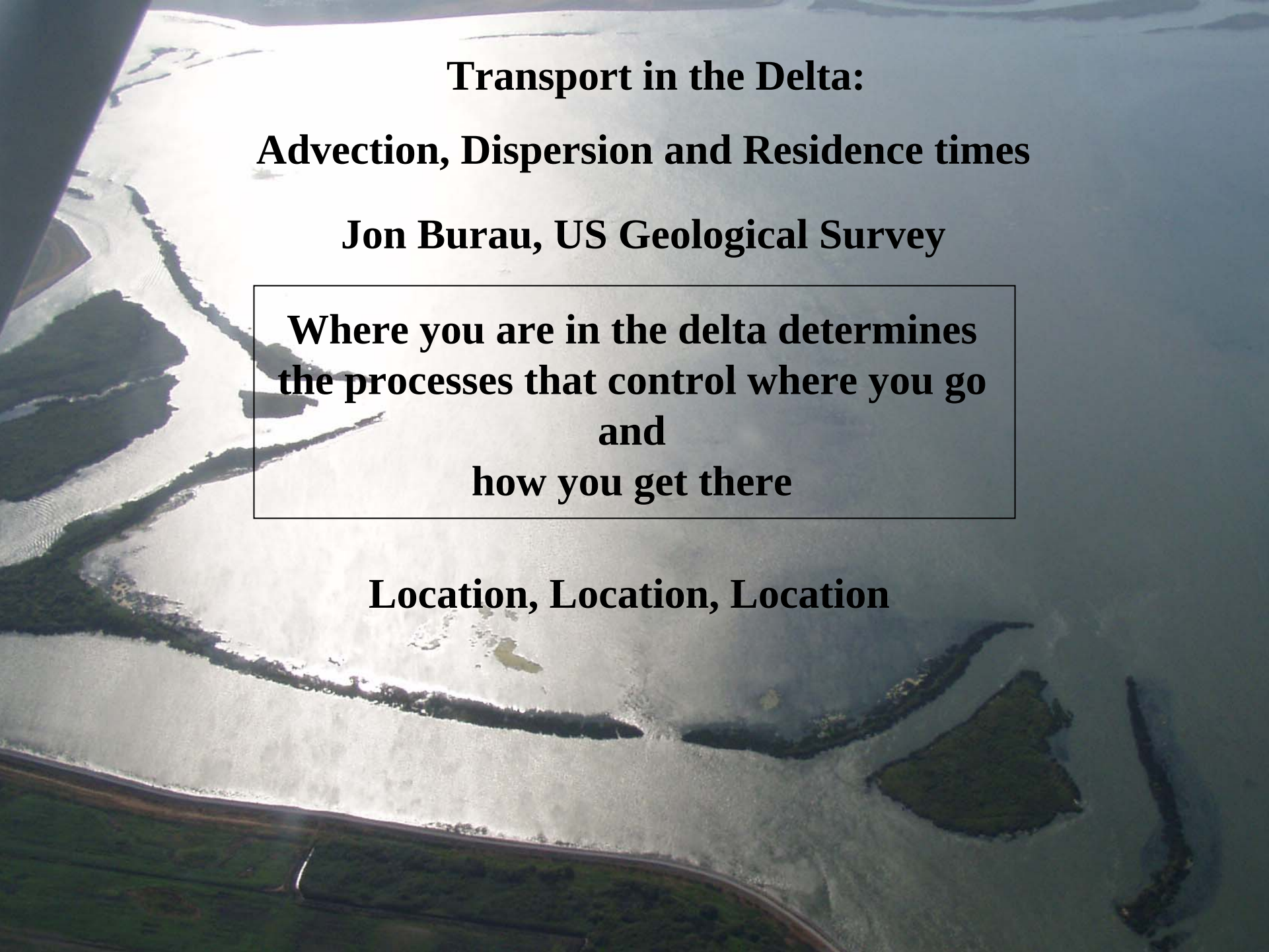


Transport in the Delta:

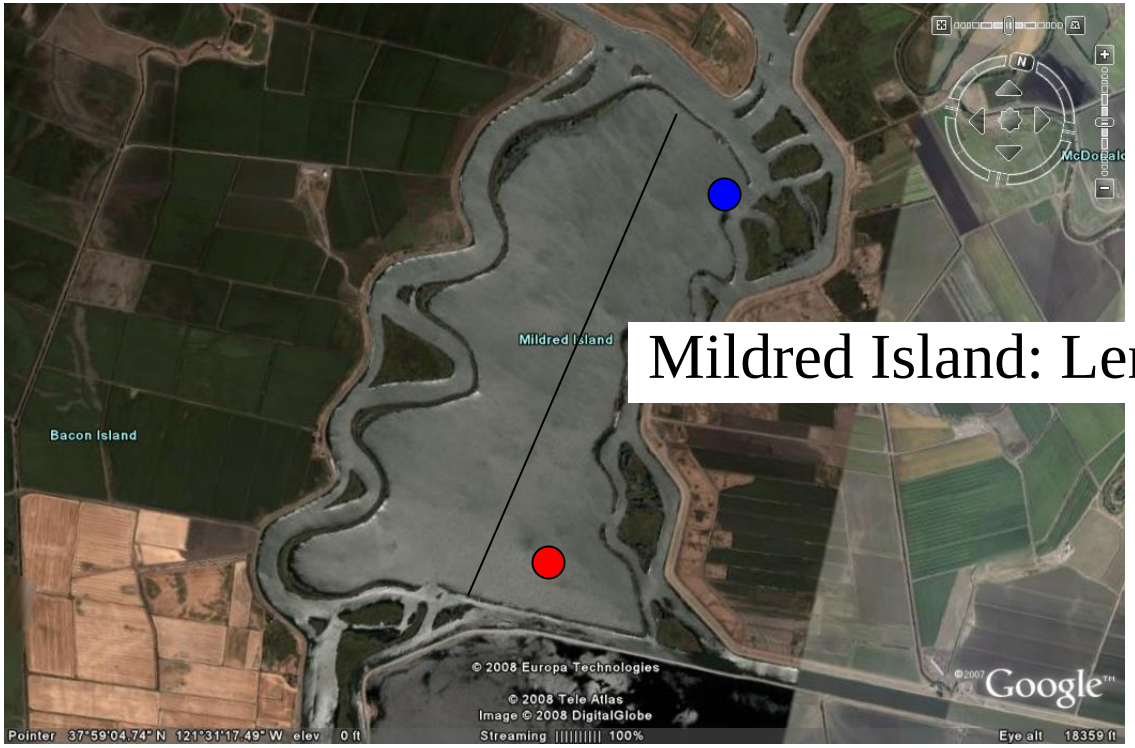
Advection, Dispersion and Residence times

Jon Burau, US Geological Survey

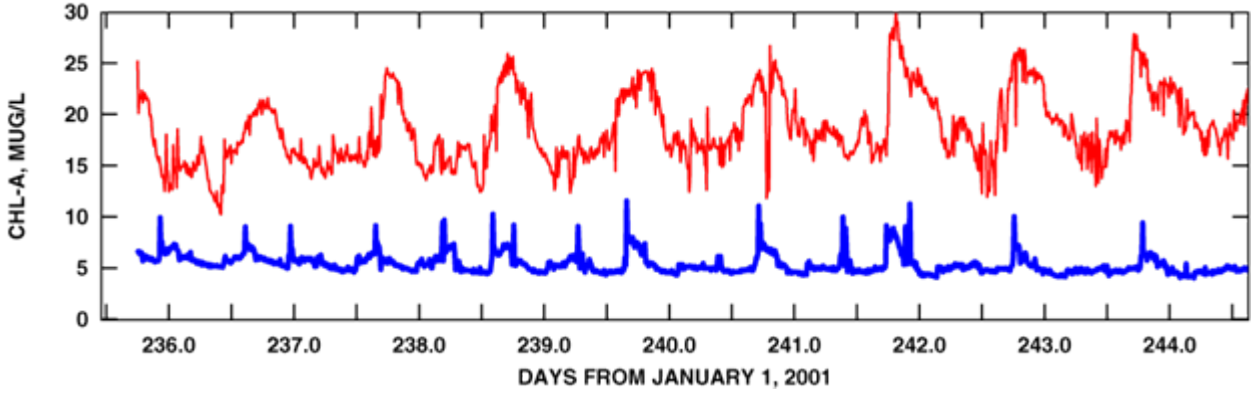
Where you are in the delta determines the processes that control where you go and how you get there

Location, Location, Location

What is Chl-a variability in delta?
(Temporal variability at a fixed location)



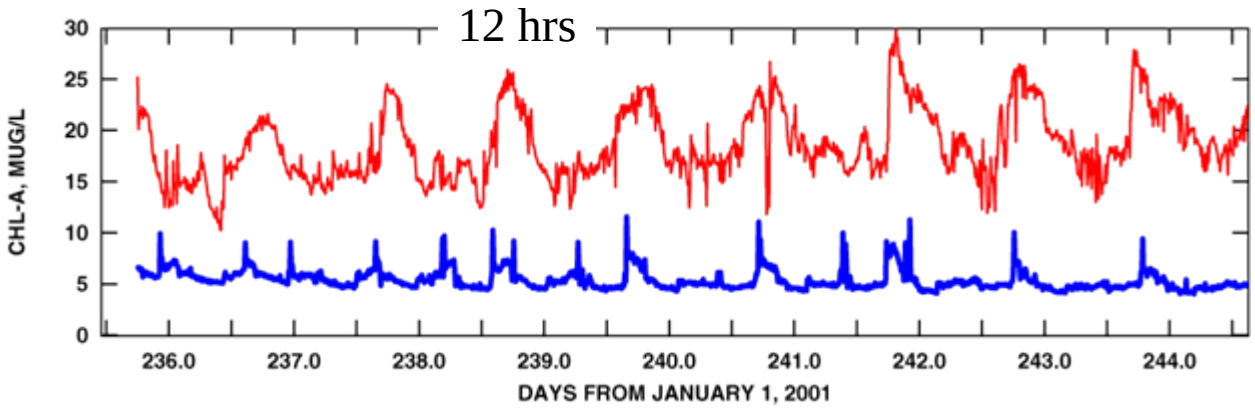
Mildred Island: Length ~2 mi



Variable in space

Variable in Time
(Local advection of spatial gradient)

What controls Chl-a variability in delta?
(Temporal variability at a fixed location)



Local production

Advection

$$\frac{\partial C}{\partial t} = -U\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} + S + chem$$

Temporal Variability

Advection

Dispersion

Transport

Sources & sinks

Phytoplankton

Sources – production (light, turbidity, water temp, temperature strat..

Sinks – Grazing (Benthos, zooplankton, old age…)
- Exports (CVP, SWP, NBA, CCWD, EBMUD, etc)
- Ag withdrawals

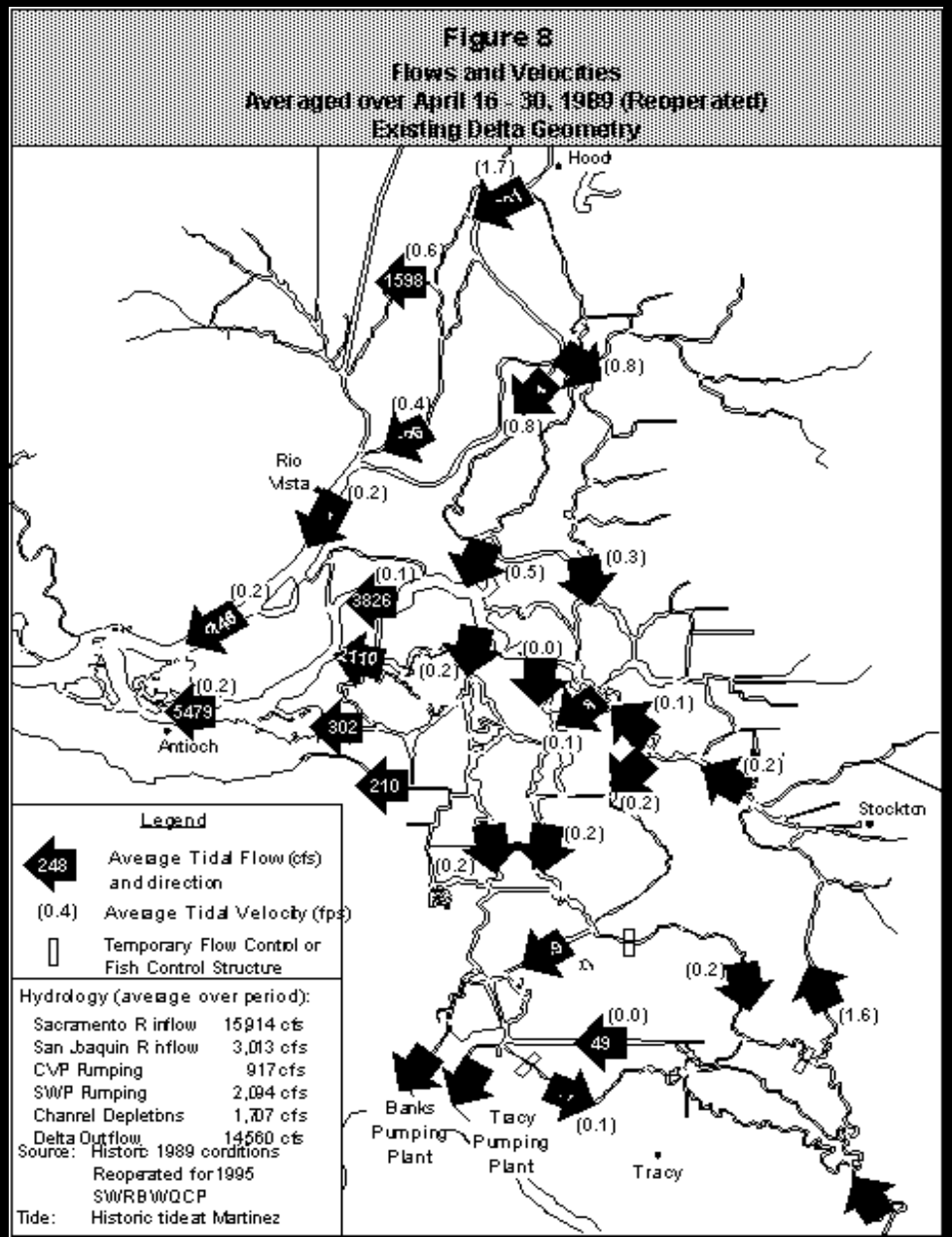
Transport Processes

In rivers: One mode of transport
(advection)

In tidal lagoons: Two modes of transport
(advection + dispersion)

