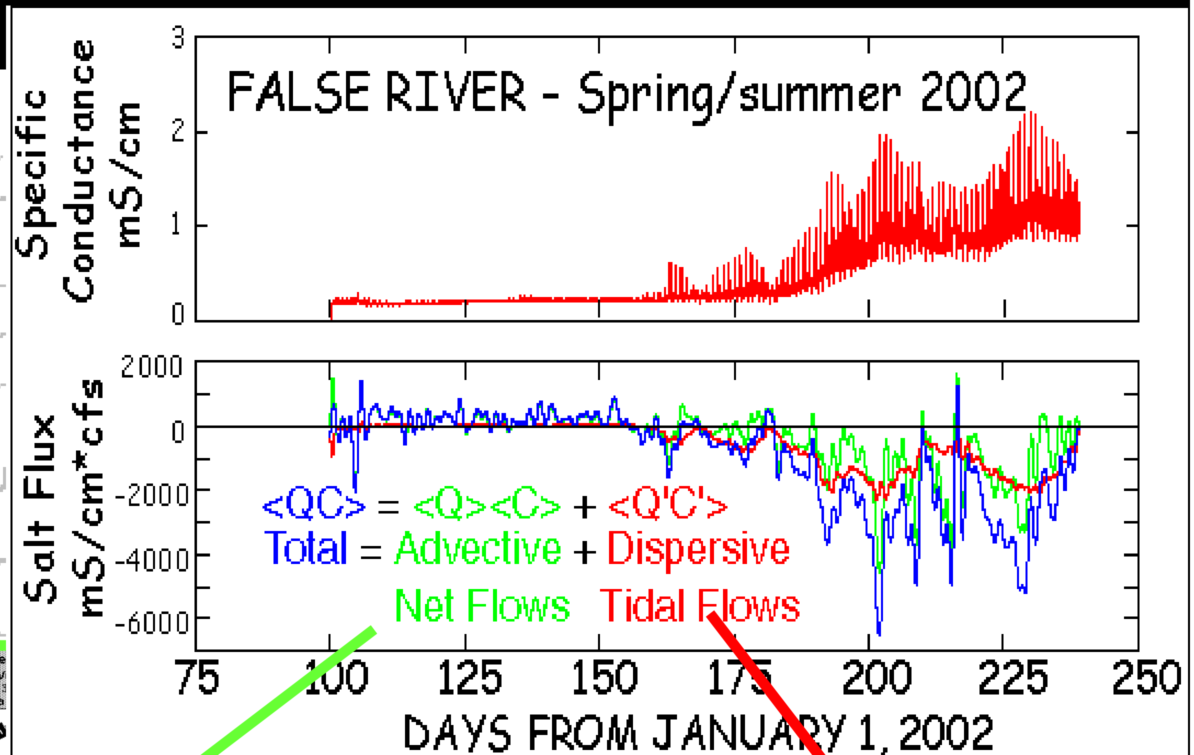


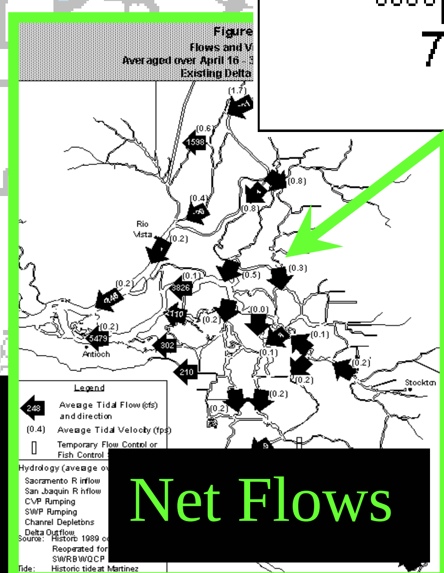


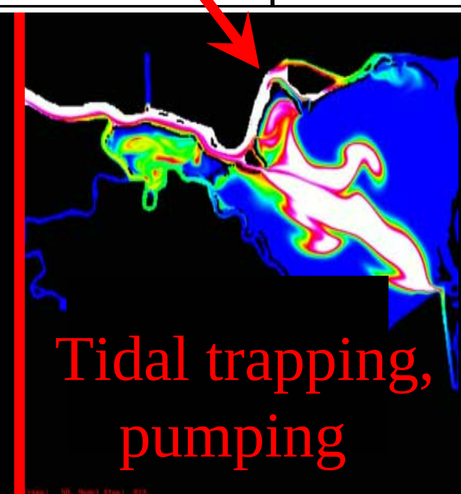
Transport (salinity intrusion is one example)
in the central Delta
is a balance between
advection (river flows and pumping)
and dispersive mixing

False River Salt Flux example









But this balance can be changed by changing the geometry

