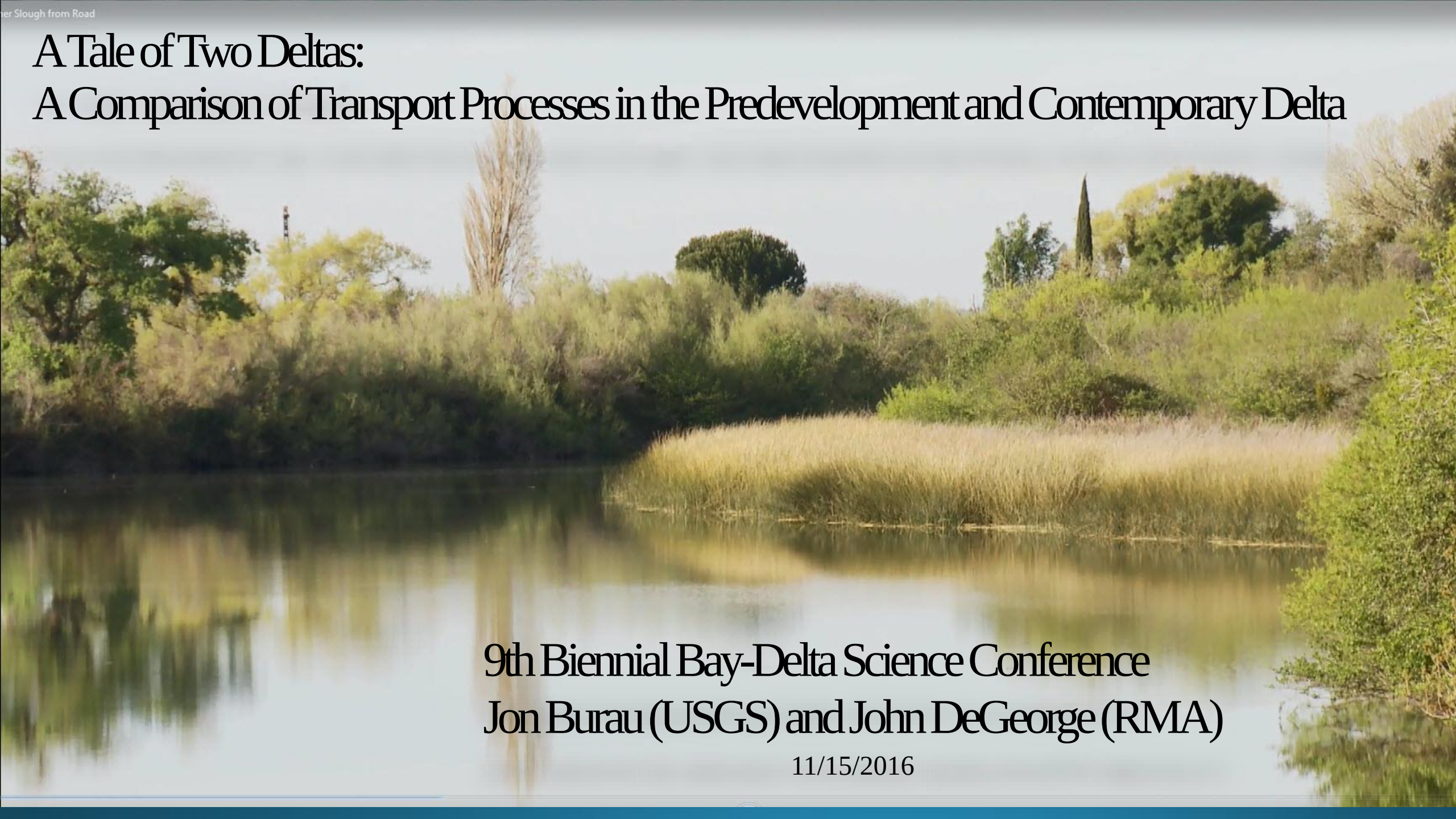


A Tale of Two Deltas:
A Comparison of Transport Processes in the Predevelopment and Contemporary Delta

9th Biennial Bay-Delta Science Conference

Jon Burau (USGS) and John DeGeorge (RMA)

11/15/2016

Acknowledgements

Chris Enright: Grey imminence, thinker dude (retired)

Amber Manfree, UCD Center for Watershed Science, Animation background

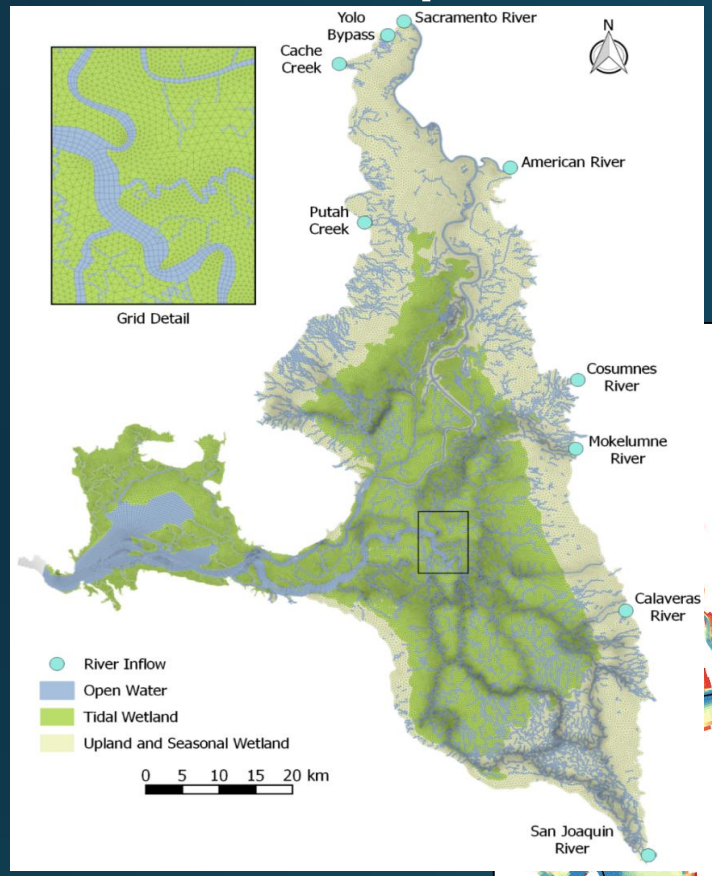
Steve Andrews and Scott Burdick, RMA: Numerical Model runs, Animations

Discuss Changes in Transport between

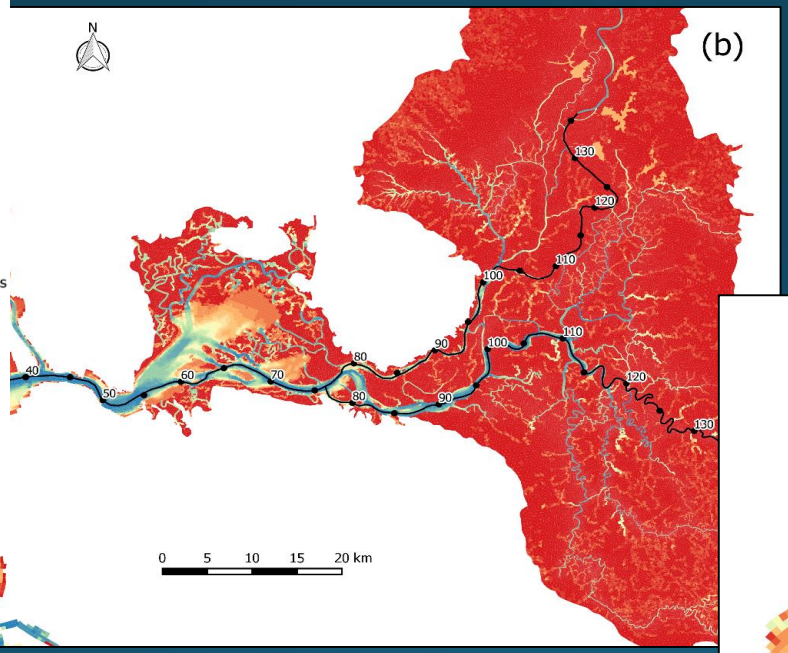
Pre-development Delta: a network of dendritic (tree-like) dead-end channel systems

Contemporary Delta: a web of conveyance canals.