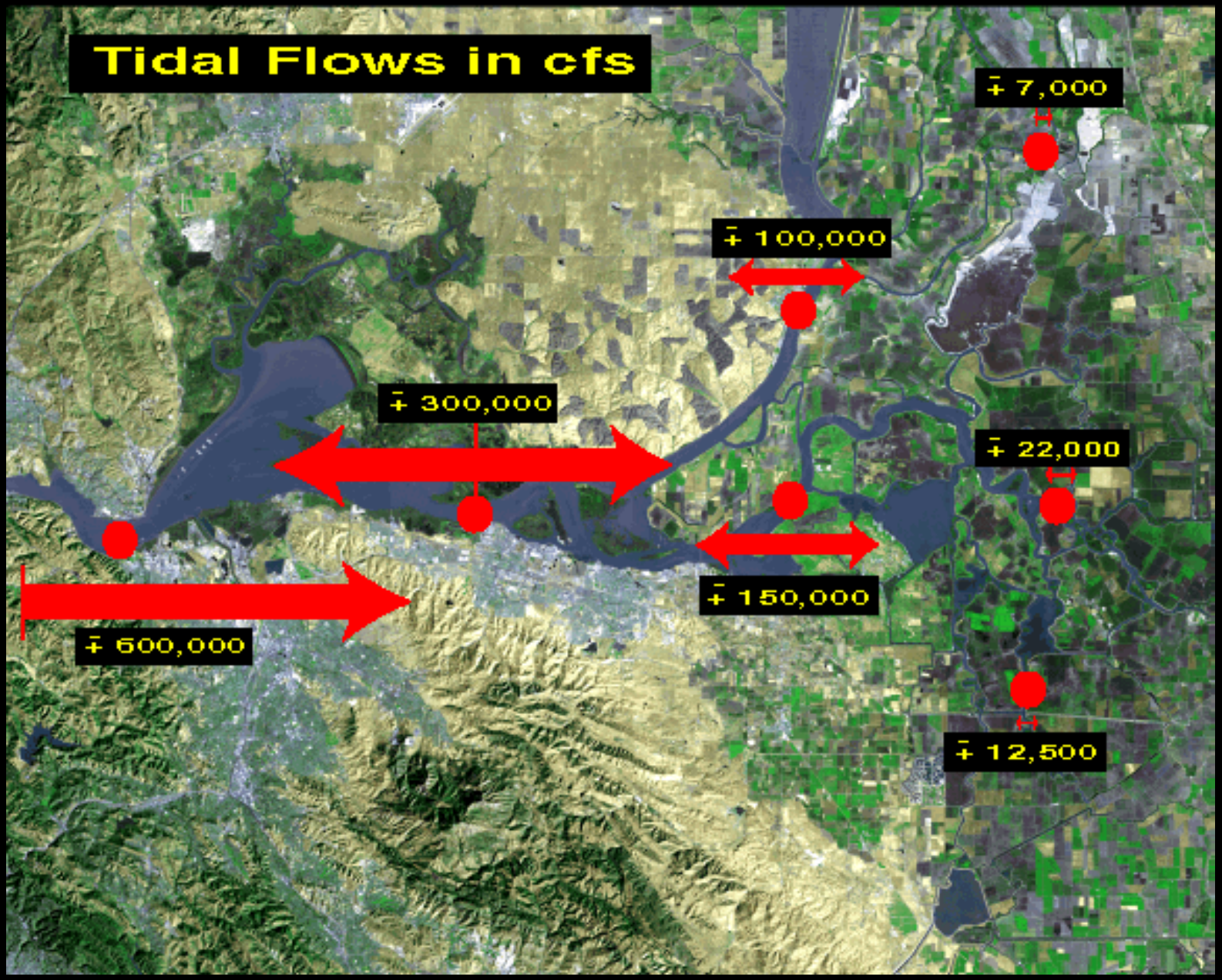
In estuary: Three modes of transport
(advection + dispersion + gravitational circulation)

River Model of the Delta
(Net Flow Picture)



Courtesy of the
DWR Modeling Section
web page

Tidal influence in the Delta



Why do we care (with regard to organic carbon production)?

Things are almost always in motion?

There are very very few long residence time areas in the delta

Which means we have very little residence time diversity in the delta
(e.g. almost everything is moving, all the time, almost everywhere)

Why do we care (with regard to transport)?

Things move large distances

And thus

Lots of mixing of water of different origins occurs

Drifters track water parcel movement

Tidal excursion - Distance traveled in ½ tide cycle

Drifters track – Tidal Excursion

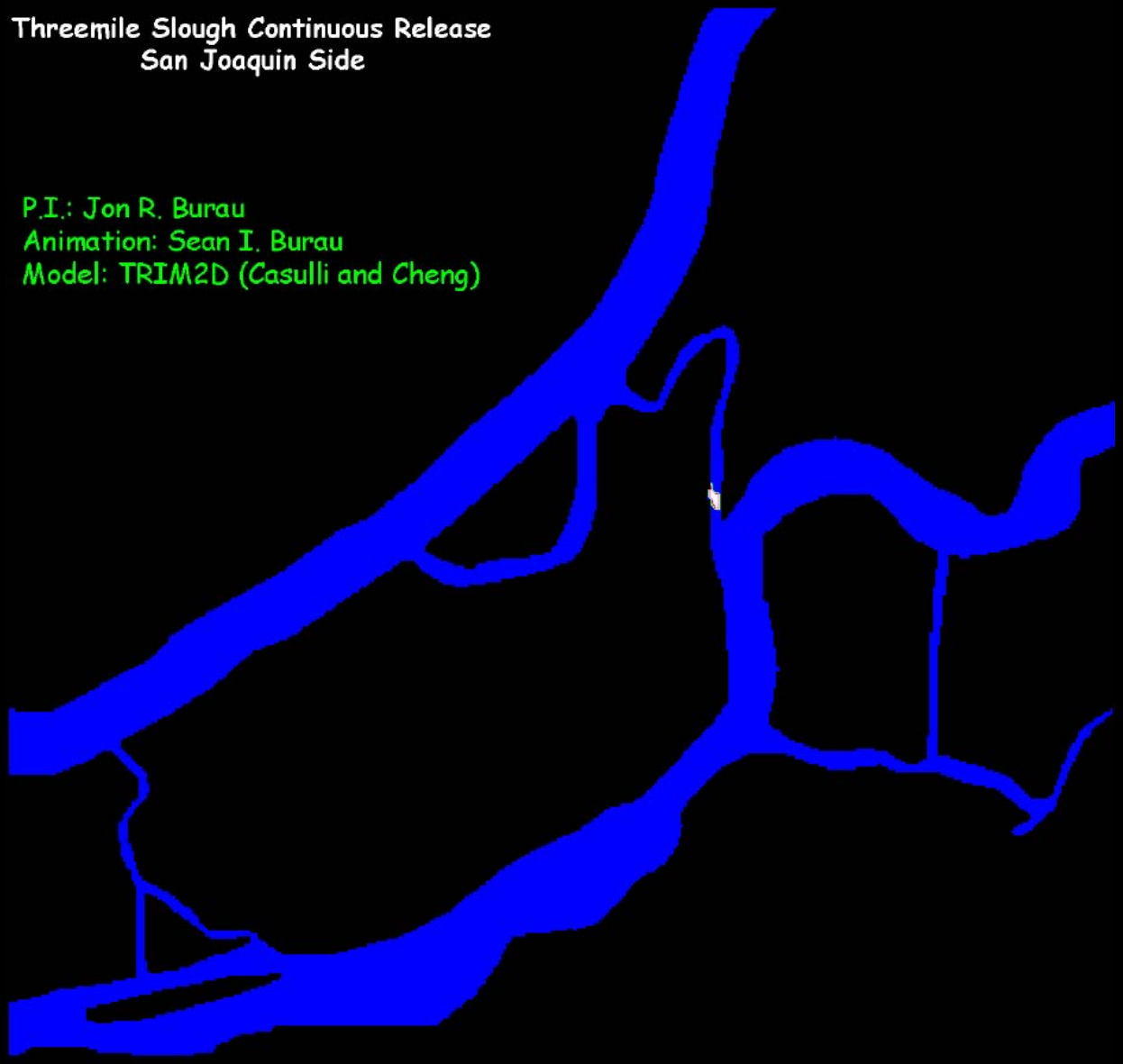
Drifters track – Tidal Excursion

Implications for Transport

So what if the currents are strong?
So what if the tidal excursions are long?
Why do we care?

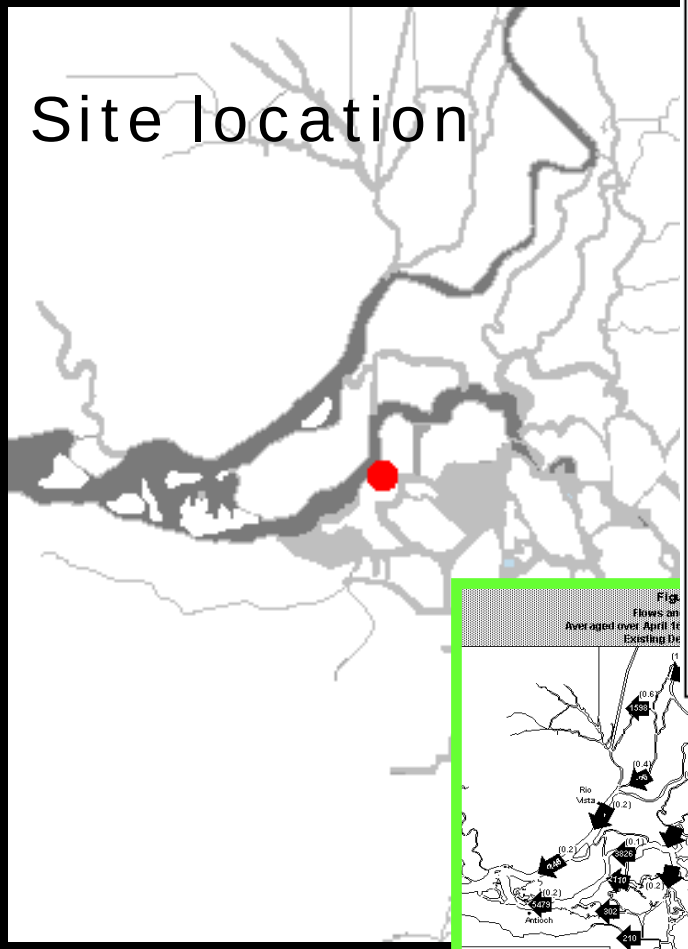
We Care: because there is this transport mechanism called dispersion

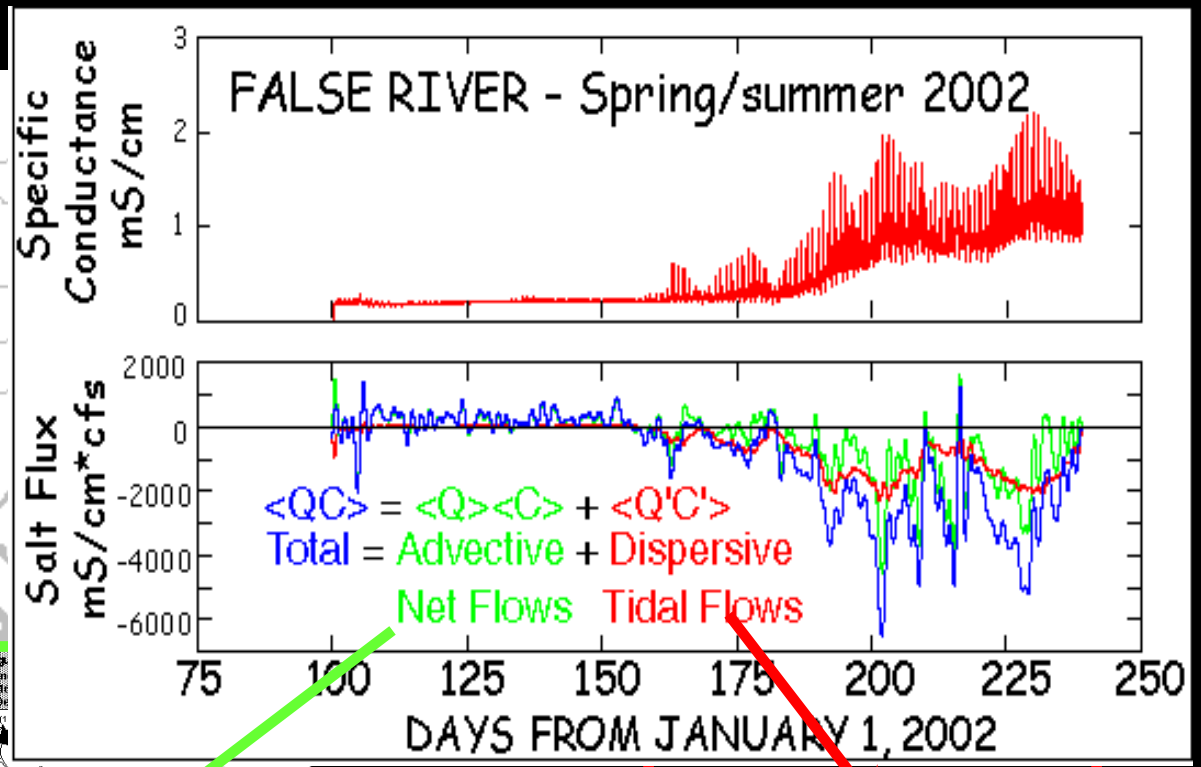
In tidal systems – two modes of transport (advection + dispersion)

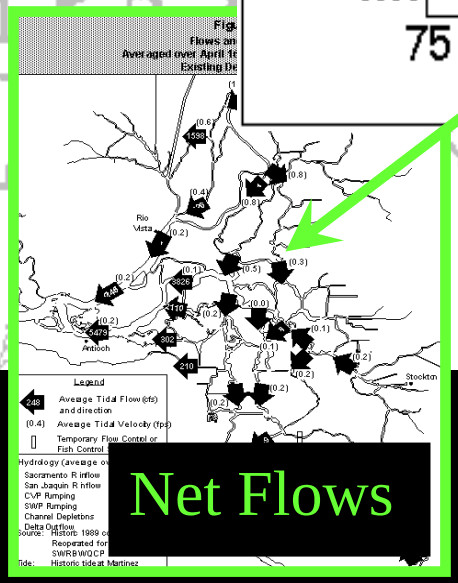


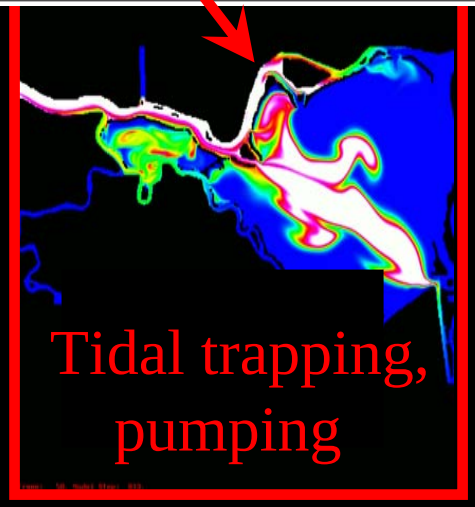
Dispersive Transport – Into Franks Tract