Two examples:

(1) Changes to the Franks Tract geometry

(2) Changes in the South/central delta Geometry to reduce the risk to CA's water supply

Franks Tract example

Simple changes in geometry: water quality improvements

Example WQ improvements

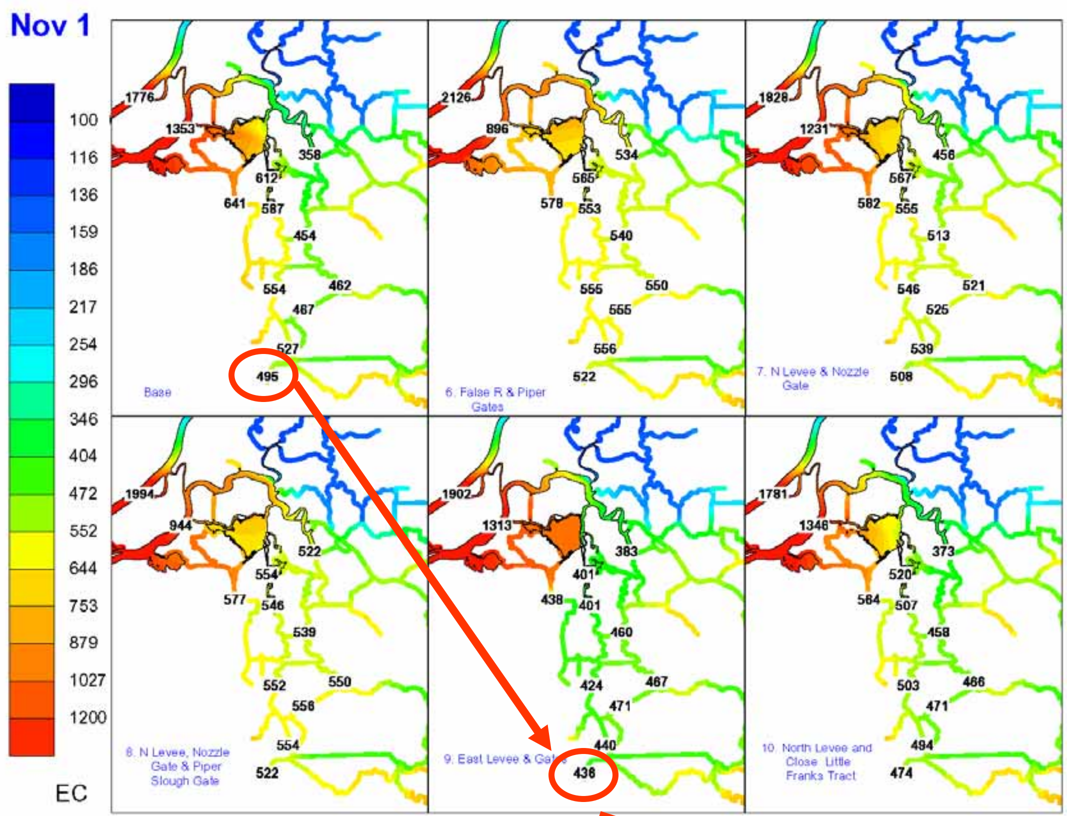


Figure 4-23 Tidally averaged EC contours on November 1, 2002.