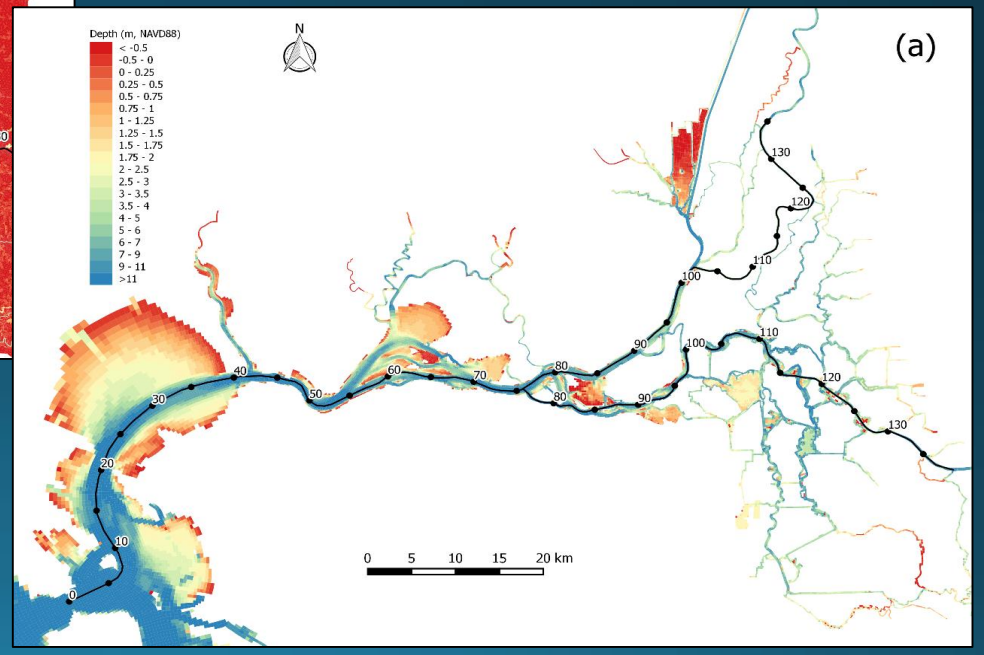
Predevelopment Delta



Predevelopment Delta Model DEM



Contemporary Delta Model DEM

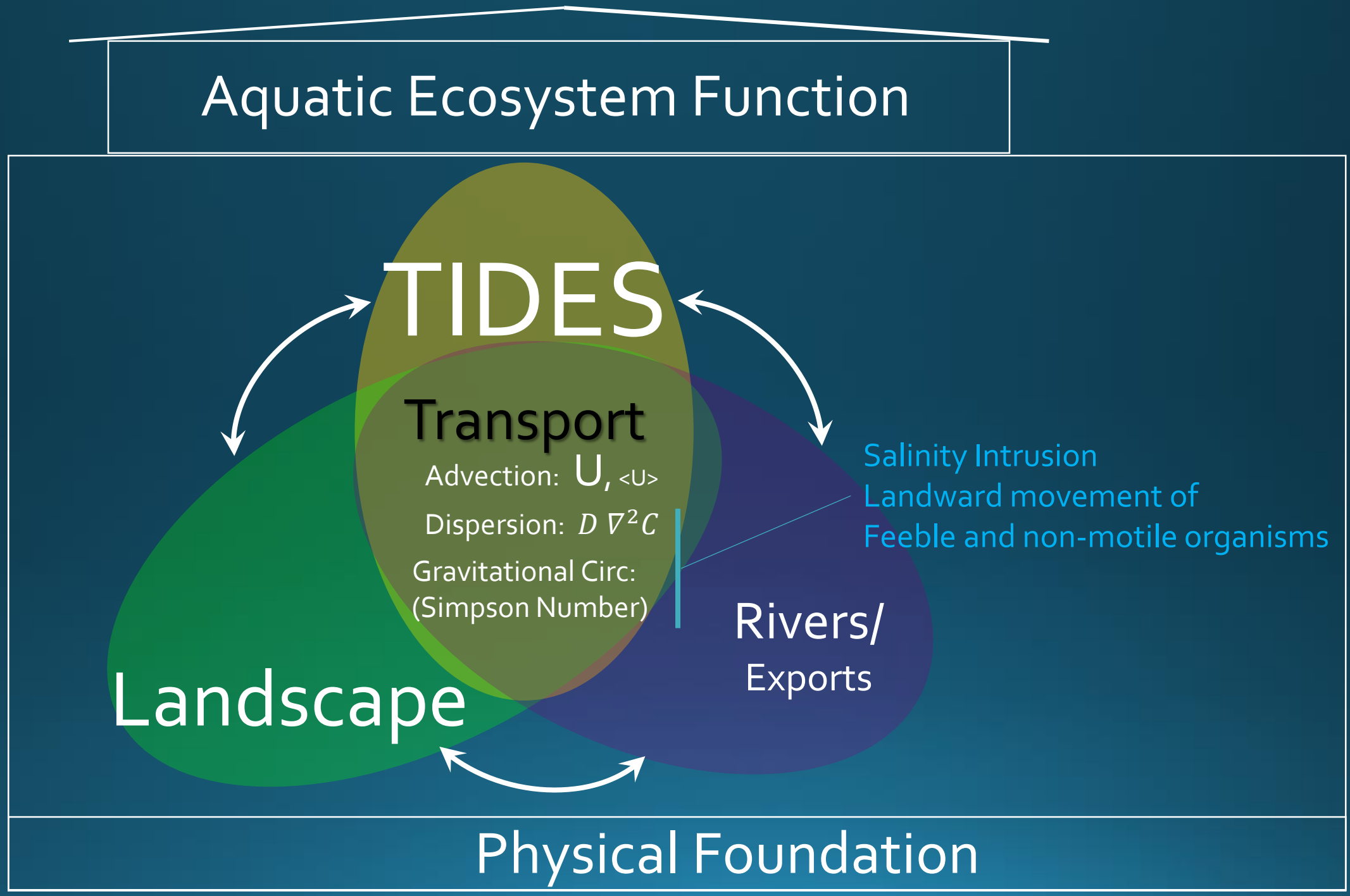


Habitat was classified and delimited
by Whipple et al. (2012) and Manfree (2014)

S.W. Andrews, E.S. Gross, P.H. Hutton (submitted)
Modeling salt intrusion in the San Francisco Estuary prior to anthropogenic influence

3D model = UnTRIM: V. Casulli

Transport 101


Aquatic Ecosystem Function
TIDES
Transport
Advection: U, <U>
Dispersion: $D\ \nabla^2 C$
Gravitational Circ:
(Simpson Number)
Salinity Intrusion
Landward movement of
Feeble and non-motile organisms
Landscape
Rivers/
Exports
Physical Foundation

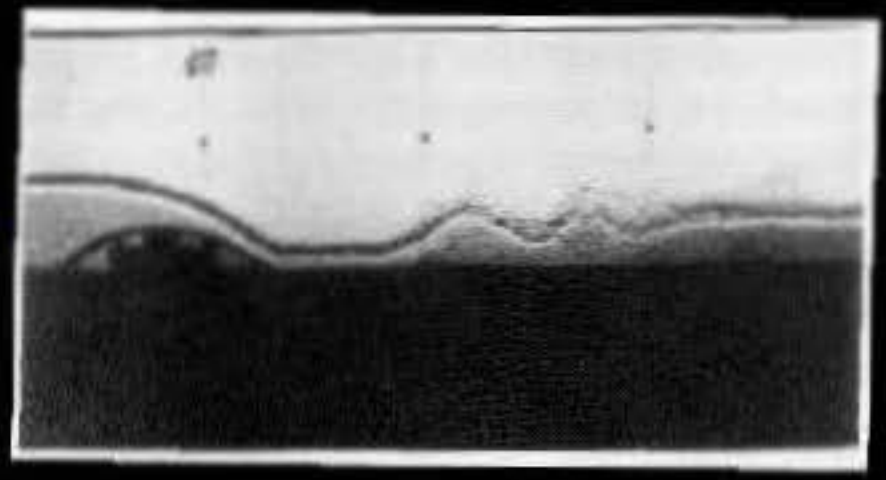
Strength of Gravitational Circulation similar because channel depth similar in Suisun Bay

Dispersion in Bay similar because salinity intrusion is similar

Internal Hydraulic Control at Carquinez Strait

$$Fr_i = \frac{U_b}{\sqrt{g' h_b}}$$

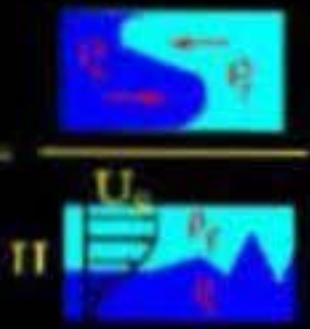
$Fr_i > 1 \rightarrow GC$



Gravitational Circulation scales with the Simpson Number

$Ri_x \uparrow = GC$

$$Ri_x = \frac{\frac{g}{\rho}\frac{\partial \rho}{\partial x}}{\left(\frac{U_s}{H}\right)^2} = \frac{}{\frac{U_s}{H}} = \frac{g U_s^2}{\rho H^2}\frac{\partial \rho}{\partial x}$$



S.W. Andrews, E.S. Gross, P.H. Hutton (submitted)
Modeling salt intrusion in the San Francisco Estuary prior to anthropogenic influence