Modes of Transport - Salt Flux Decomposition









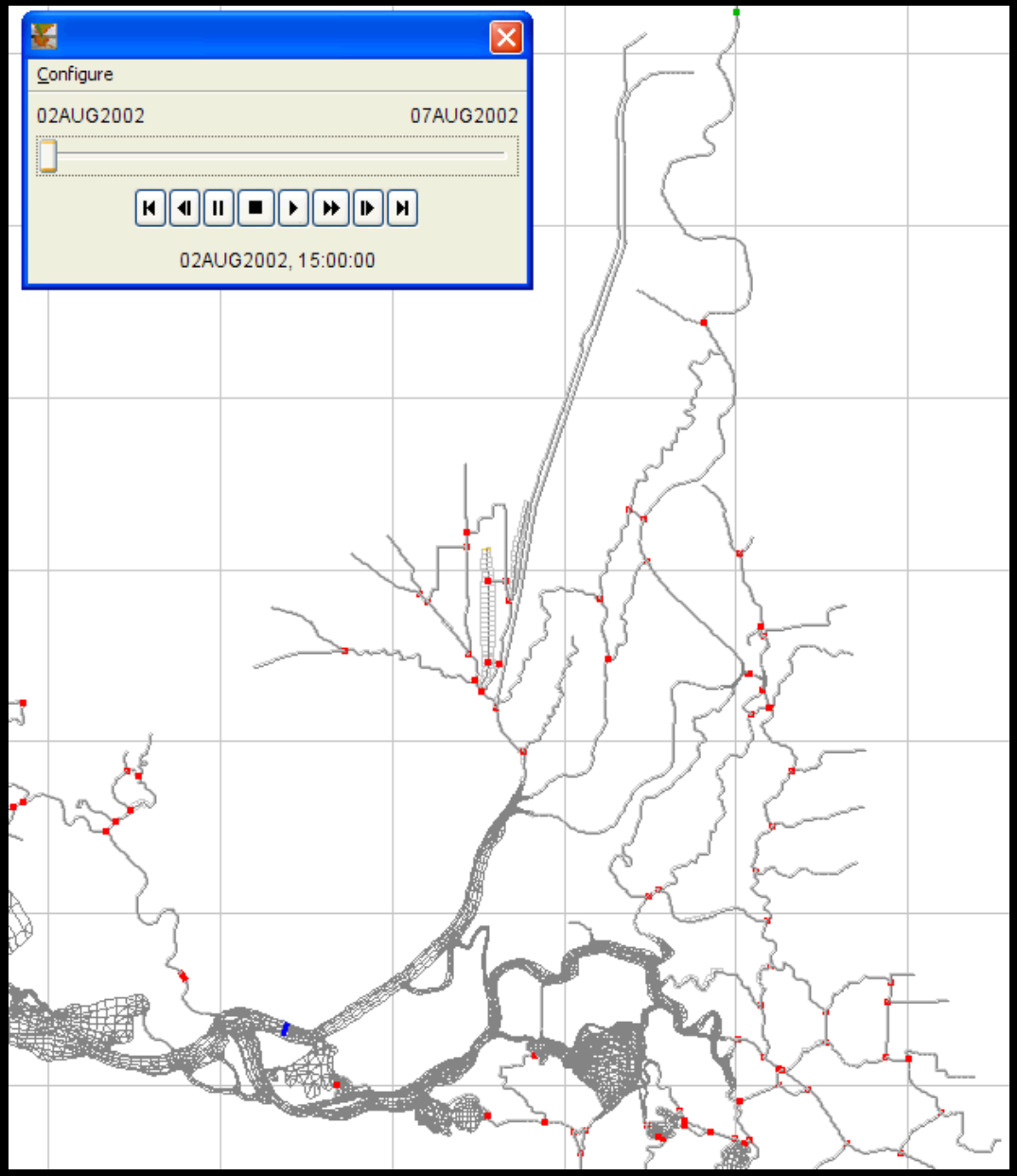
If DOC produced in FT – transported out dispersively

So we’ve talked about the basic mechanisms

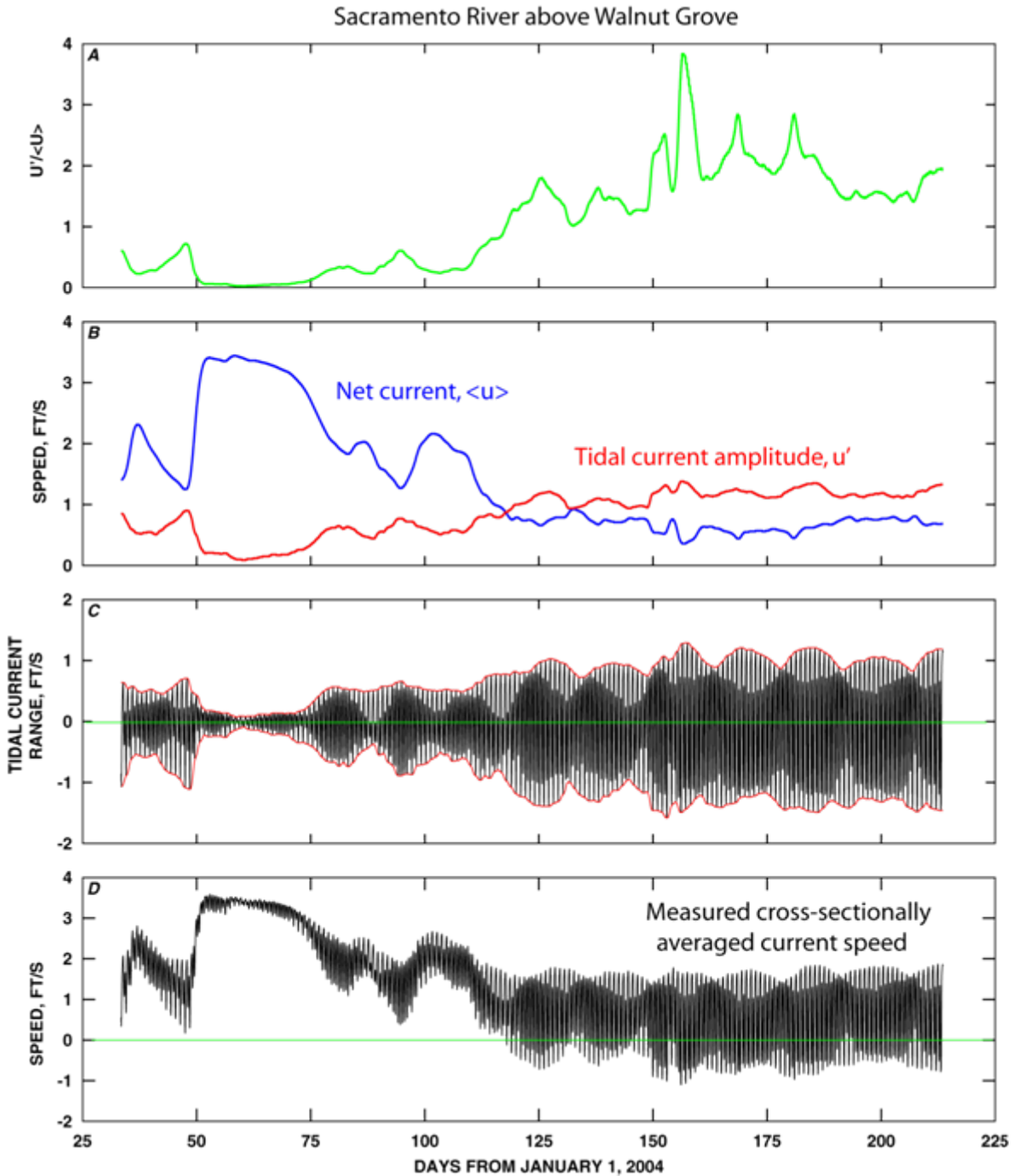
How do they vary in space?

Location, location, location

Numerical particles released at west Sacramento

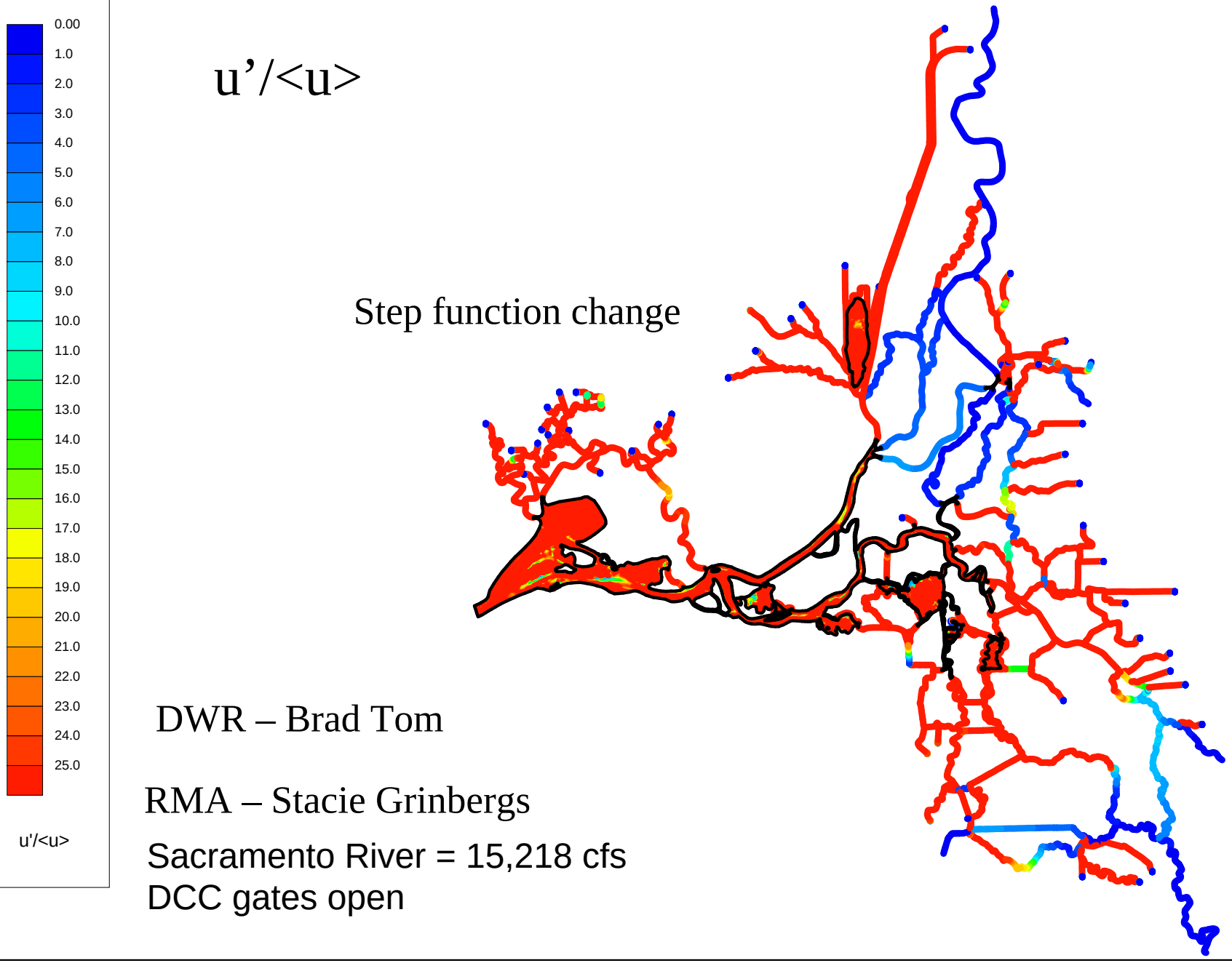


RMA


Sacramento River above Walnut Grove
A
U'/<U>
B
SPPED, FT/S
Net current, <u>
Tidal current amplitude, u'
C
TIDAL CURRENT RANGE, FT/S
D
SPEED, FT/S
Measured cross-sectionally averaged current speed
DAYS FROM JANUARY 1, 2004