4-32

~12%

We can also reduce the risk to the water supply by changing the geometry

Put barriers in

Describe how this would reduce risk to water supply

Show improvements in wq

Show that a configuration that reduces risk
To water supply is more consistent with historical delta
And this configuration would create residence
Time diversity or a diversity of pelagic environments
could argue that the pod occurred when the delta was reclai
For agriculture creating these loops and homgenizing the delta
and that pelagic species have been on life support ever since

This brings us to the central delta

Central delta bathymetry is a manmade anachronism

Lots of loops due to argicultural reclamation

These loops tend to homogenize gradients
And homogenize habitats – pelagic habitat diversity is weak
Residence time diversity is weak – everything is mixed up

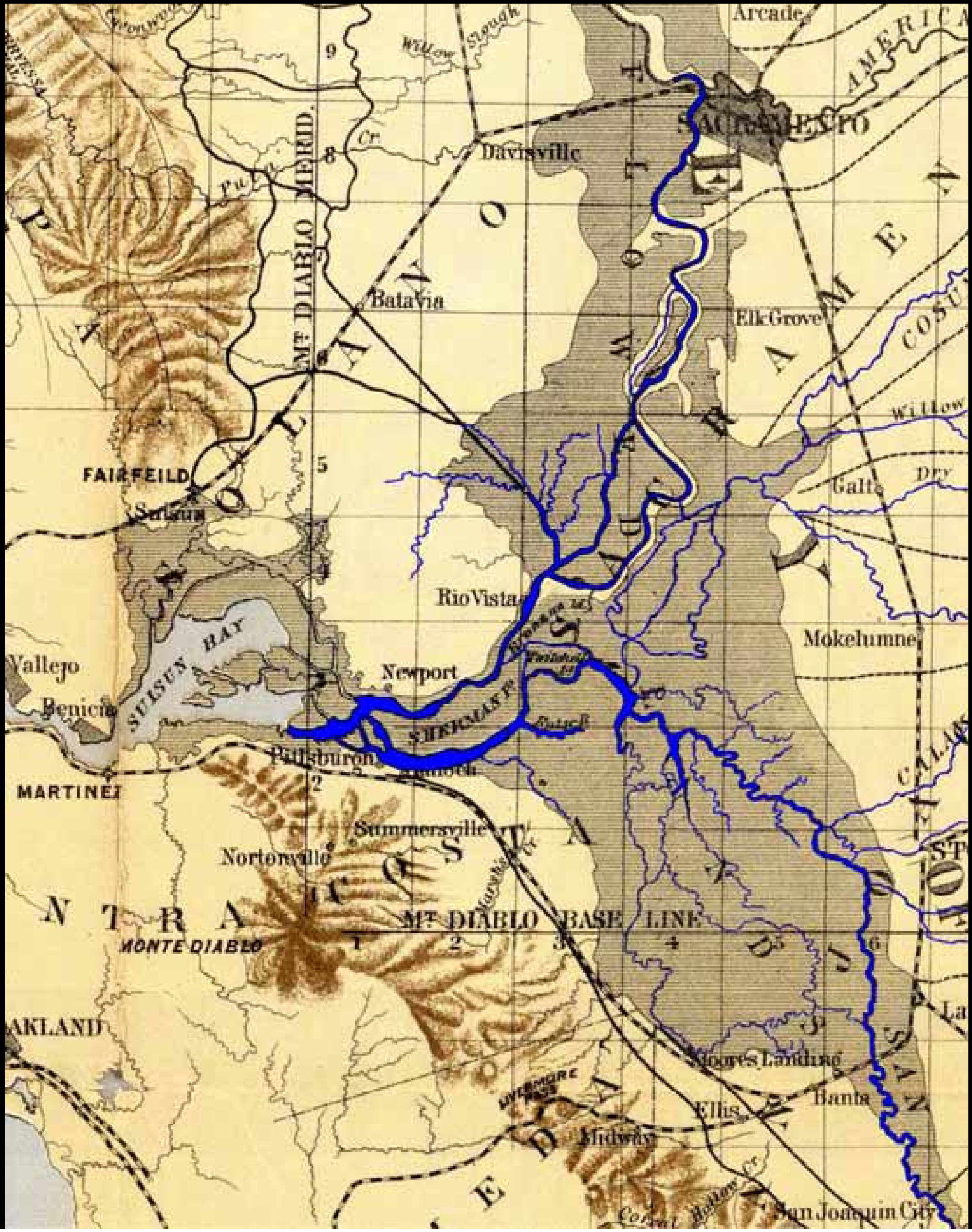
Interconnetectedness “loops” means

Homogenization of pelagic habitats

Increase in risk to water supply due to levee failures