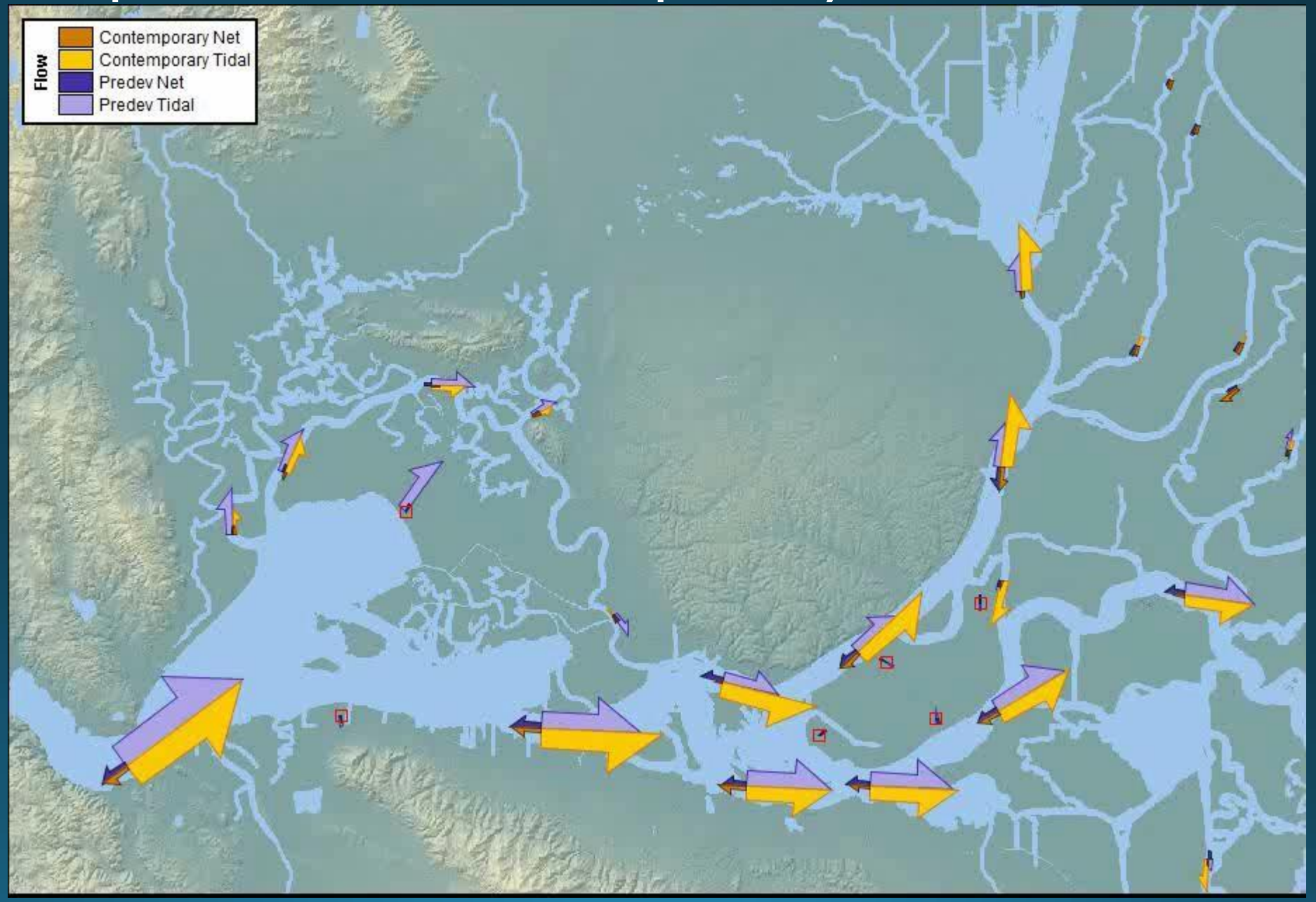
Carquinez Strait is a
(surface water) hydraulic control

Tidal energy between
Predevelopment Delta = Contemporary Delta

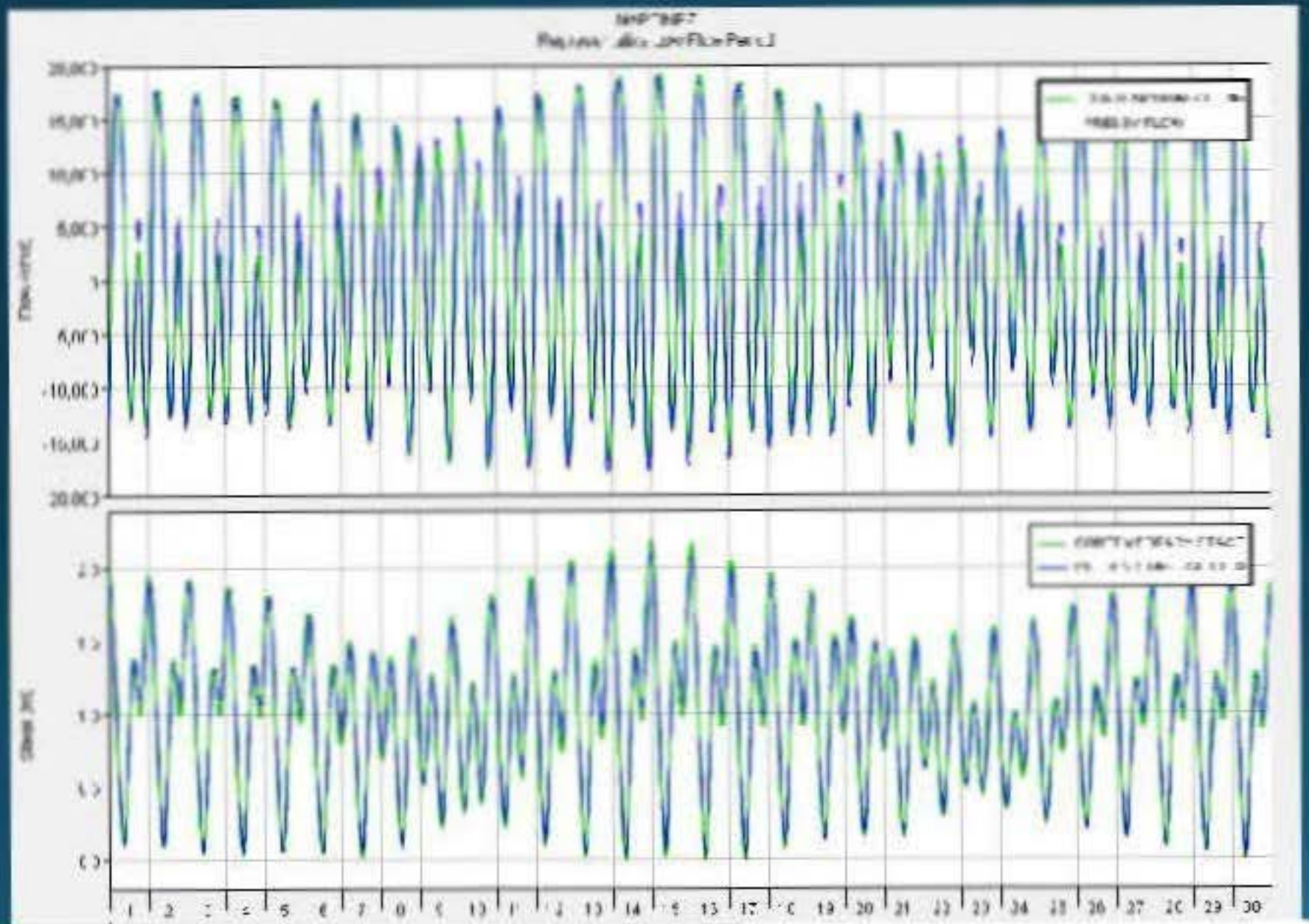
Predevelopment vs Contemporary Delta

Low River Flows

Animation



Caquinez Strait



"Tides are lazy" – they take the least path of resistance

(e.g. The distribution of the tides in the Delta involves a minimization of system-wide impedance)

Conclusion

Combination of hydraulic control at Carquinez and tides are "lazy" suggests:

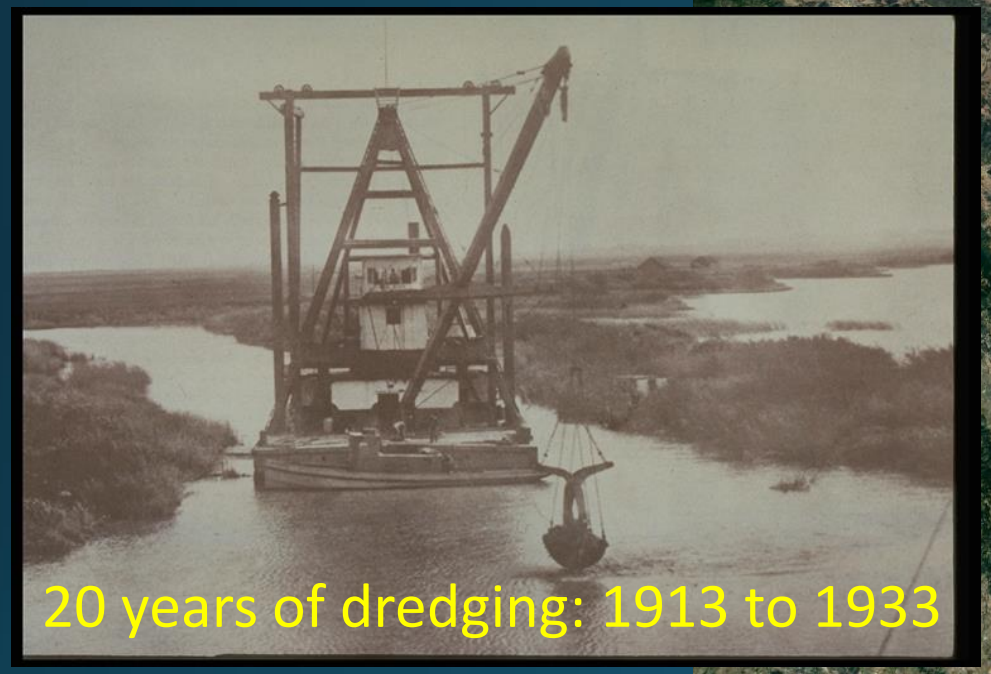
The largest changes in transport involved the redistribution of the tides in response to changes in the landscape

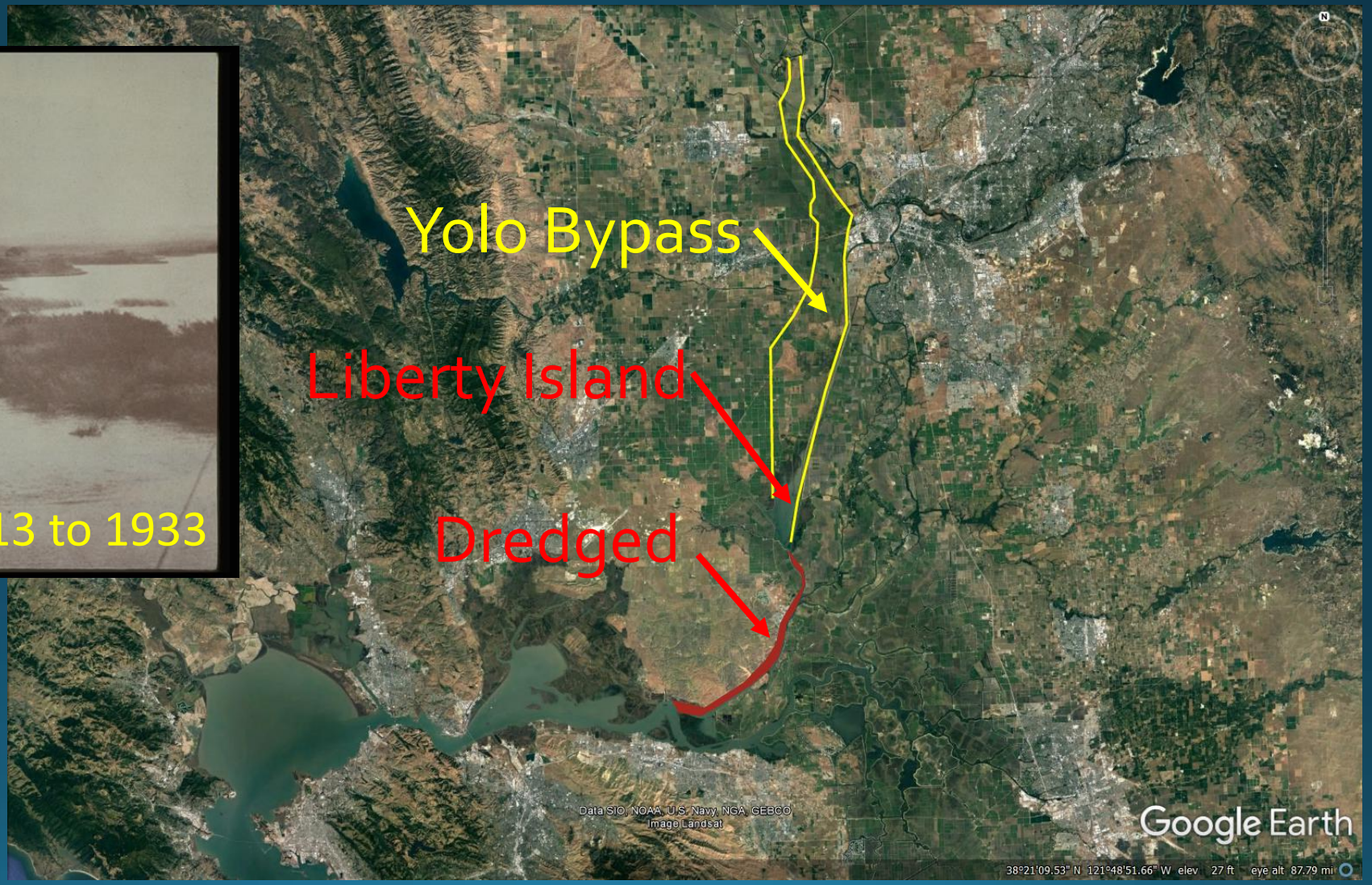
The two biggest changes in Transport:

(1) Massive dredging of Cache Slough and western Sacramento River

(2) The integrated effect of the loss of tidal marsh

(1) Massive dredging of Cache Slough and the western Sacramento River



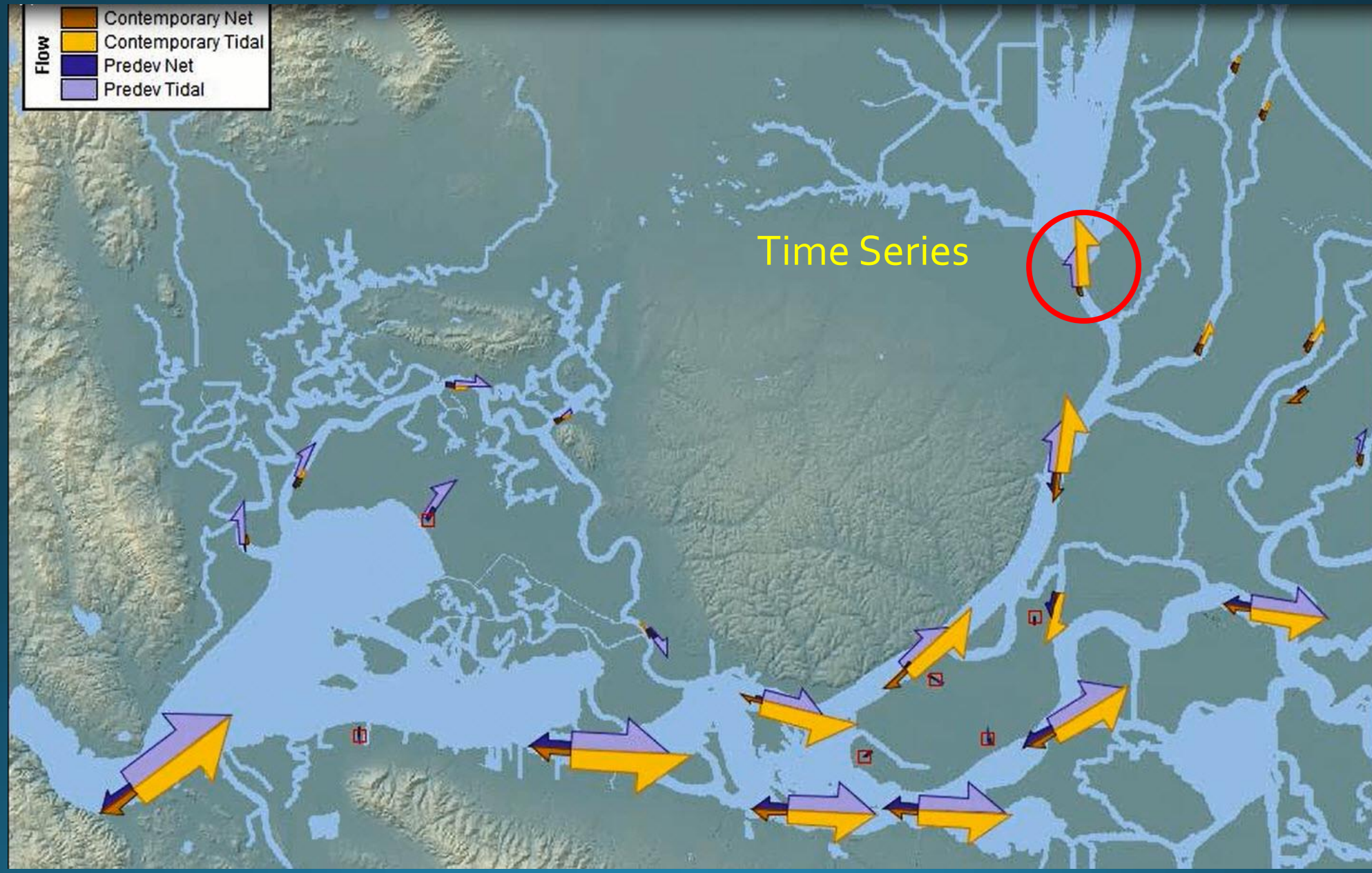


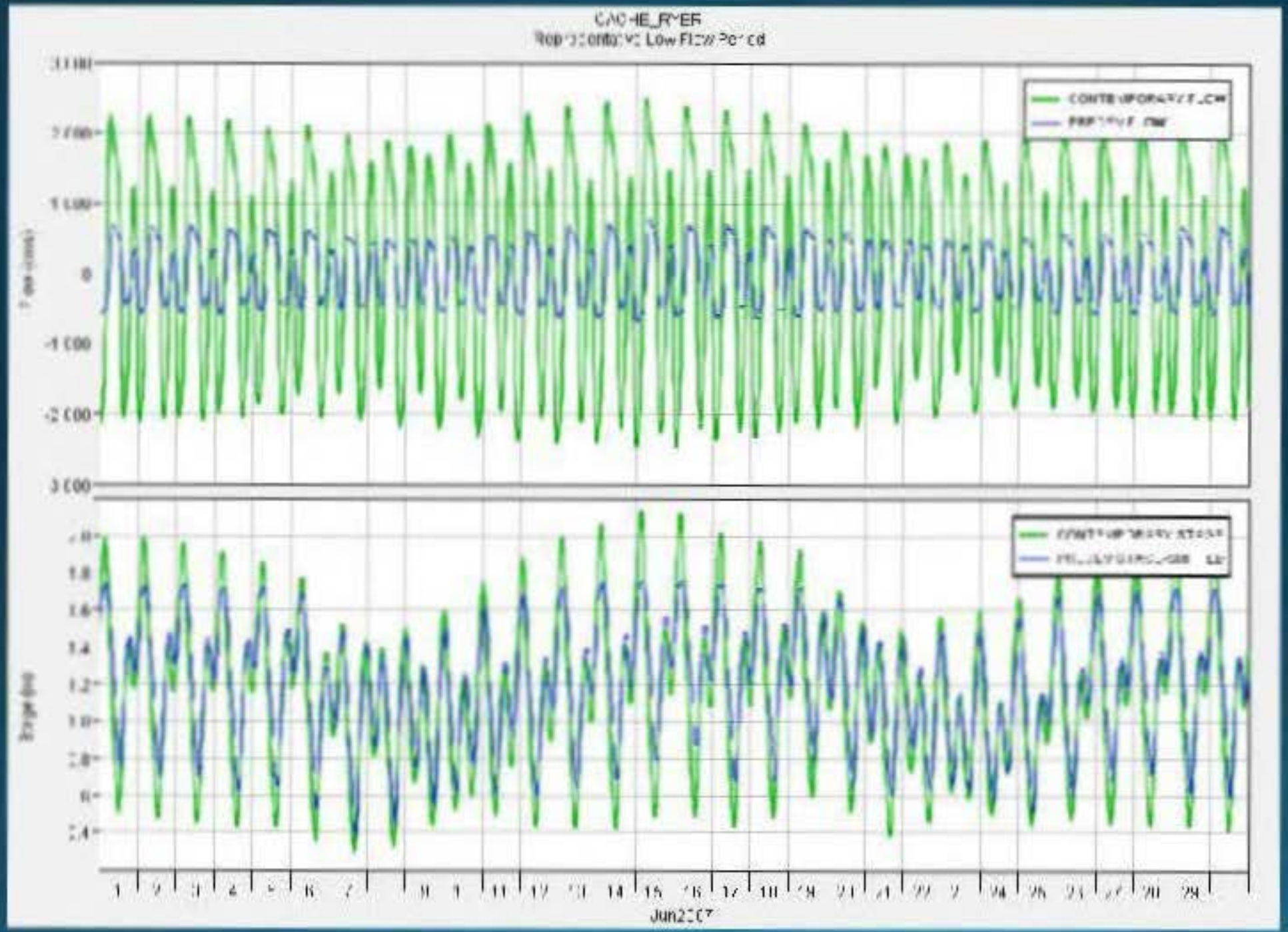
Robert Kelley (1989)
Battling the Inland Sea: Floods, Public Policy, and the Sacramento Valley

Predevelopment vs Contemporary Delta

Low River Flows

Peak Flood Tide



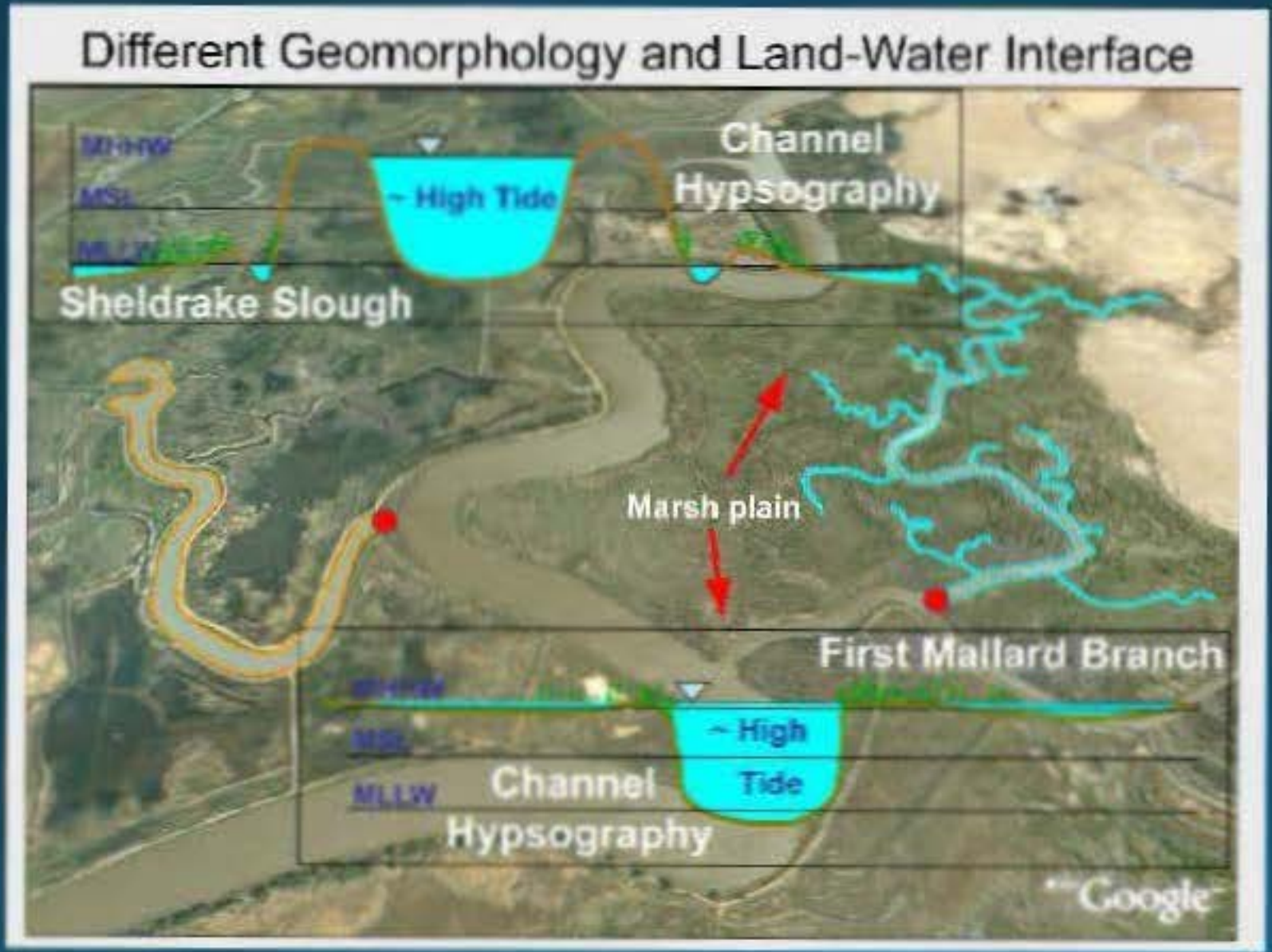

CACHE_RIVER
Representative Low Flow Period
1 000
0
-1 000
-2 000
3 000
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
Jun2007

(2) The integrated effect of the loss of tidal marsh

Spring/neap timescale:

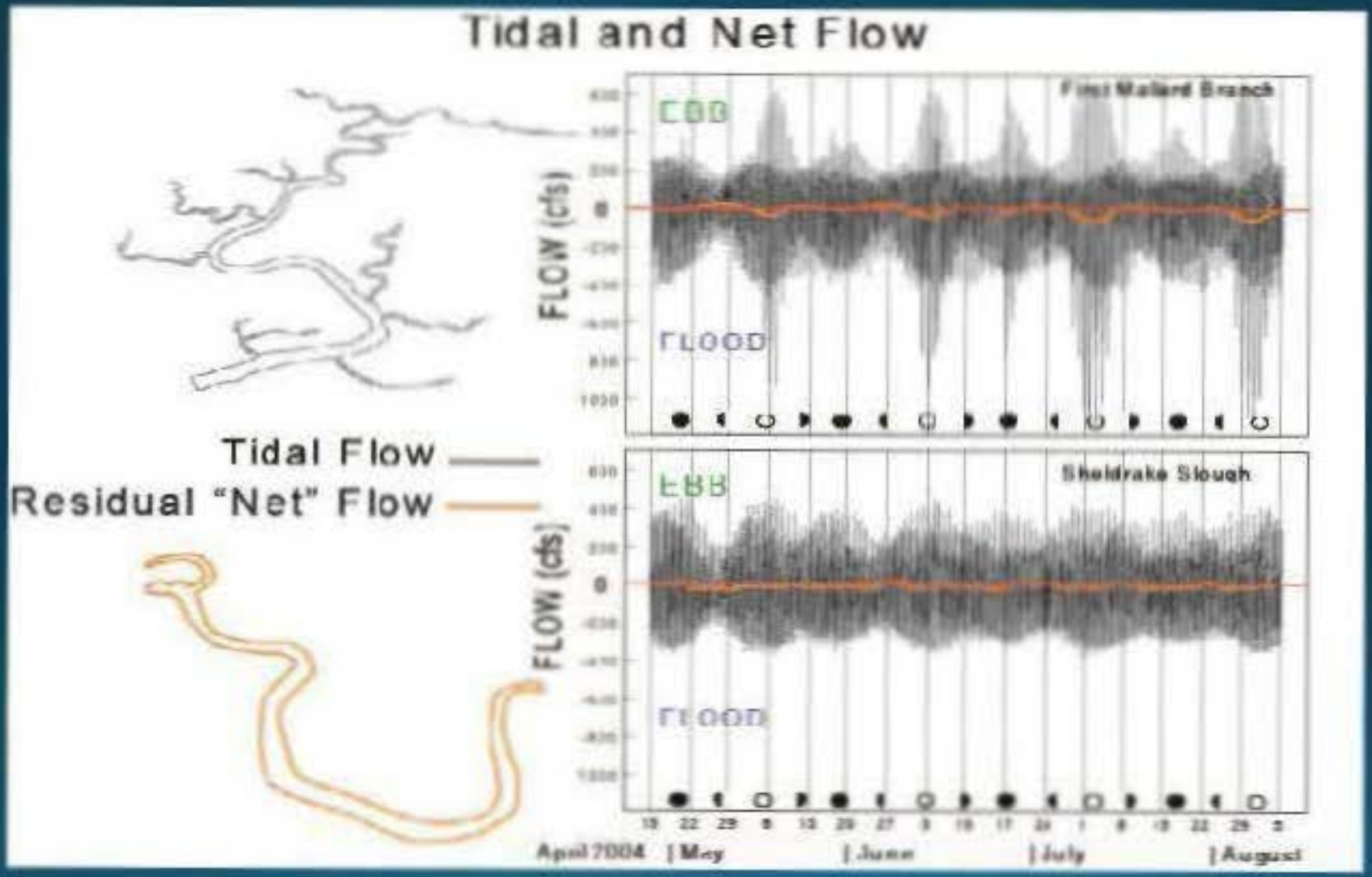
(1) redistribution of tidal energy

(2) Coupling of pelagic and marsh habitats



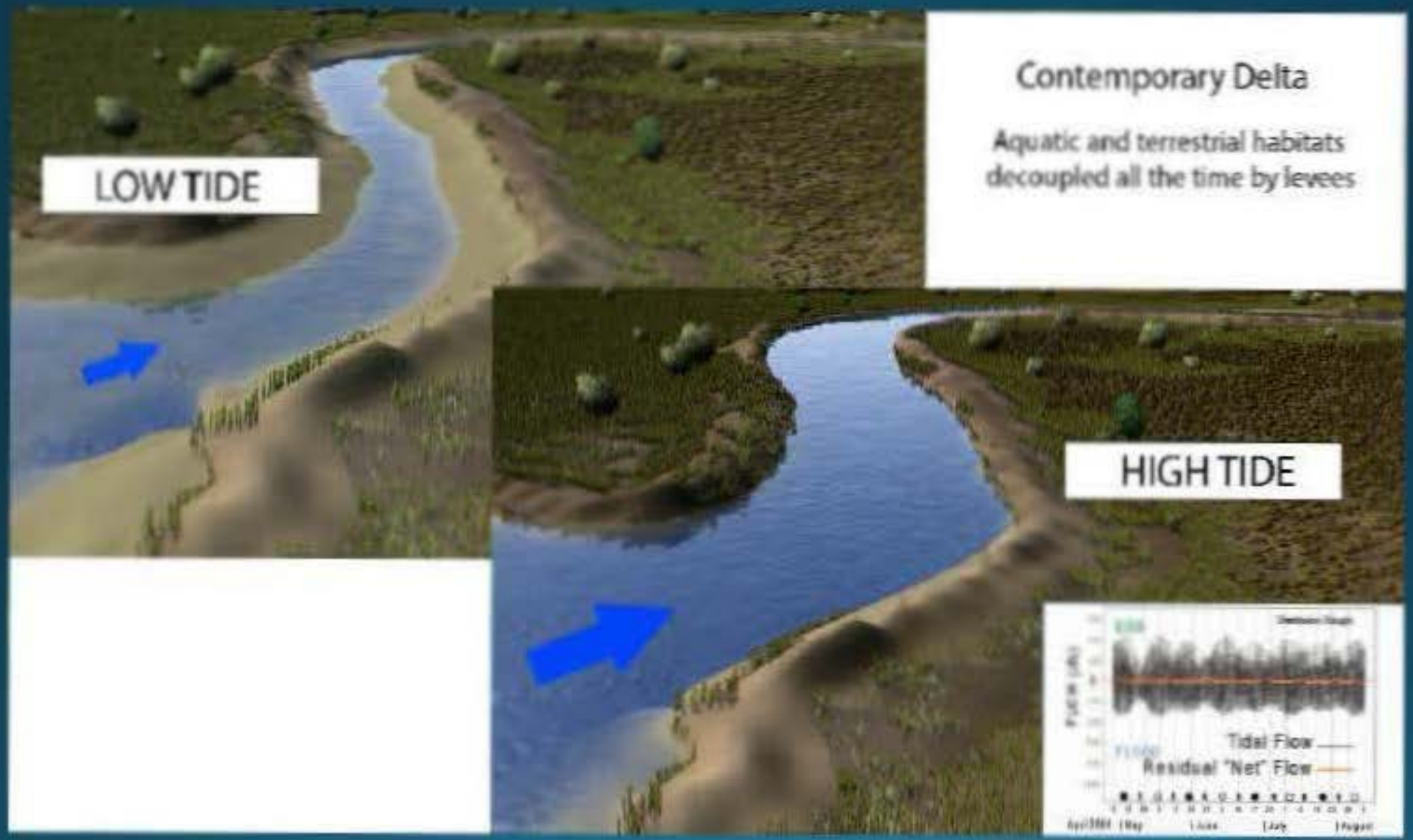
Enright, C., Culberson S.D. and J.R. Burau, 2013, Broad Timescale Forcing and Geomorphic Mediation of Tidal Marsh Flow and Temperature Dynamics, Estuaries and Coasts, 36:1319-1339 DOI 10.1007/s12237-013-9639-7