u’/<u>

Step function change

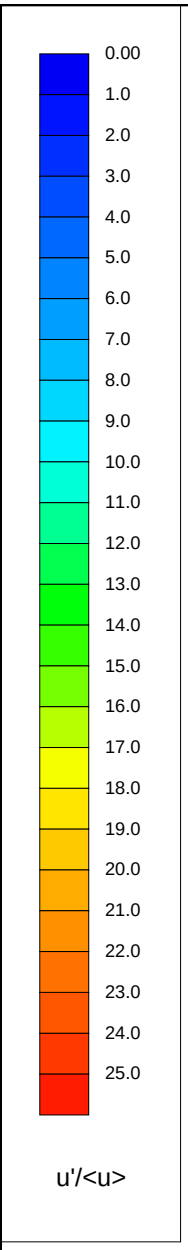


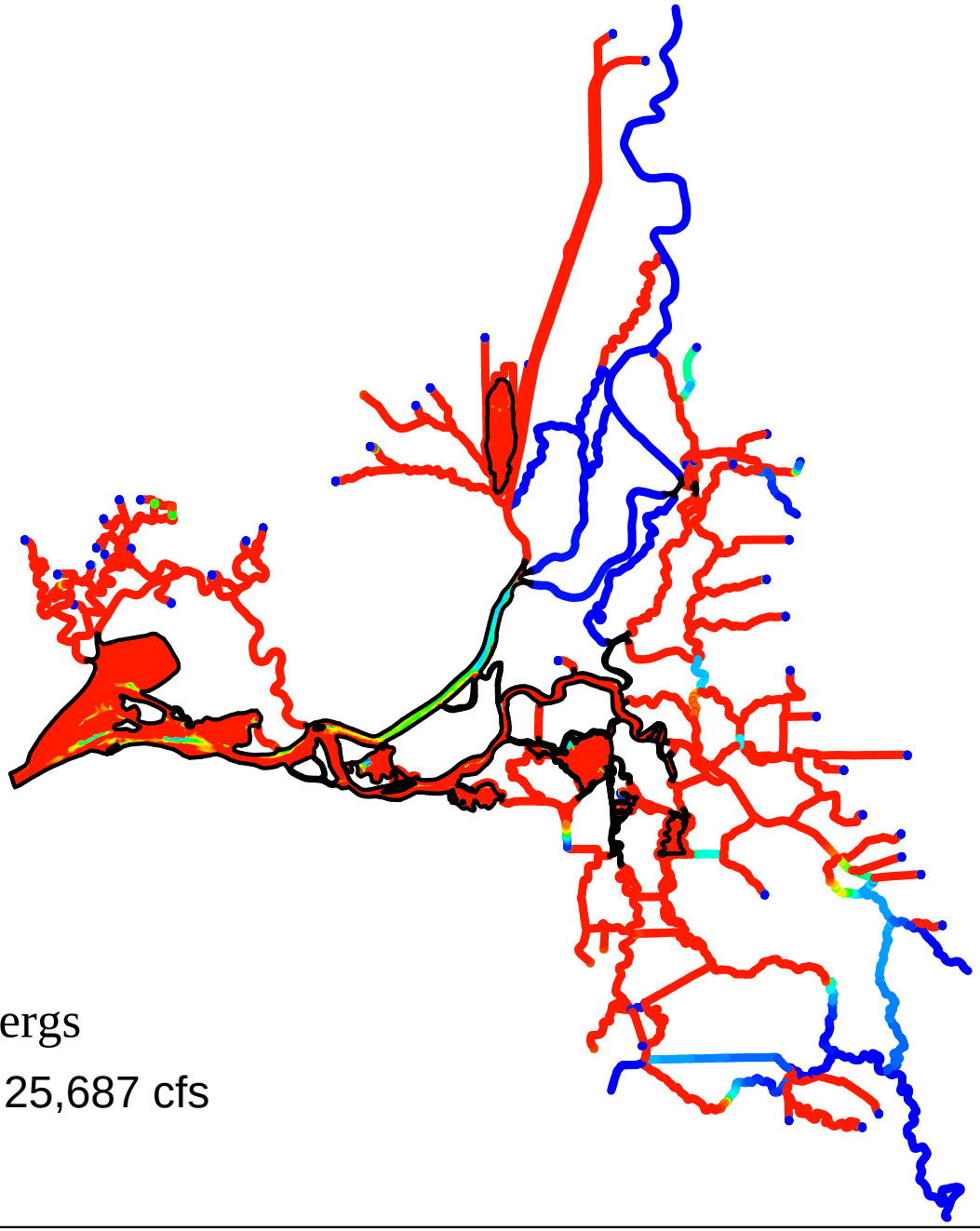
DWR – Brad Tom

RMA – Stacie Grinbergs

Sacramento River = 15,218 cfs
DCC gates open

u’/<u>



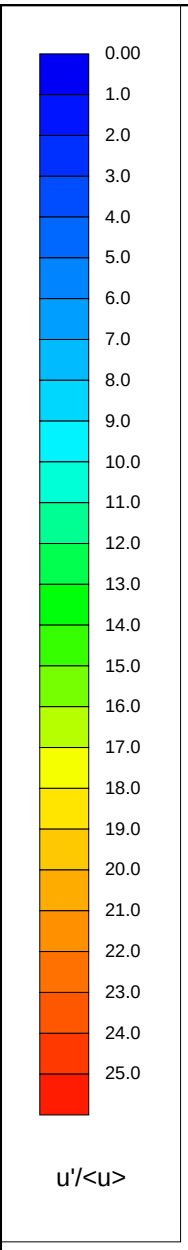


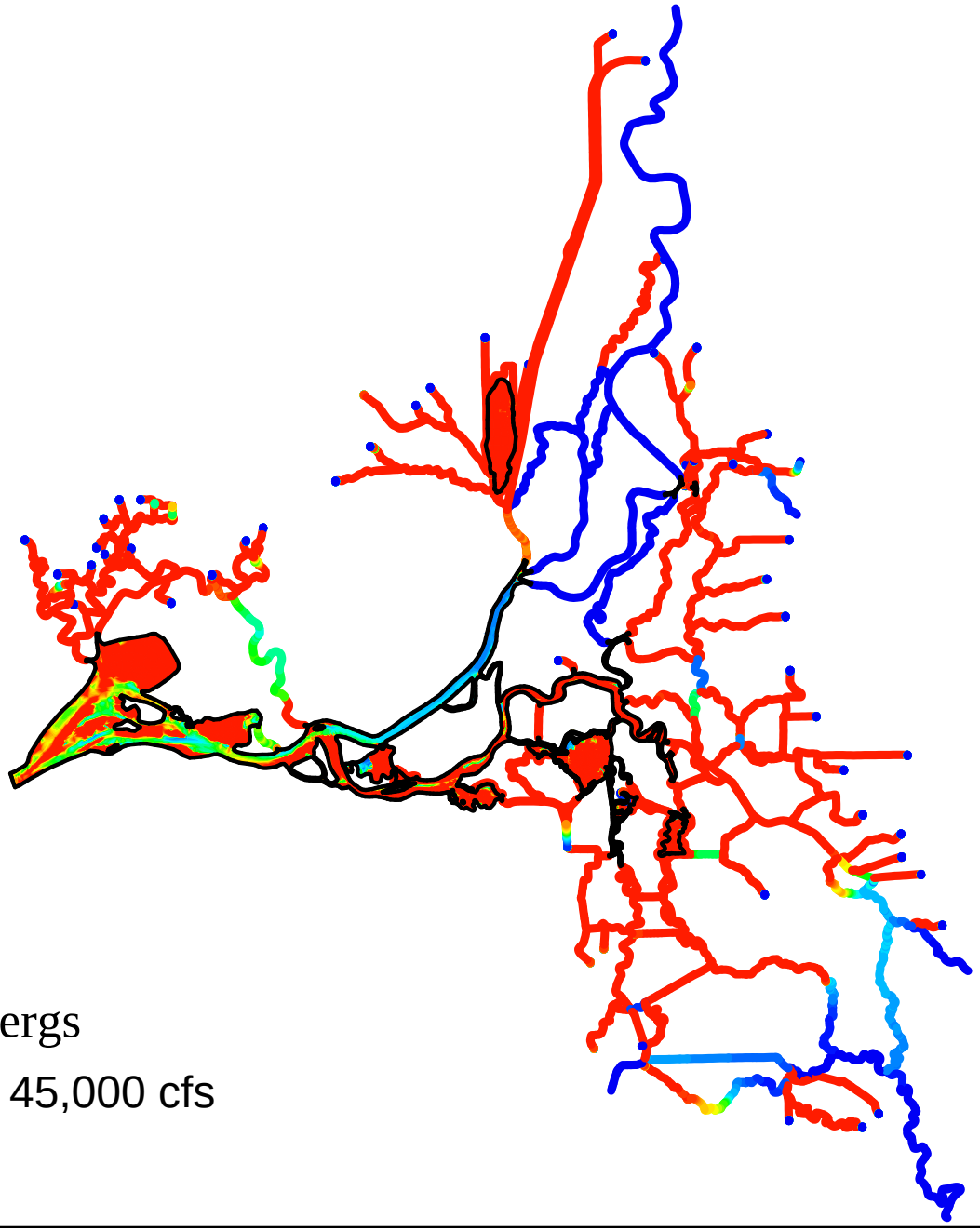
DWR – Brad Tom

RMA – Stacie Grinbergs

Sacramento River = 25,687 cfs
DCC gates closed

u’/<u>



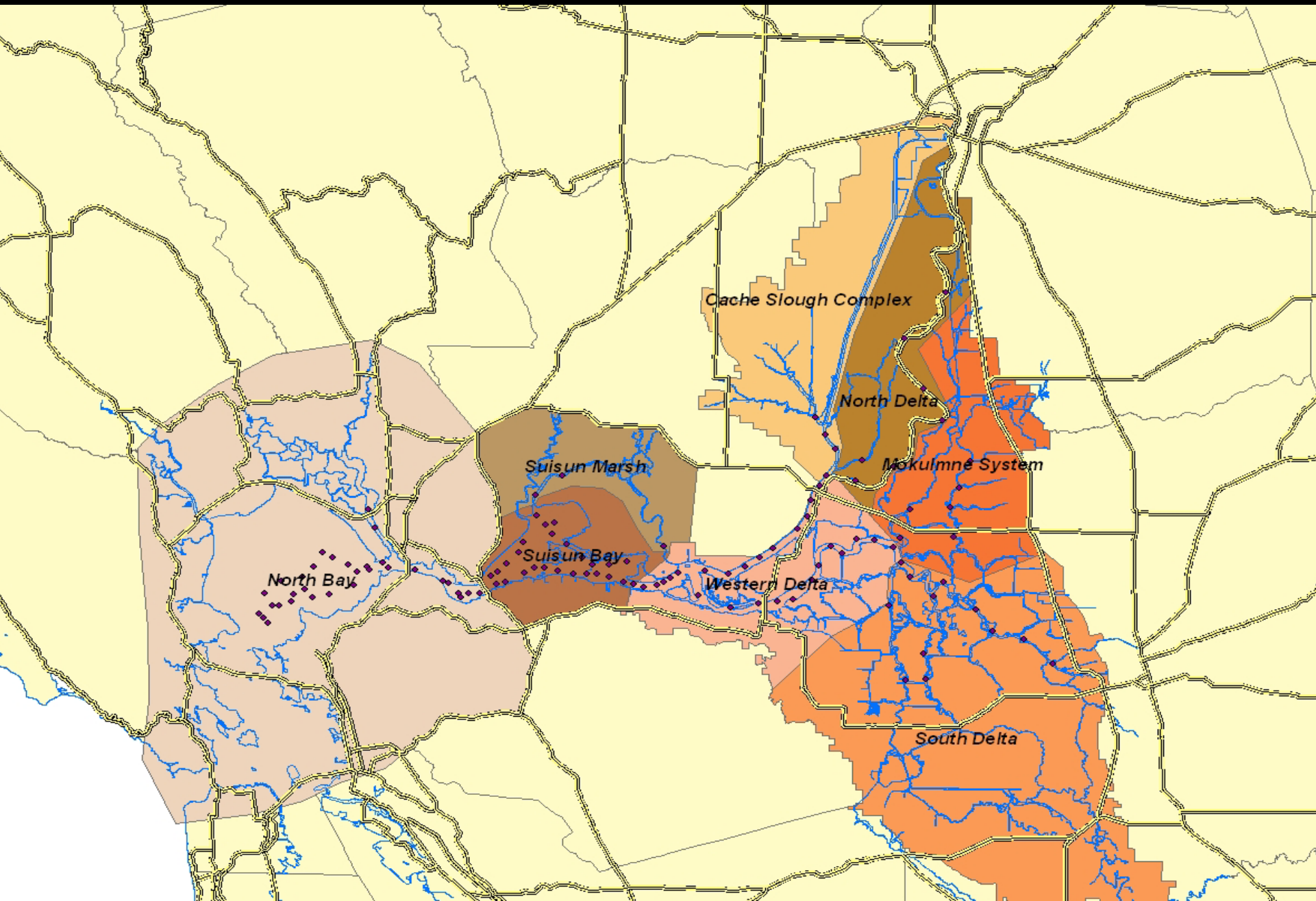


DWR – Brad Tom

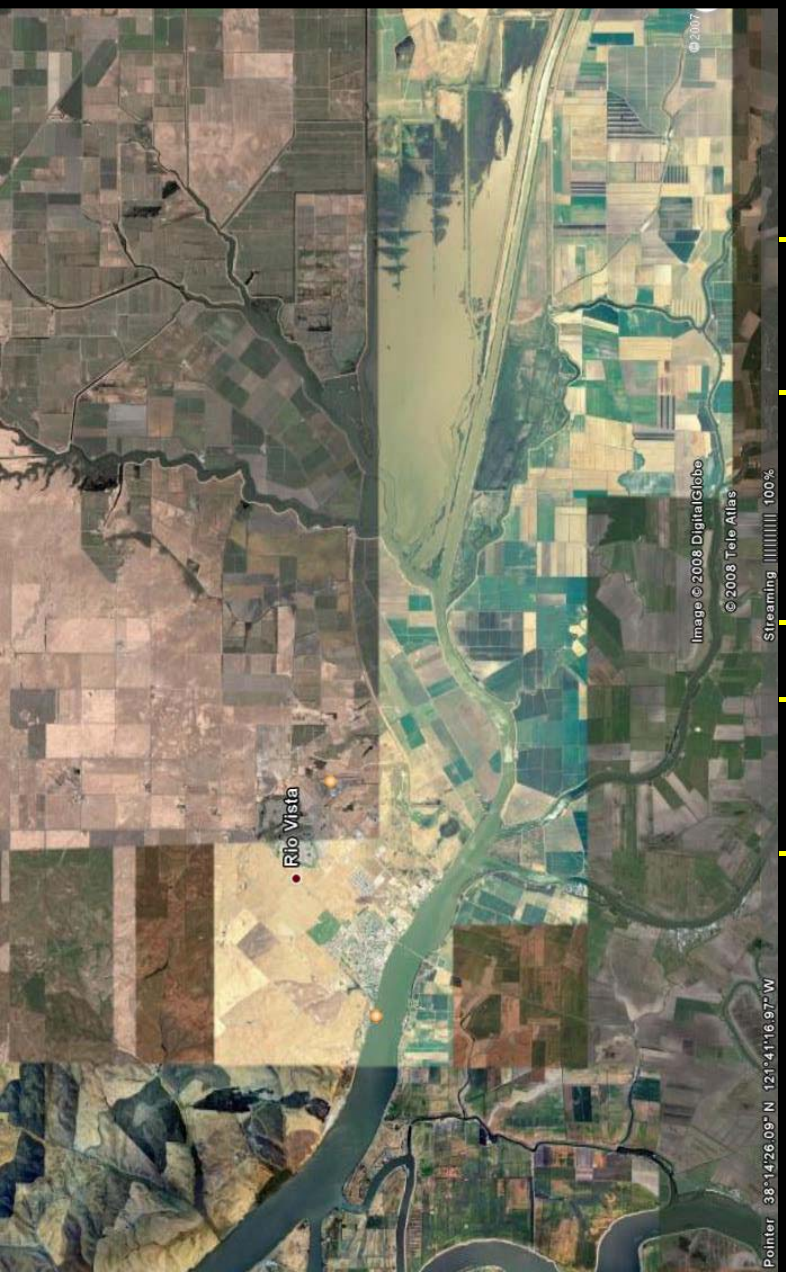
RMA – Stacie Grinbergs

Sacramento River = 45,000 cfs
DCC gates closed

Map of hydrodynamic transport regions



Cache Slough Complex



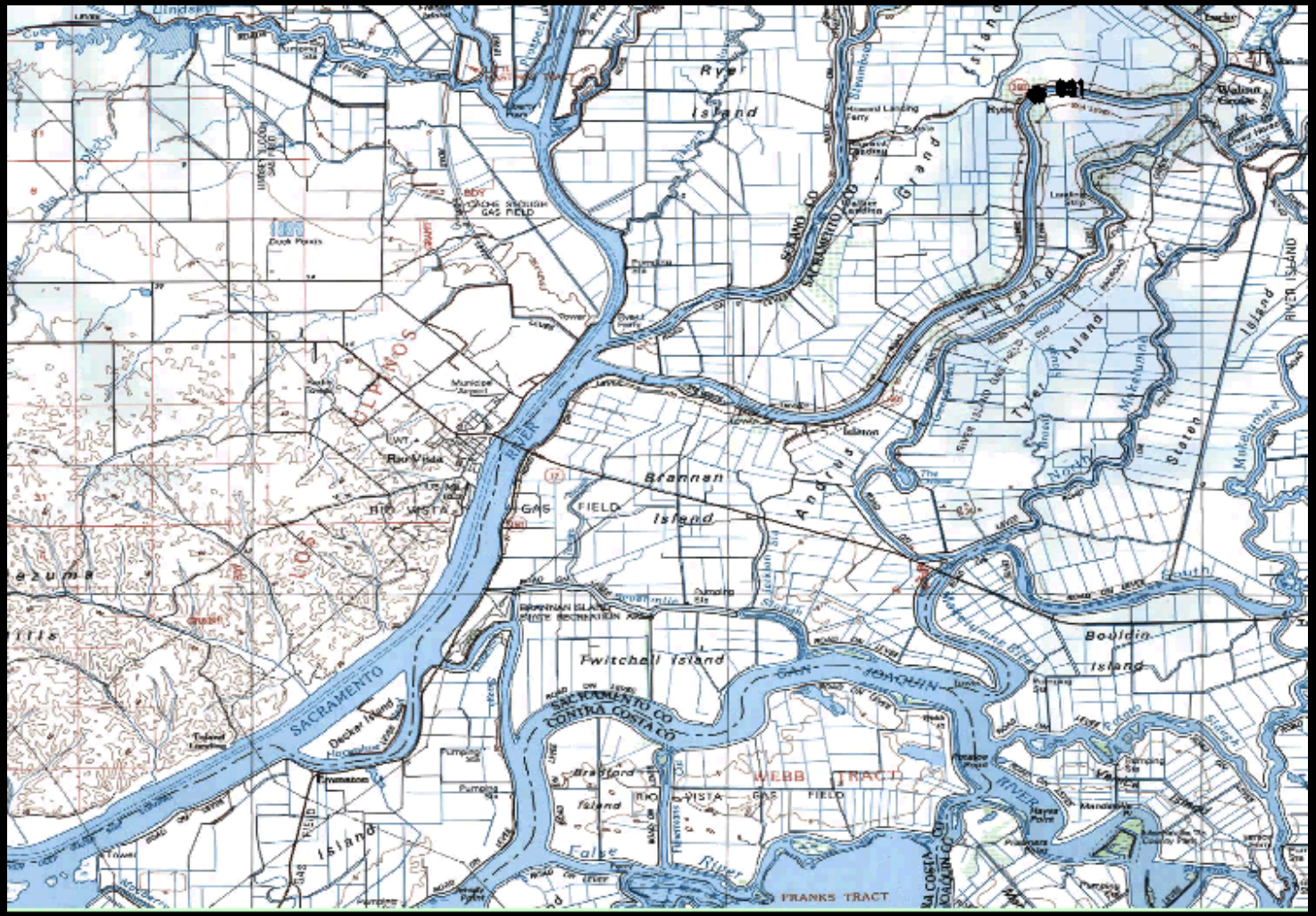
Salient Features

-Hydraulically isolated from exports
(except NBA)
- Net flows into Cache Slough are negative
(production does not go to the estuary)