Increase in rate of salinity intrusion

Delta geometry in 1873



Dentritic (tree like) geometry

Channel length >> Tidal excursion

Residence time Diversity

Distinct pelagic habitats

Pelagic species on life support since delta reclaimed for agriculture

Conclude

**Transport in the delta is controlled by:
(interaction of tides, river flows and
pumping with system geometry**

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

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

Conclude

I've tried to give you a sense of
the importance of geometry for things you care about
(1) Water supply, (2) water quality, (3) fish

The geometry of the system has
been stable for several decades

This is about to change

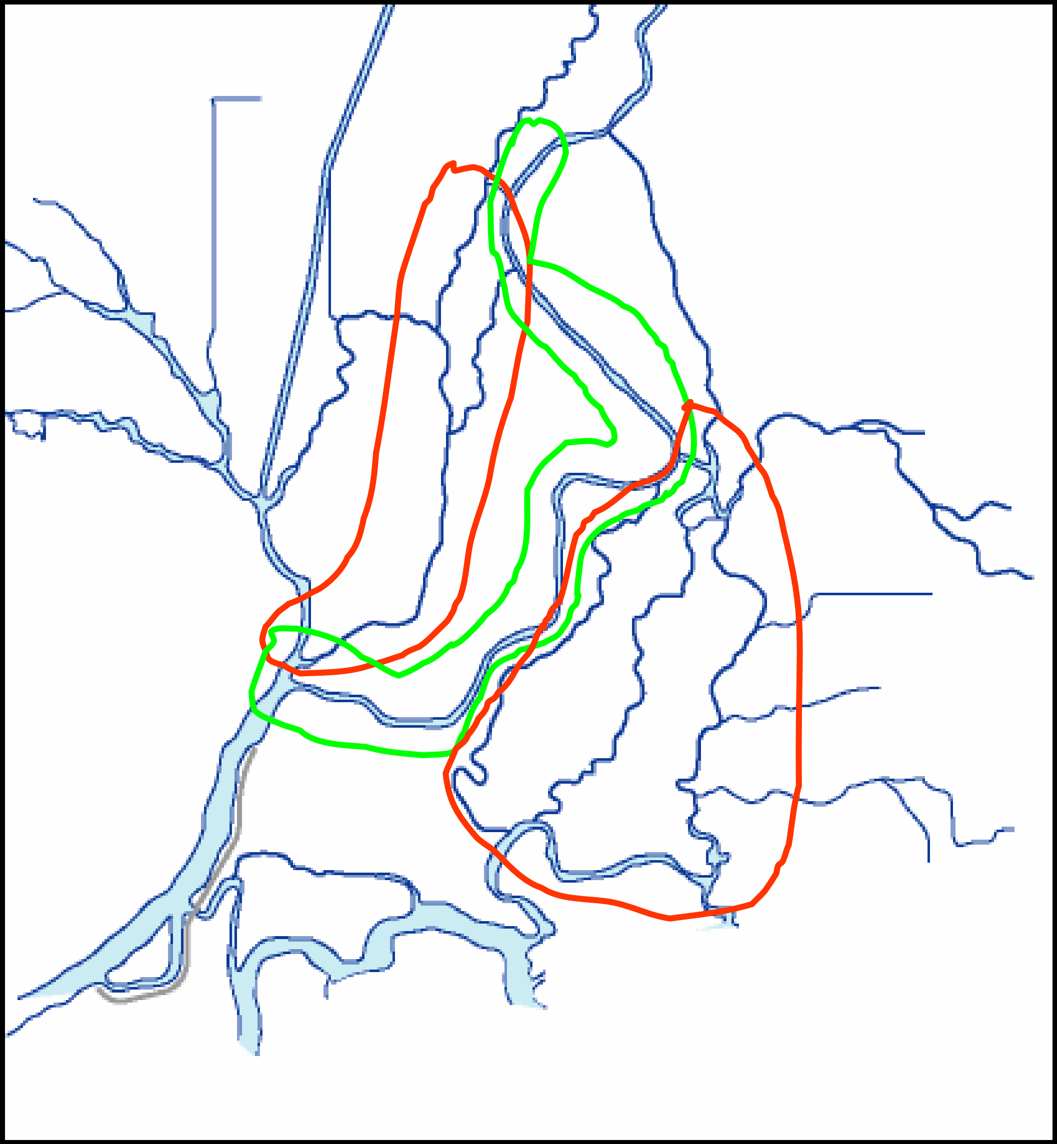
Water management agencies are beginning to realize
that changes in geometry can help them:
(1) deliver more water, or (2) improve water quality (salinity)
(3) Reduce the risk to the water supply due to levee failures