Spring/Neap coupling between pelagic and marsh habitats



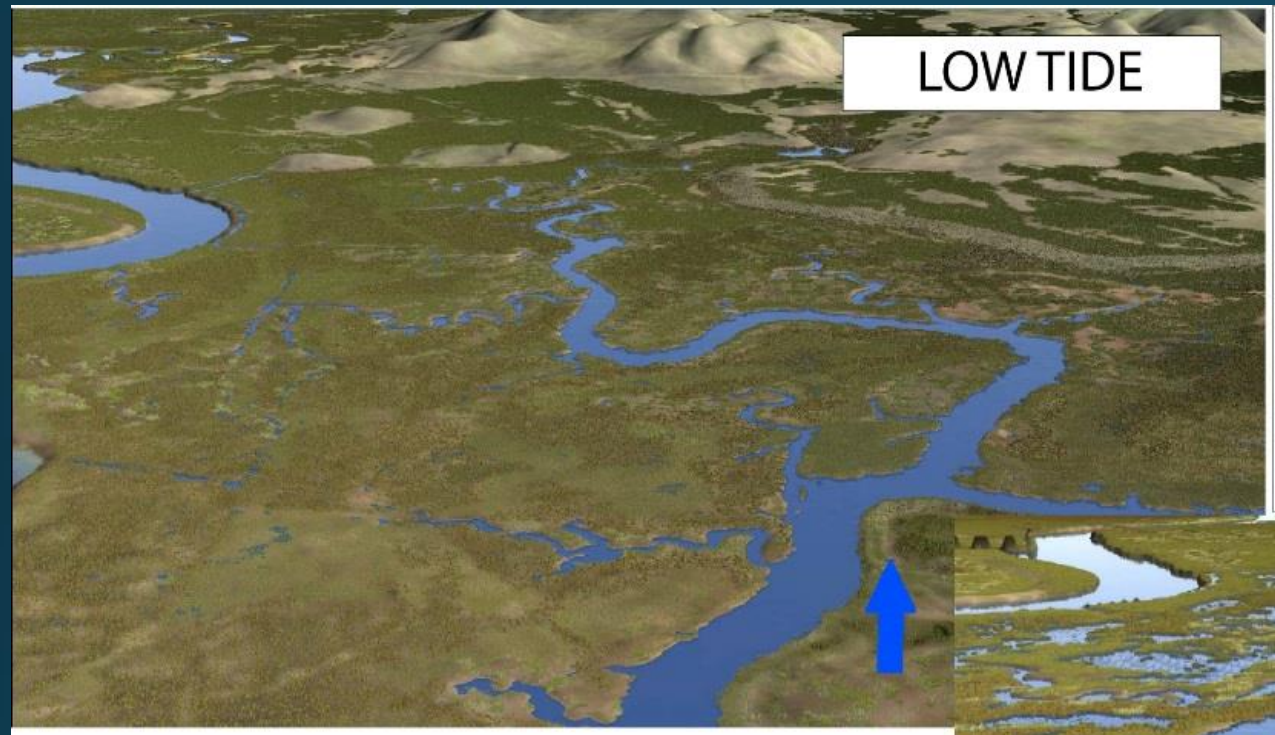
Enright, C., Culberson S.D. and J.R. Burau, 2013, Broad Timescale Forcing and Geomorphic Mediation of Tidal Marsh Flow and Temperature Dynamics, Estuaries and Coasts, 36:1319-1339 DOI 10.1007/s12237-013-9639-7

Contemporary Delta – Pelagic and terrestrial habitats always disconnected



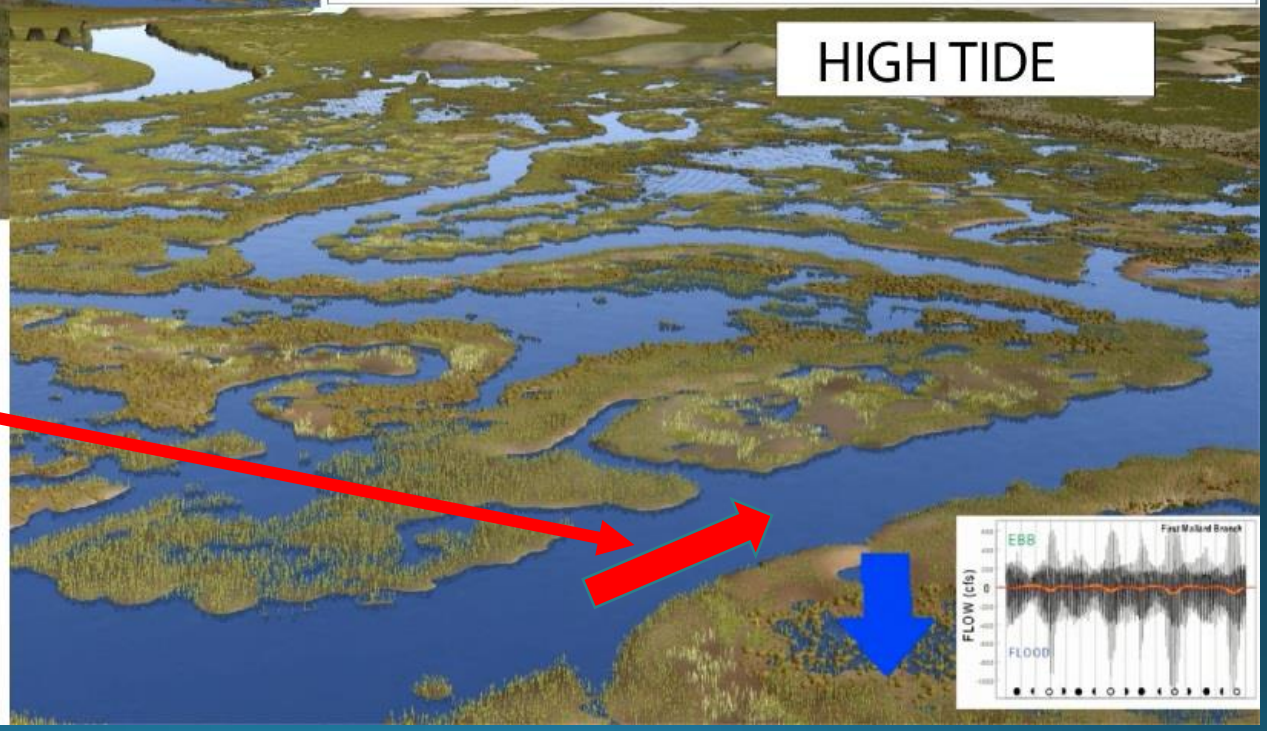
Courtesy of 34North

Pre-developement Delta – Pelagic and terrestrial habitats coupling at spring/neap timescales



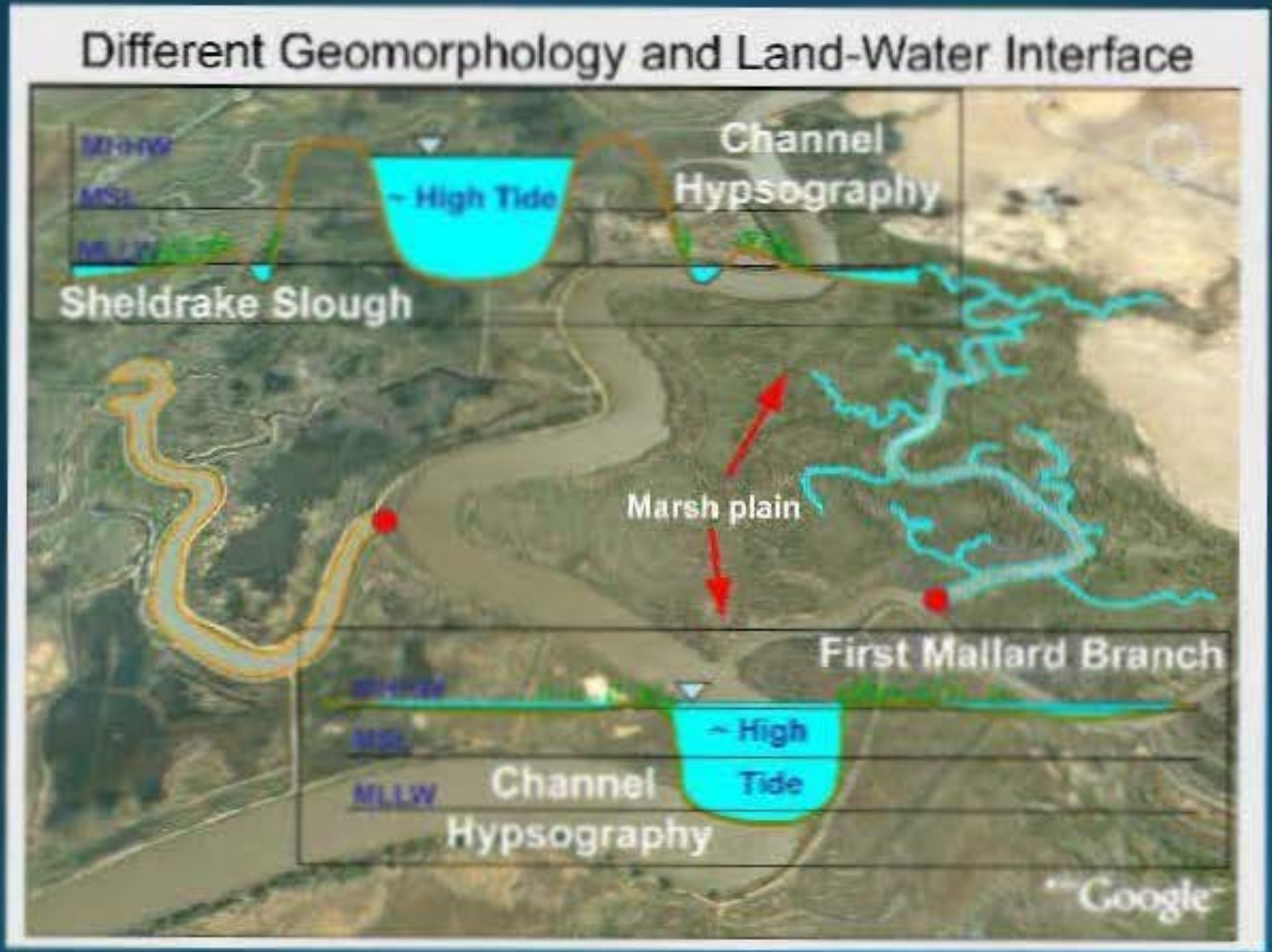
Historic Delta

Aquatic and terrestrial habitats
decoupled during neap tides
coupled (4-6 days) during spring tides



Pelagic ecosystem developed on neap tides
– fully advected into the marsh on spring/tides

Courtesy of 34North



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(1) The large difference in exchange in 1st Mallard branch is more than happened historically - because it is the only one.