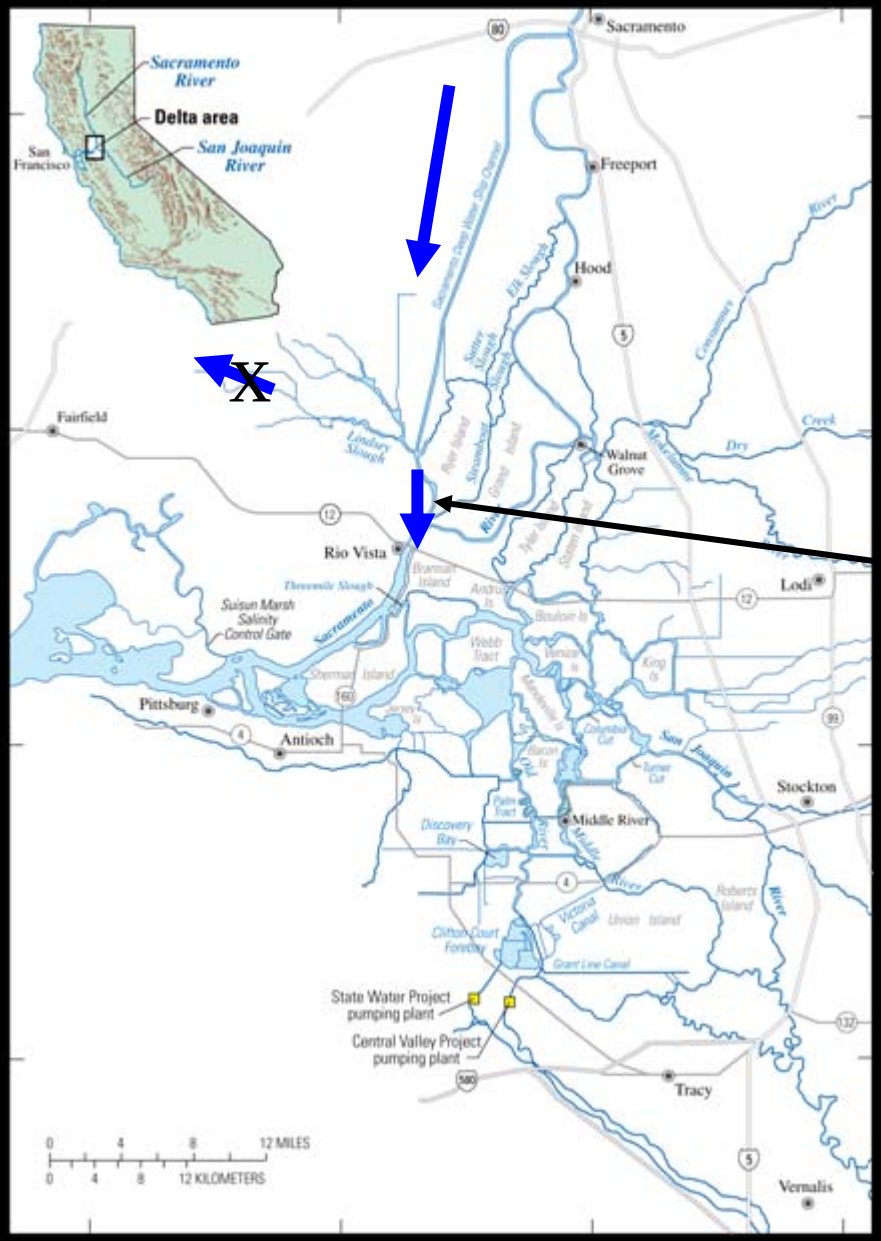
- Connected to Yolo Bypass
- Strongly tidally forced (dredging of Sac)

- Big change – Liberty I. flooded
- increased turbidities
(wind wave re-suspension)

Radio Tag Results – Sacramento River


River
Island
Grand
Brannan
Island
Andrus
Tyler Island
Staten
Bouldin
Island
Twitchell Island
SACRAMENTO
RIVER
SACRAMENTO CO
CONTRA COSTA CO
WEBB TRACT
FRANKS TRACT
RIO VISTA GAS FIELD
Decker Island
Bradford
Island
Sherman
Island
Walnut Grove
Isleton
Ryde
Locke
Walker Landing
Howard Landing Ferry
Municipal Airport
Rio Vista
Fairmanor
Ryer Island
Mokelumne
River Island
Mokelumne River
Sutter Slough
Steamboat Slough
Cache Slough
Lindsey Slough
Ulatis Creek
Elkhorn Slough
Cache Slough
Ship Channel
Sacramento Slough
Sacramento Slough
Sacramento Slough

Increase organic carbon to the "delta"?



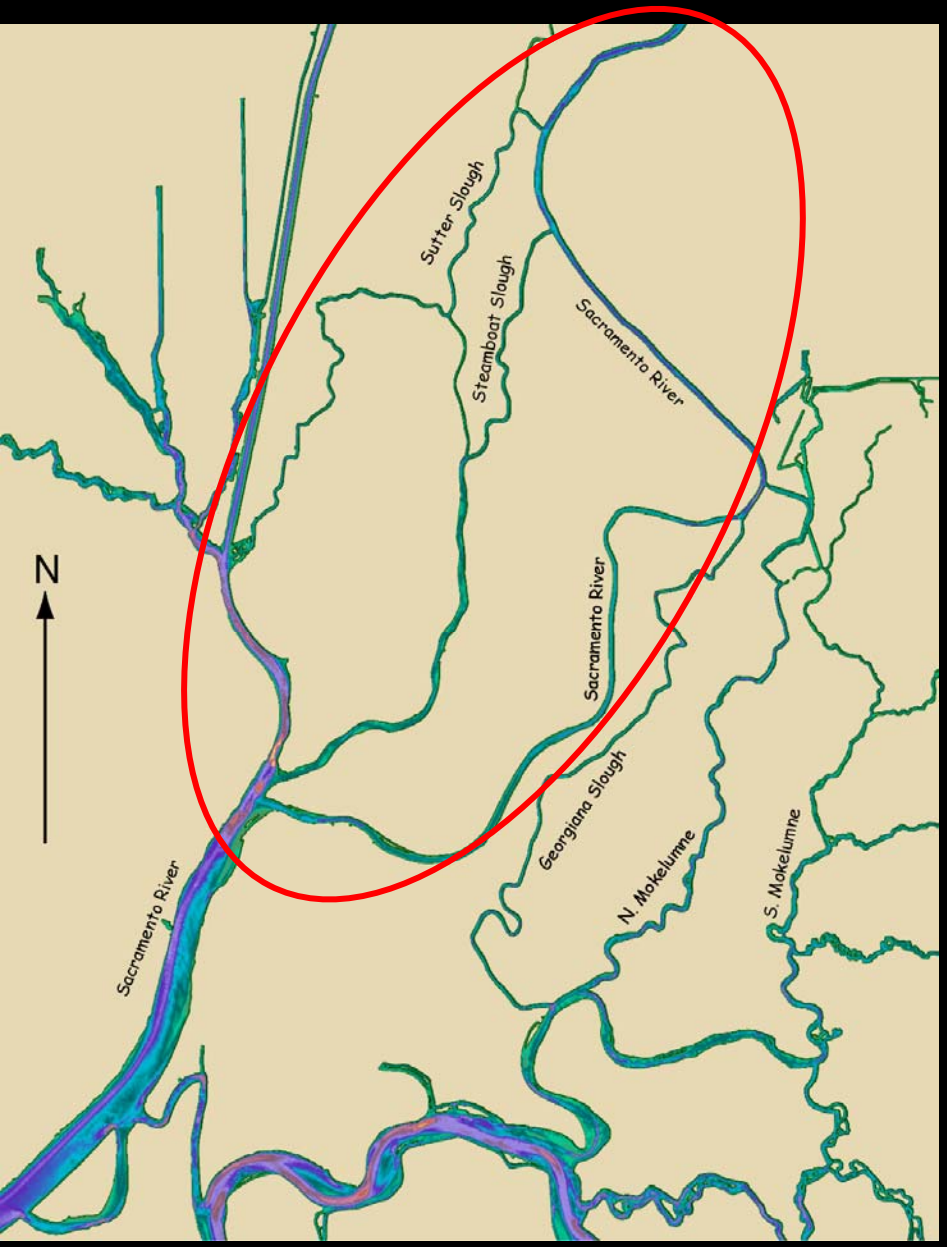
Possible solution:

Create net Flow out of Cache Slough complex

Sink of DOC

North Bay Aqueduct

North Delta



Salient Features

Geometrically – network of canals

Dominated by advection
(Sac River Inputs)

Strongly coupled with
Cache Slough complex

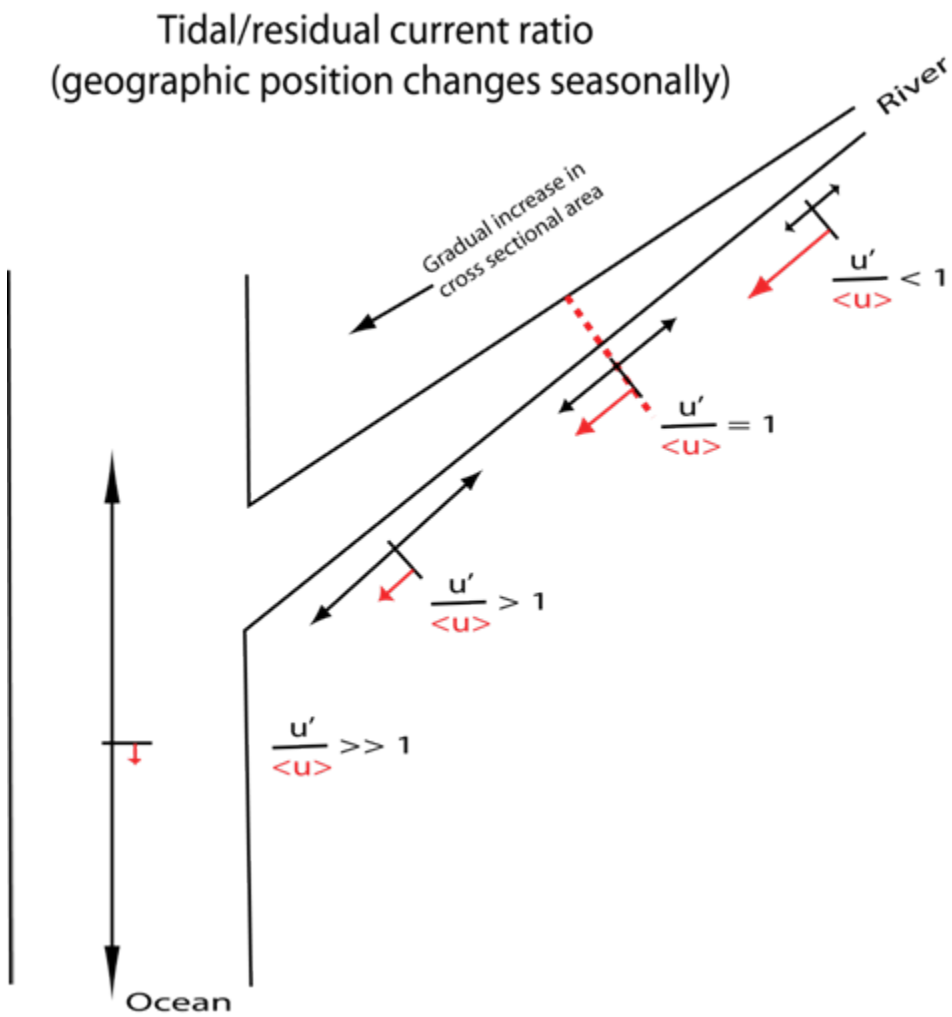
Bidirectional flow up to DCC
(Can go upstream of Freeport)

u’/<u>=1 contour is important:

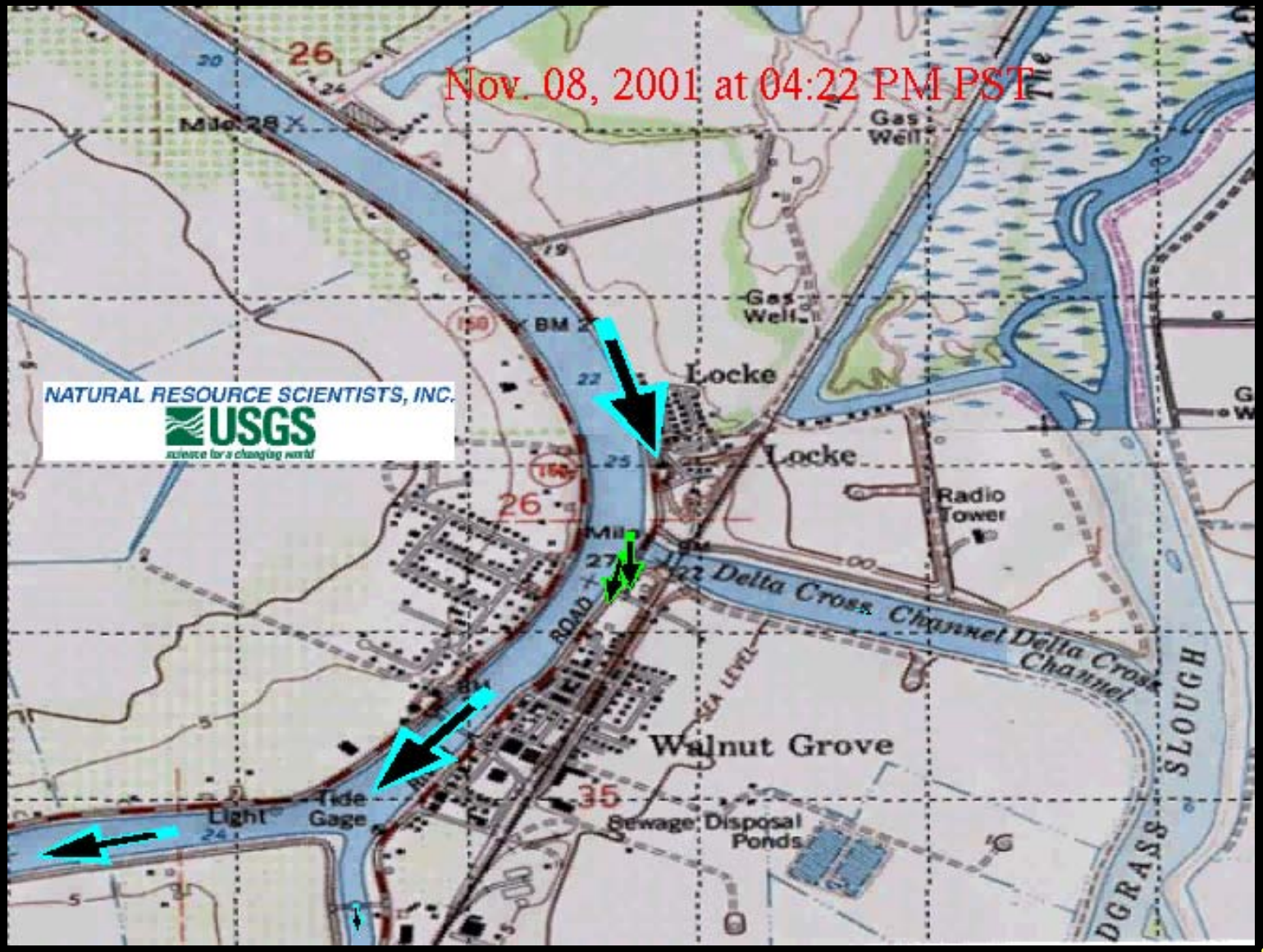
(1) Upstream limit of dispersive transports
(2) Upstream limit of organisms that “surf the tide”

Important for Isolated Facility!