Improvements in:
(1) water supply
(2) water quality (salinity)
(3) reductions in risk to the water supply
are extremely strong motivations to change the geometry

What geometry do you want?

Regional tour begins in the north delta

Three primary transport pathways

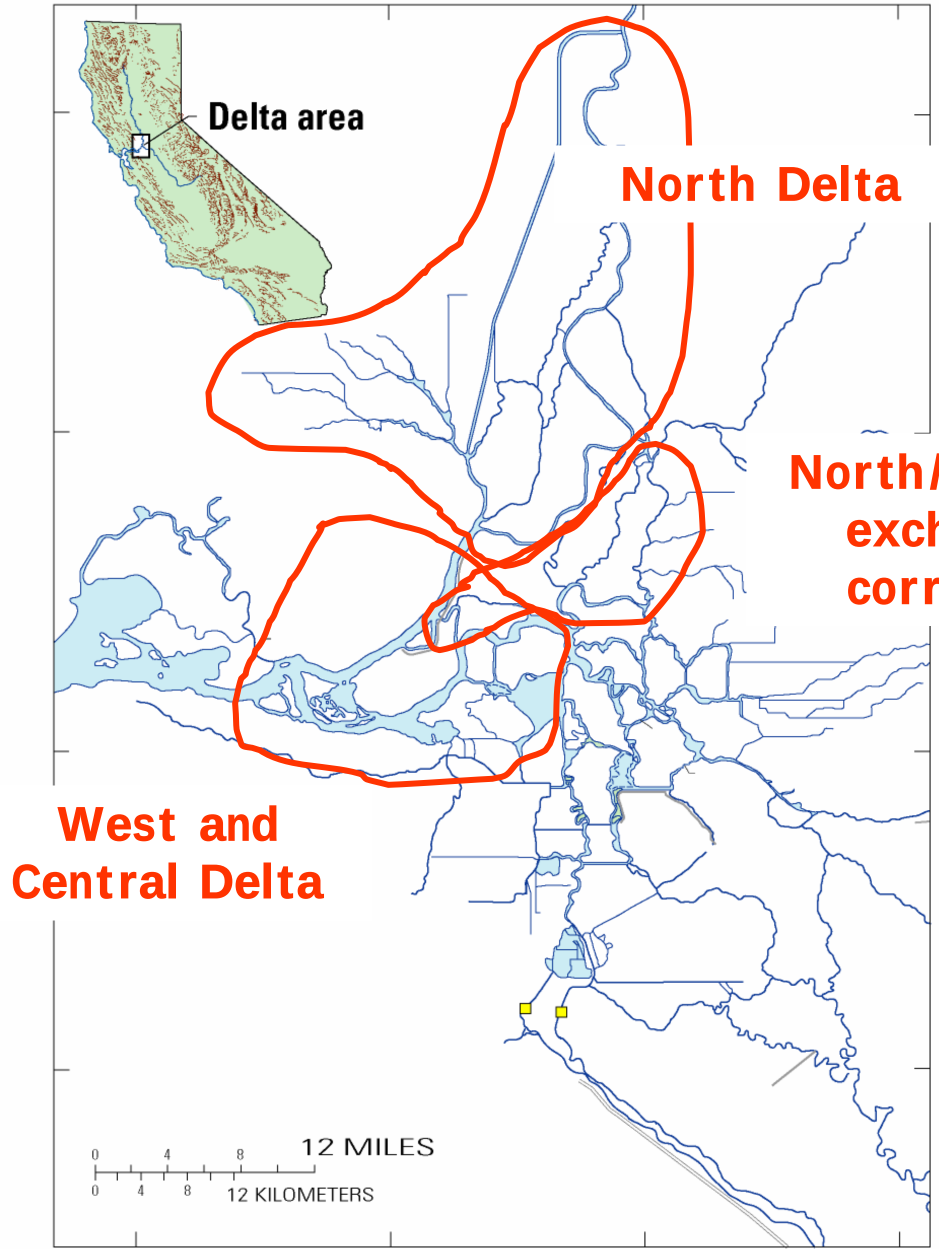


Sutter/Steamboat

Sacramento R.

Mokelumne system

Regional differences in transport characteristics exist



If pelagic habitat homgeniety
(at local and regional scales)
is a bad thing

Then the delta geometry we have
is not helping pelagic organisms

So, in a perfect world, what would the Delta
geometry look like to support the ecosystem we want

and

How does an ecosystem centric geometry compare
with geometries that improve
Water quality, supply, and reduce risk to water supply

If Jones Tract had been allowed to remain flooded
it may have improved
Water quality at the pumps
and/or increased water supplies south of the delta

With the geometry the way it is
we are steaming in the Titantic in
Burg infested waters without water tight bulkheads

One leak in the ship and we're sunk

Similarly one levee failure brings the whole system down
because it is so interconnected

One way to reduce the risk to the water supply is to
Compartmentalize the delta –
into three conveyance pathways to the pumps
if we have a breach on one pathway
exports can still be made in the others while repairs are mad

Water project operators tools (supply and quality):