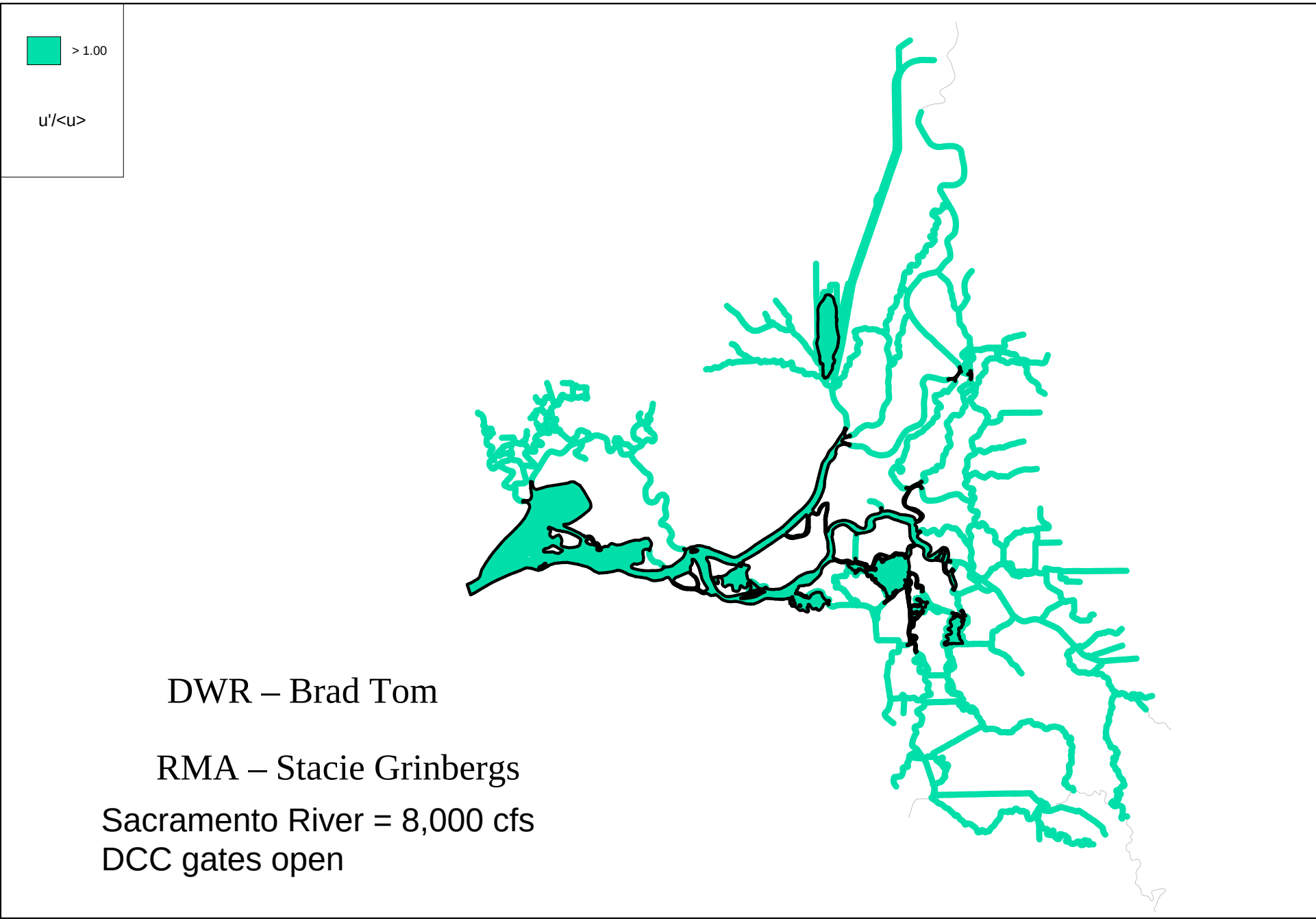
Example u'/<u> ratio used for setting regional boundaries



Bi-directional flow at DCC
water enters DCC on flood tide



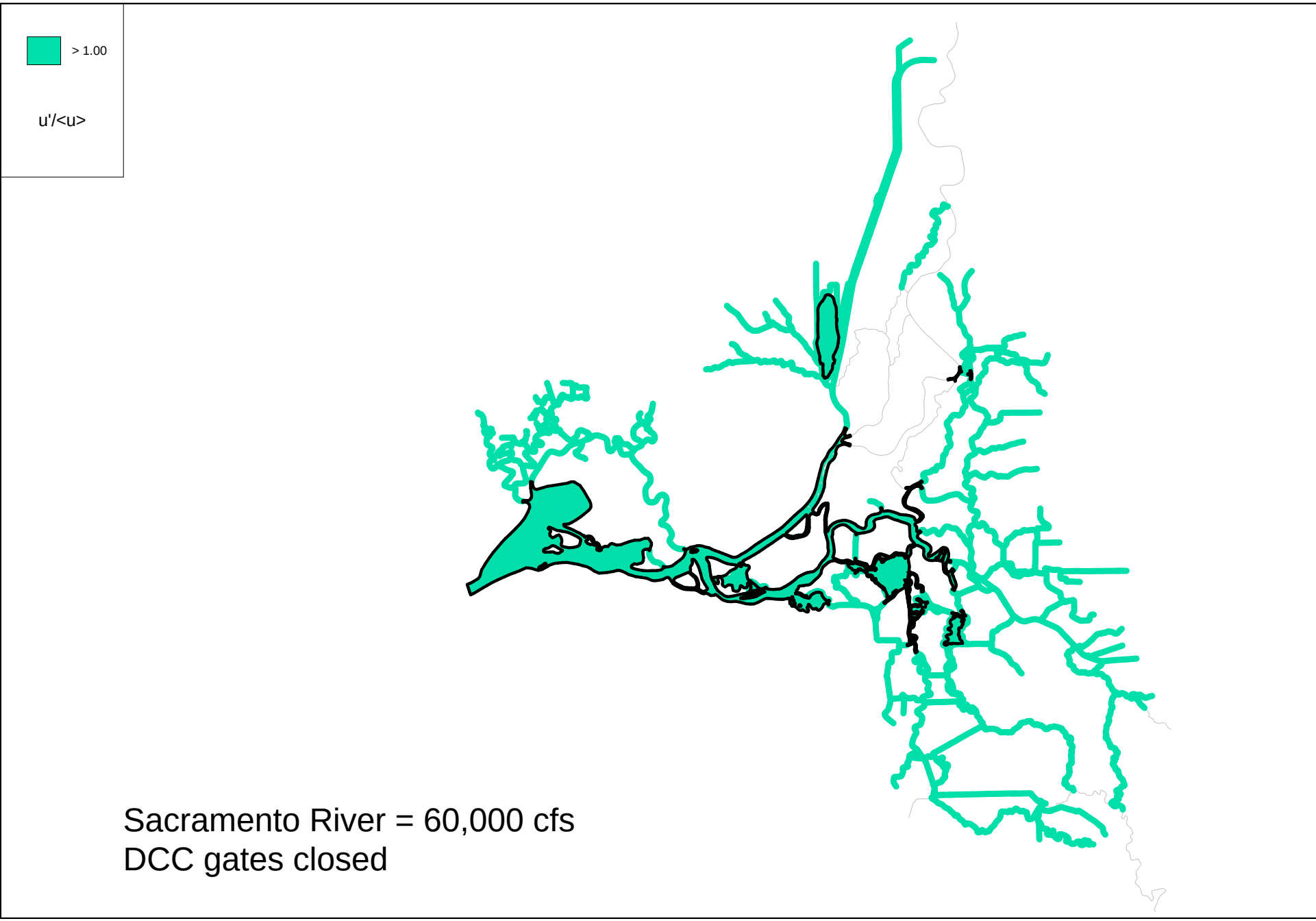
Vogel



DWR – Brad Tom

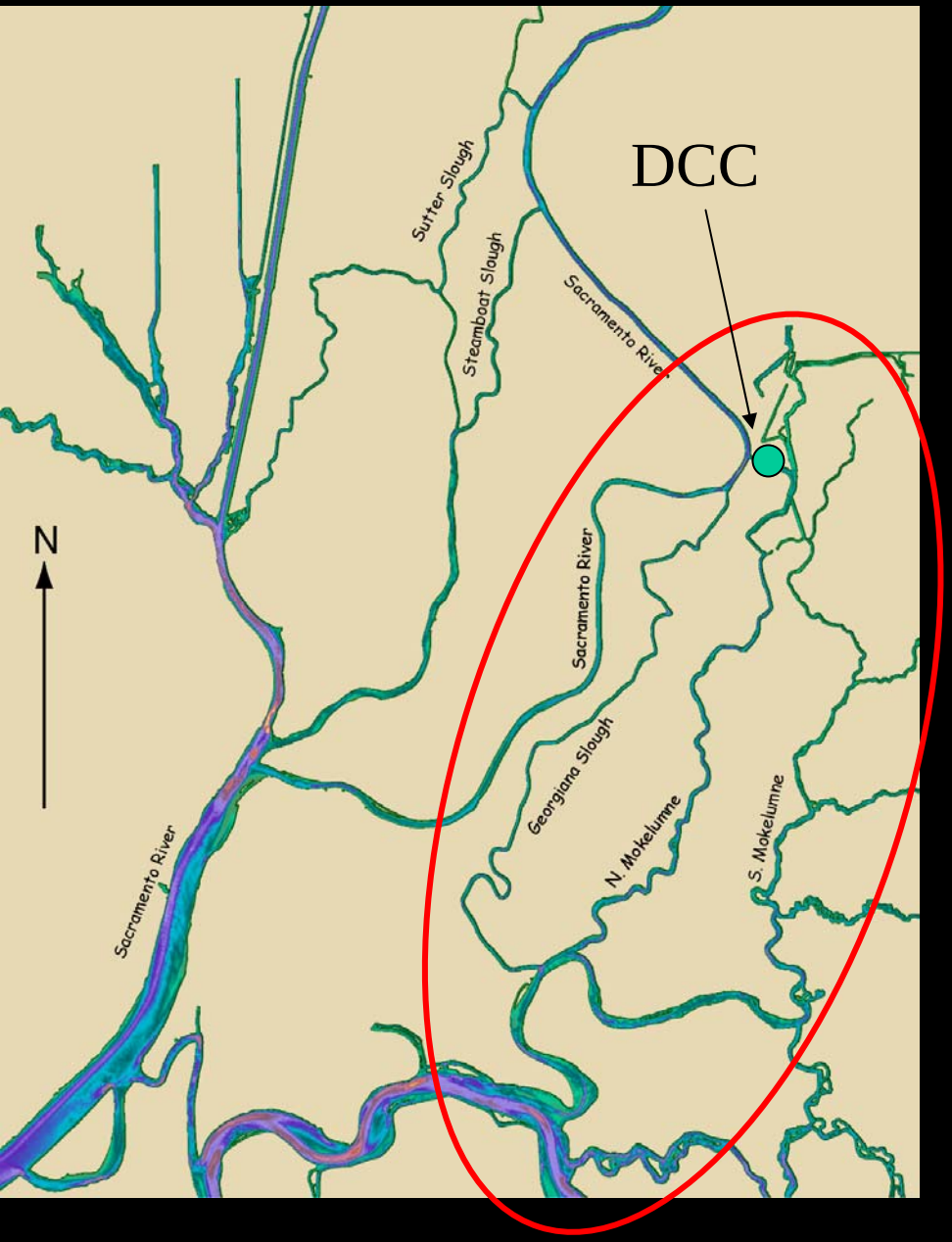
RMA – Stacie Grinbergs

Sacramento River = 8,000 cfs
DCC gates open



Sacramento River = 60,000 cfs
DCC gates closed

Mokelumne System



Salient Features

Geometrically – network of canals

- Connected to floodplains

- Dominated by advection (during high Mok Flows or when DCC open)

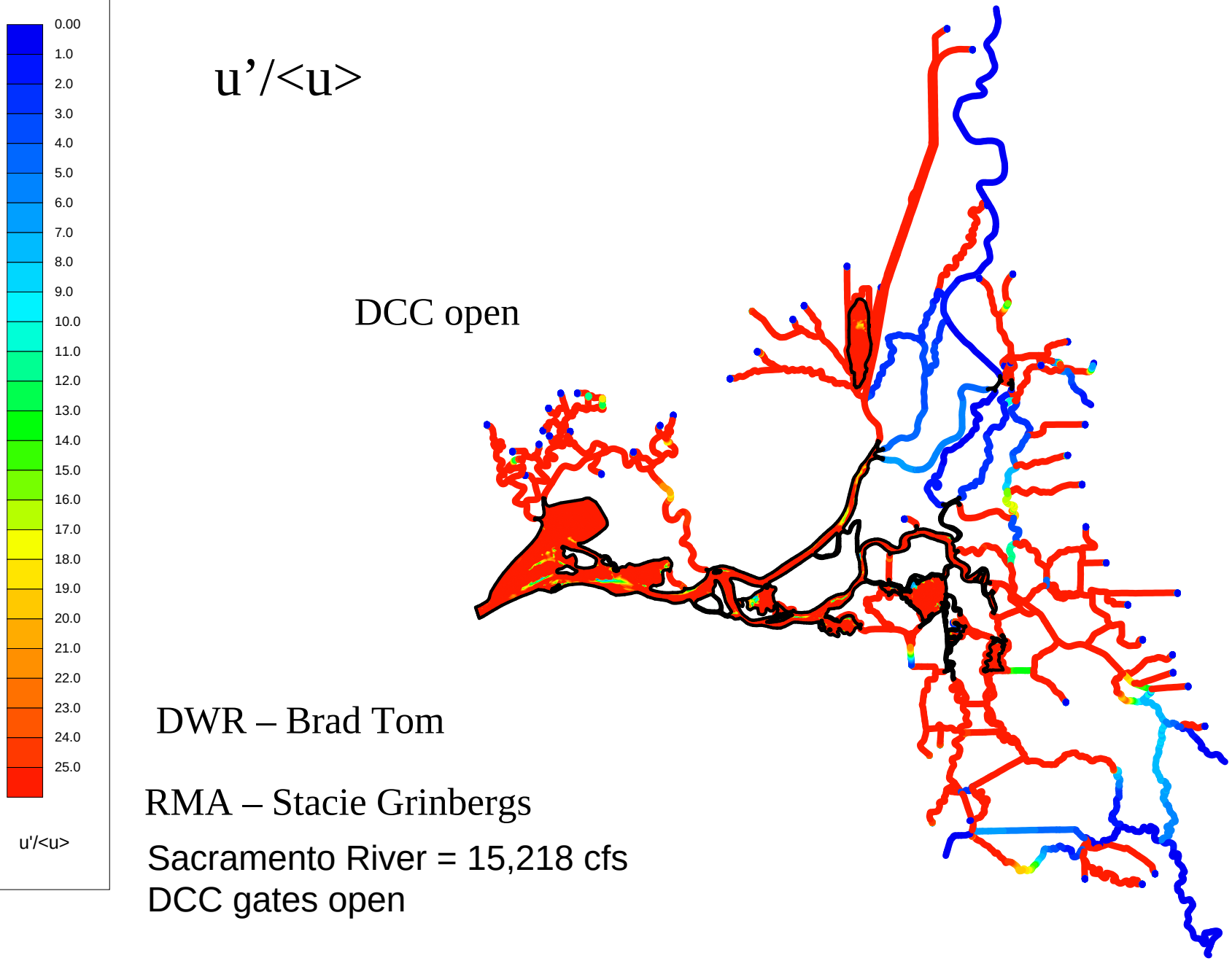
- Dominated by dispersive mixing when DCC closed

-Long transit times for salmon when DCC closed

- Water from Mok system exported

u’/<u>

DCC open



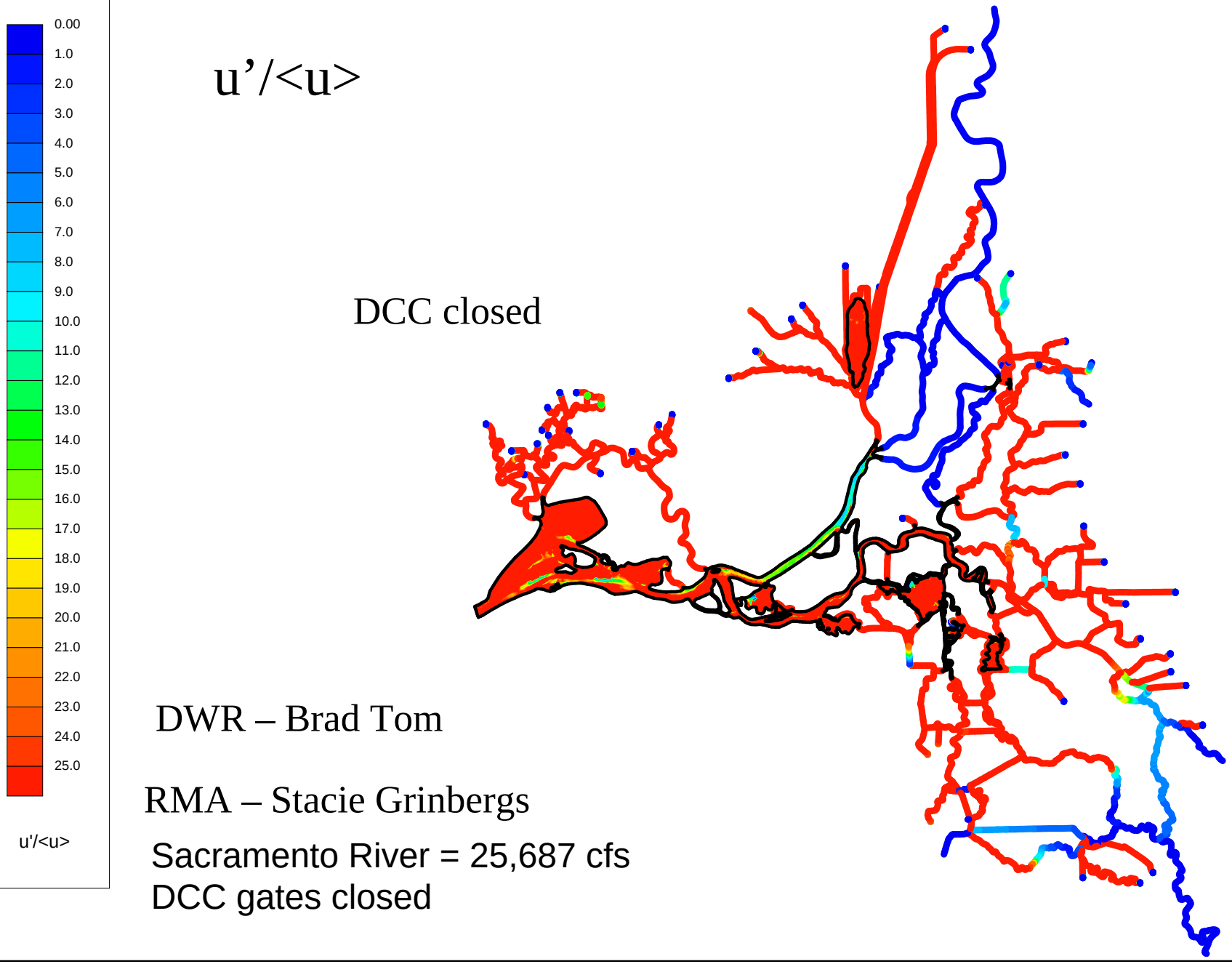
DWR – Brad Tom

RMA – Stacie Grinbergs

Sacramento River = 15,218 cfs
DCC gates open

u’/<u>

DCC closed



DWR – Brad Tom

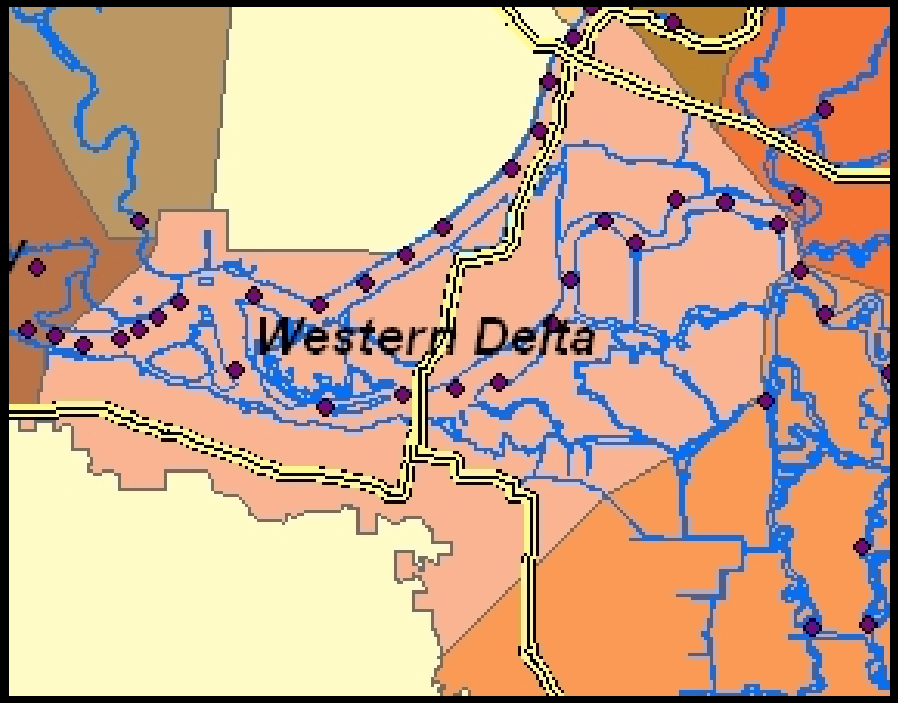
RMA – Stacie Grinbergs

Sacramento River = 25,687 cfs
DCC gates closed

Radio Tag Results – Georgiana Slough

SACRAMENTO
RIVER
Brannan
Island
GAS
FIELD
RIO VISTA
Twitchell Island
SAN JOAQUIN
SACRAMENTO CO
CONTRA COSTA CO
Bradford
Island
WEBB TRACT
RIO VISTA GAS FIELD
False River
FRANKS TRACT
Bouldin
Island
Tyler Island
Andrus
Decker Island
Emmaton
Rio Vista
Duck Ponds
Municipal Airport
SOLANO CO
SACRAMENTO CO
Grand
Walker
Landing Site
Pumping Sta
Ferry
Levee
Tower
Island
Slough
Mokelumne River
North
South
Sisters
Sidney Point
Hayes Point
Pumping Site
Pumping Sta
Pumping Site
Pumping Site
Pumping Site

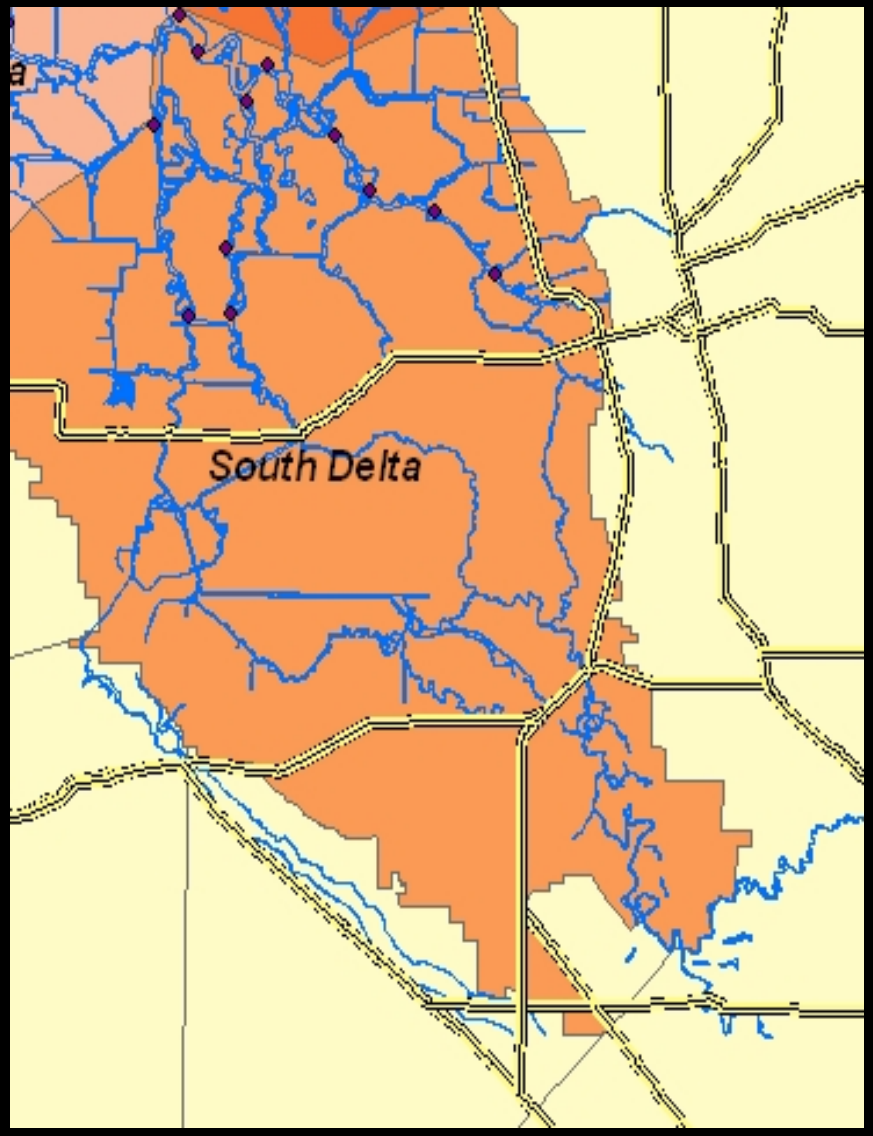
Western Delta



Geometrically characterized by wide channels
– lots of lateral variability (mixing)
- Weak net currents

-Franks Tract
-Transport is balance between dispersive mixing and net flows

South Delta



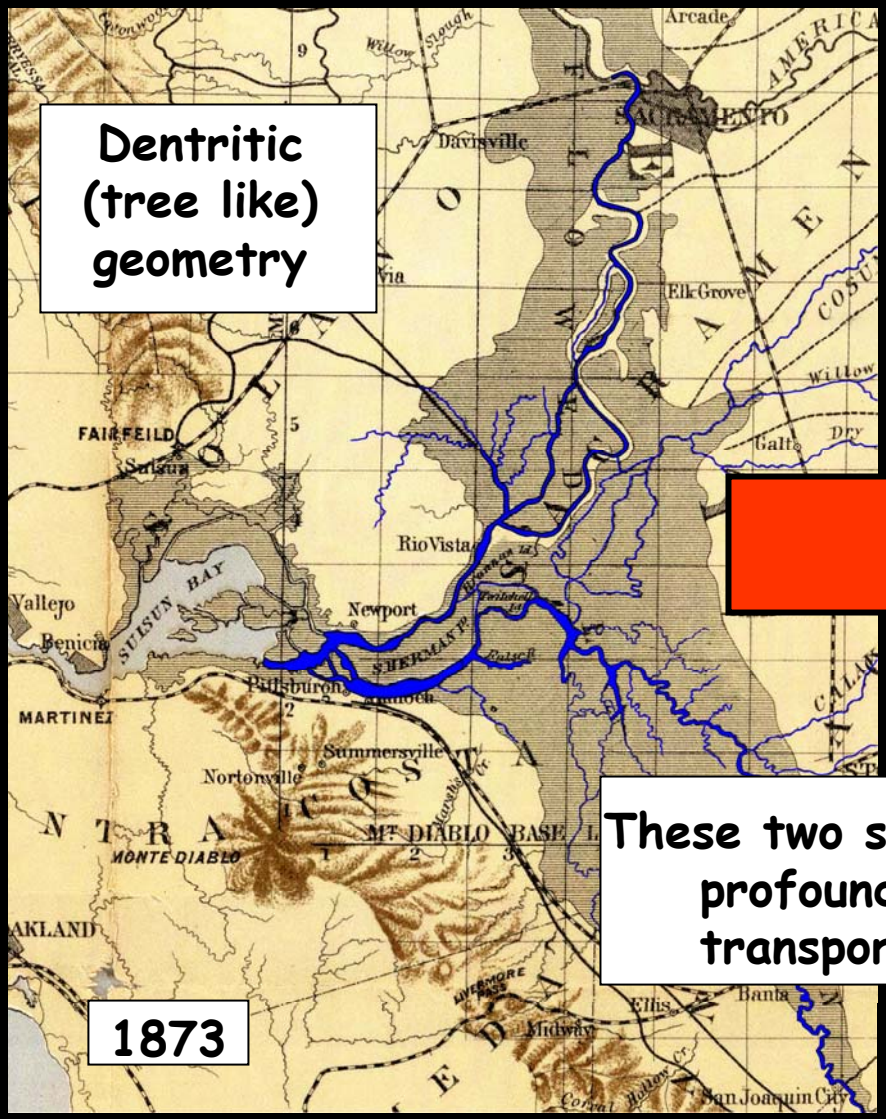
Salient Features

- Strongly influenced by:
 exports, temporary barriers

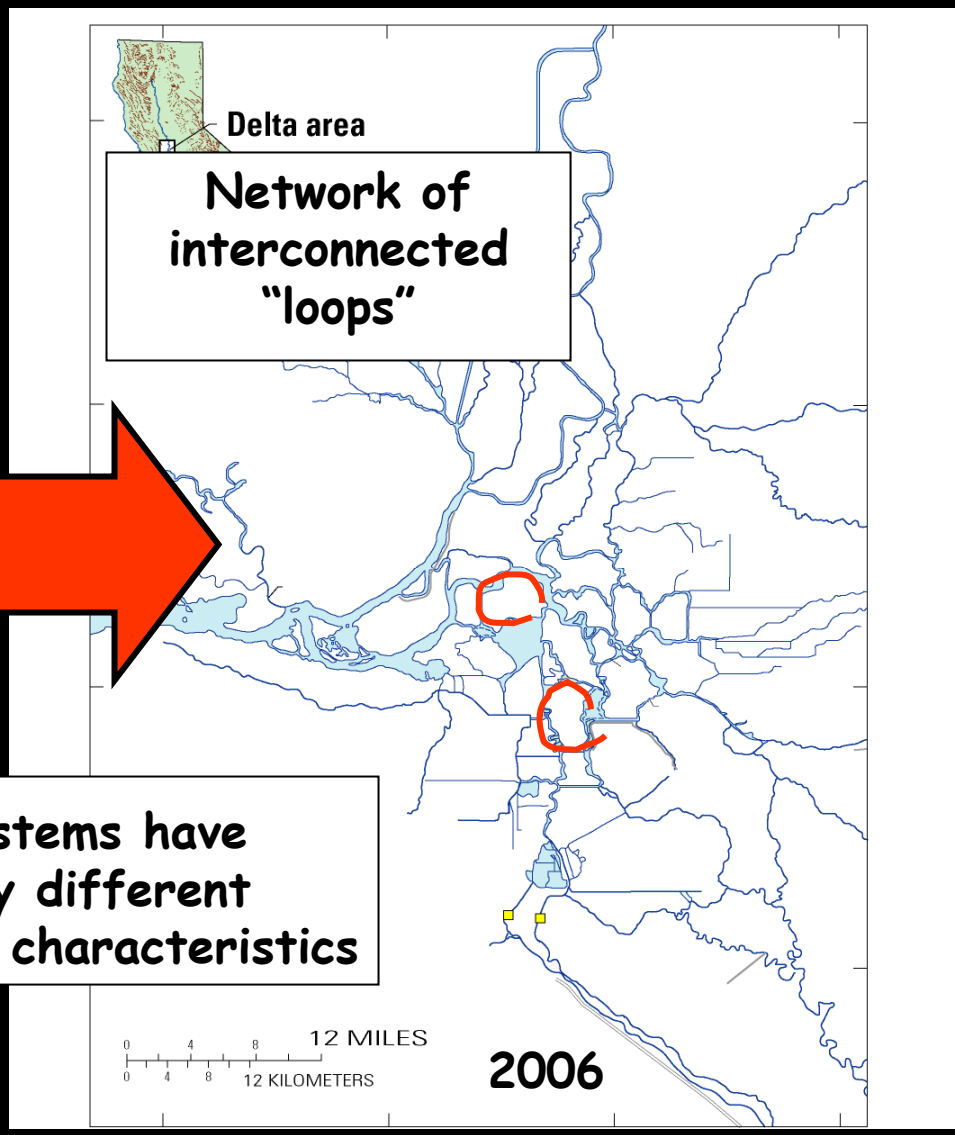
- Homogenized habitats
 loops vs dendritic structure