(1) Reservoir releases
(2) Export rates
(3) DCC gate operation
(4) Changes in Geometry
(5) Tidal flows (tide gates)

Ecosystem improvement tools:

(1) Reservoir releases
(2) Export rates
(3) DCC gate operation
(4) Changes in Geometry
(5) Tidal flows (tide gates)

Entire Delta is a man-made geomorphologic anachronism

(Ordered from small to regional features)

(1) Rip-rap – Channels geomorphologically locked in place
- Lack of habitat (rock)
-Lack of cross-channel bathymetric variability
(leads to lack of cross channel velocity structure)

Delta is a system of interconnected canals (not channels)

(2) Pre-man Delta – Dendritic tidal system
Post-man – A network of "looped" interconnected channels
(lots of regional scale mixing – residence time homogeneity)

(3) Flooded Islands (clearly unnatural)
Large bathymetrically homogeneous shallow water environments
[Lack of habitat (residence time) diversity]

(4) Length scale considerations

Advective fluxes dominate transport throughout the Delta
Except where:

(a) Cross channel lateral variability exists (Western Delta)
(b) Tidal excursion “long” relative to channel length

Examples: 3mi slough (dispersive flux big)
(importance of tidal propagation assymetries)
False River (dispersion flux big)
Mokelumne River (advective flux big)

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

Connected distinct habitats characterized
by very different residence times don’t exist in the Delta