-When exports > SJR flows almost all of SJR production exported

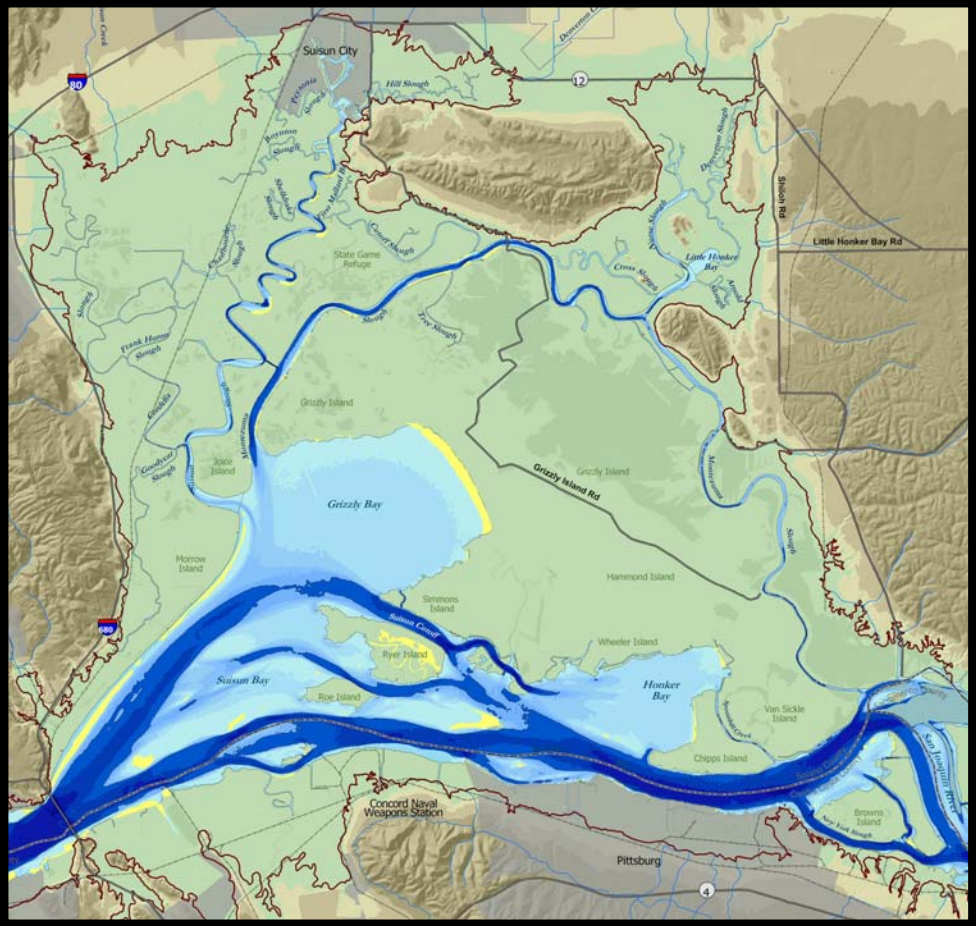
South Delta network homogenizes pelagic environment



These two systems have profoundly different transport characteristics



Suisun Marsh



Salient Features

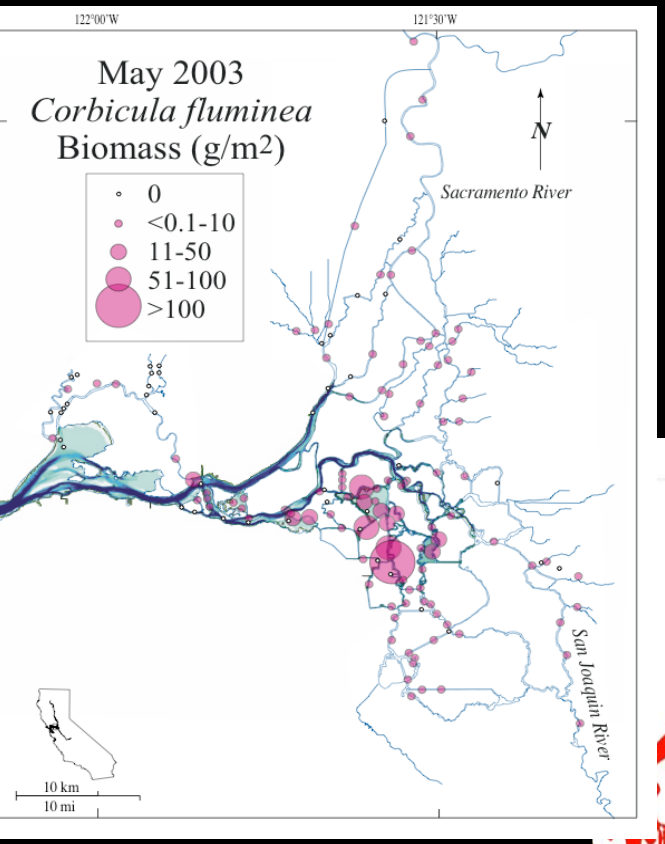
Salt water Marsh

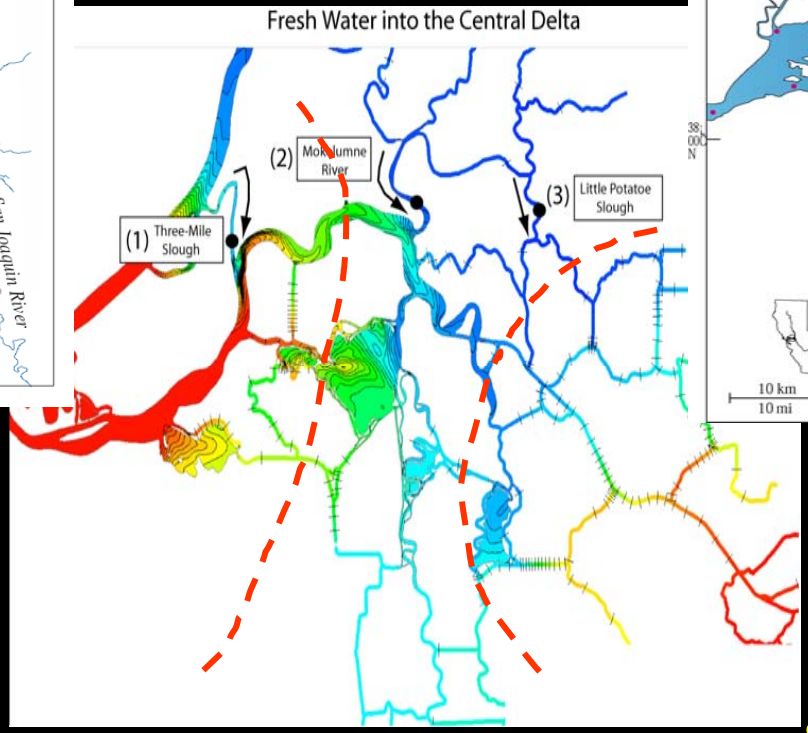
Natural land-water interfaces (although limited)

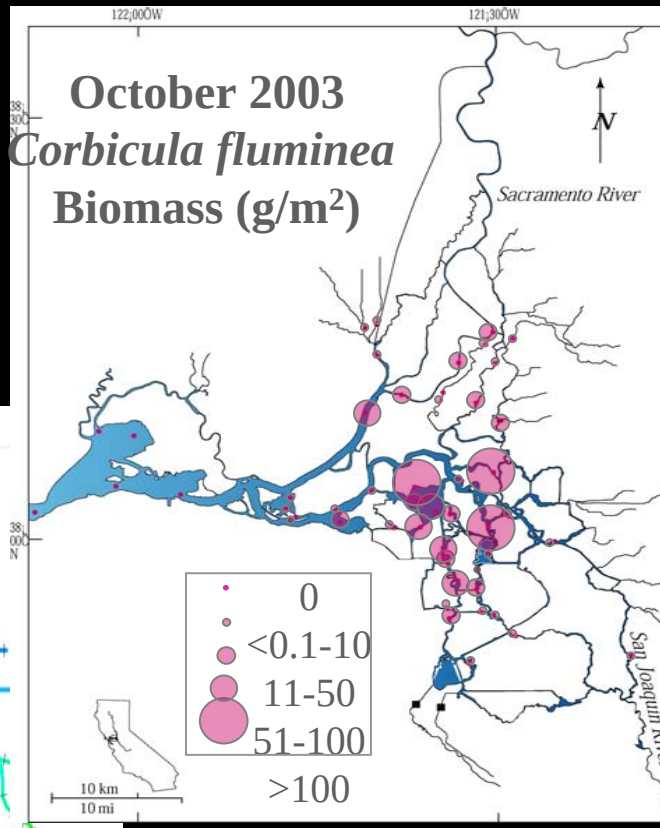
Not directly influenced by exports

What about salt?

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







J. Thompson (USGS)

Uncertainties

Hydrodynamic models – very good predictive capability

We can: Accurately predict residence times
under a variety of scenarios
(levee failures, planform changes, sea-level rise)

Models that can accurately predict ecosystem impacts
(even on lower trophic levels) are years away.

So what do we do?

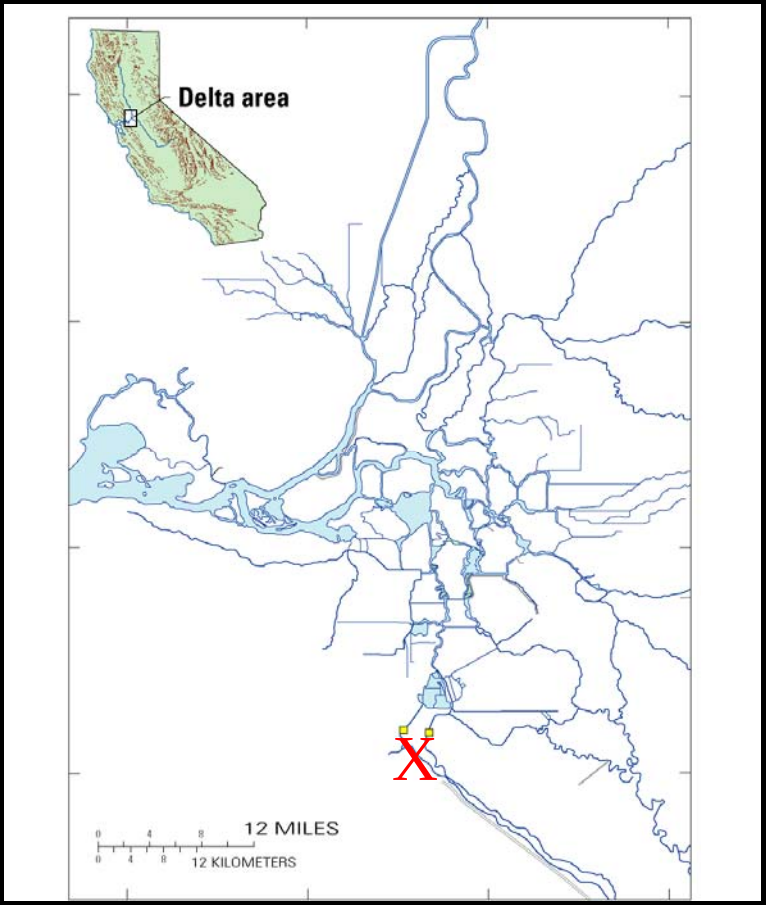
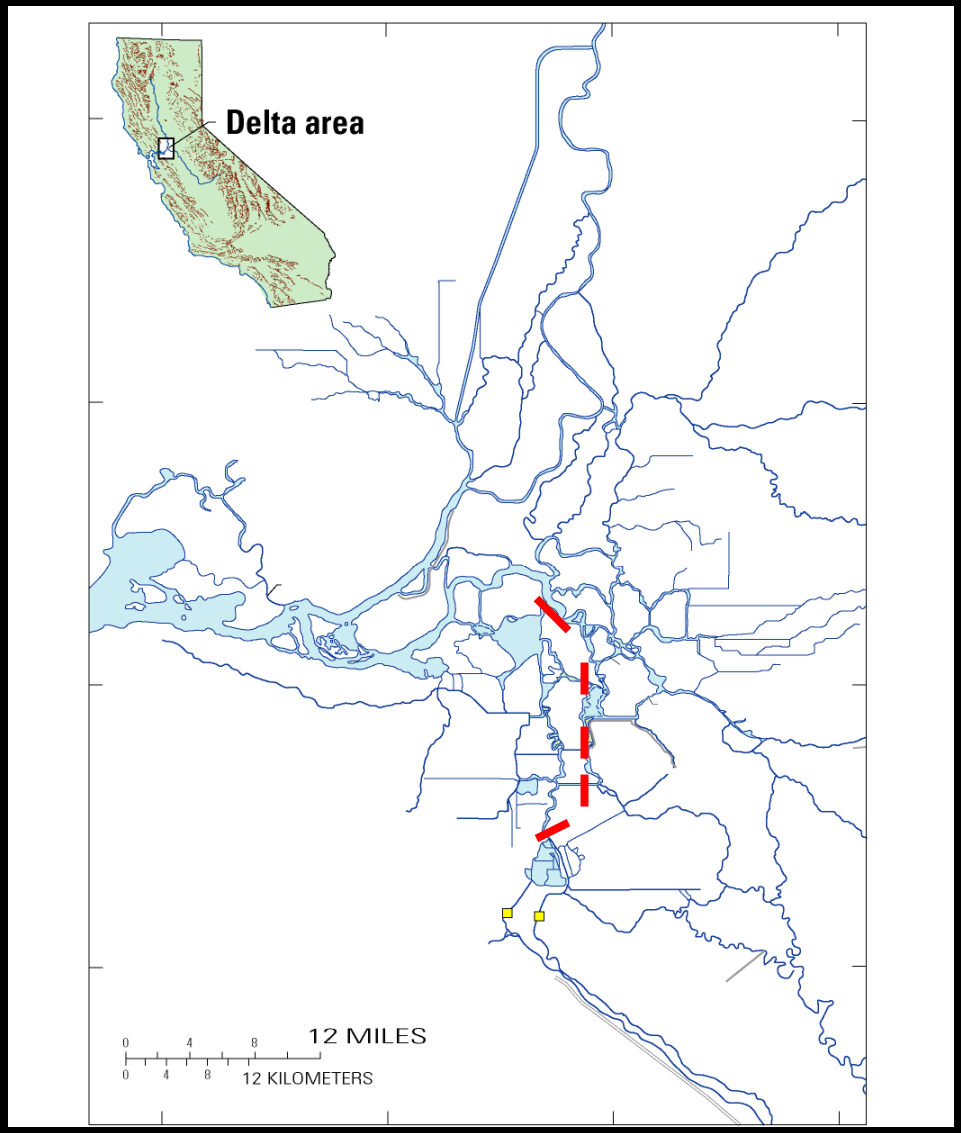
Short term: Conduct large scale experiments

Long Term: Aggressively invest in tools that can be used to predict ecosystem responses (phytoplankton models, Salmon outmigration models, etc.)

EXPERIMENTS

To investigate lower food web response to an Isolated Facility:

(1) Shut of the pumps for a couple of weeks
(e.g. in August when the air temps ~ 100 deg.)



(2) Isolate the central delta from exports using temporary barriers (look at effects of longer residence times and residence time diversity)