(2) Large increase in tidal exchange on spring tides did not occur uniformly throughout predevelopment Delta.

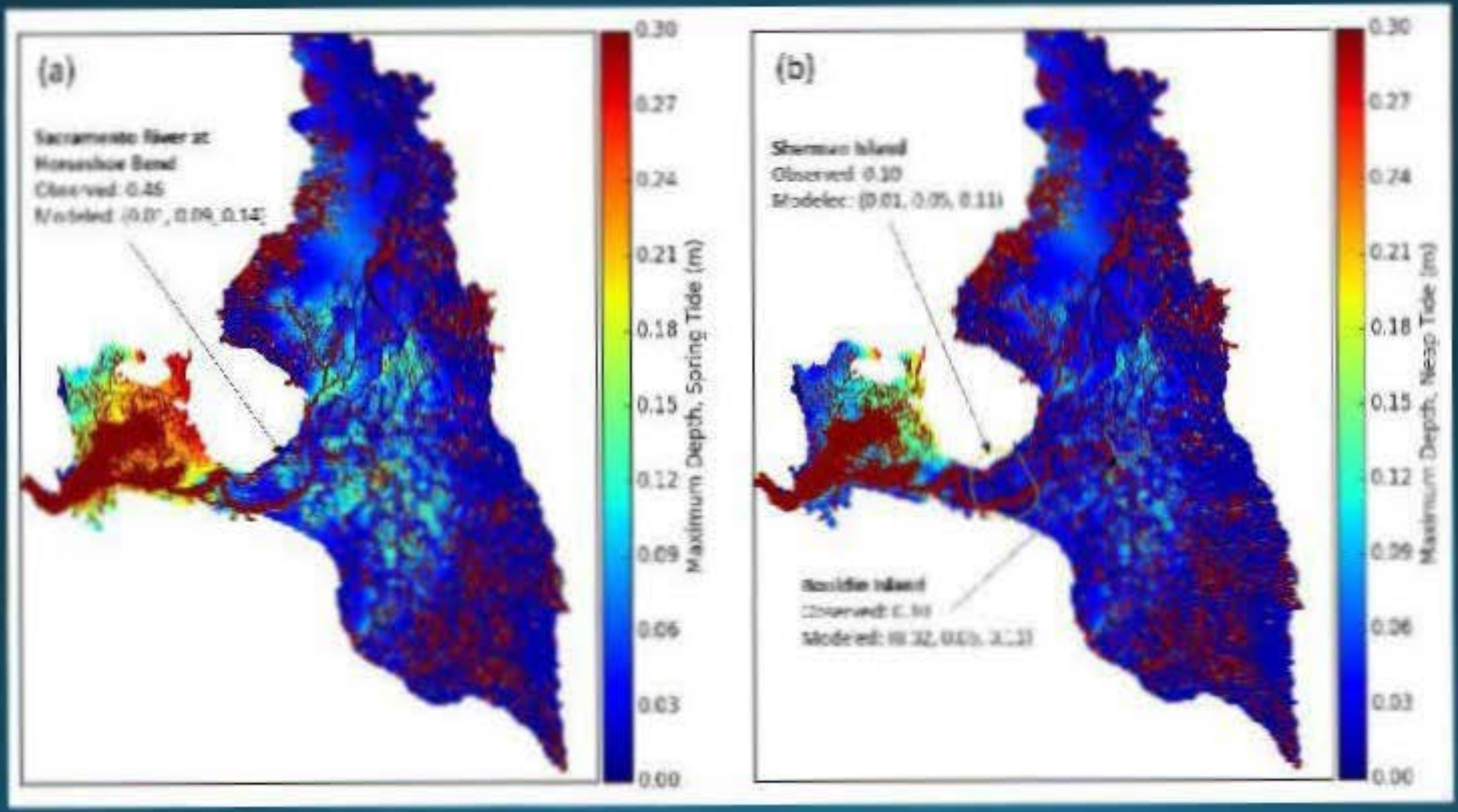
Marsh overtopping occurred more in western part of the system – tides are "lazy"

- spring/neap redistribution of tidal energy…

Inundation Depth

Spring Tide

Neap Tide



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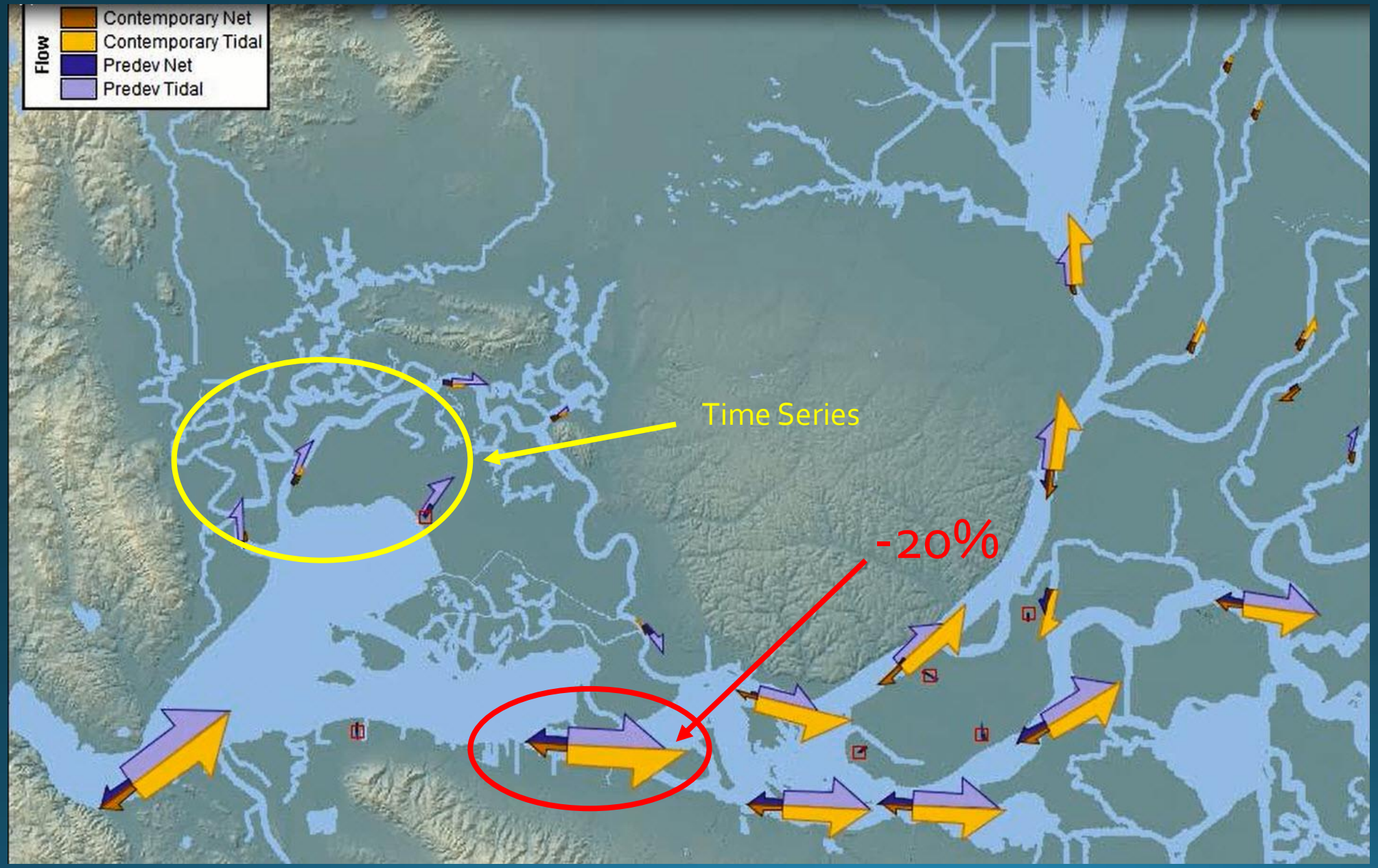
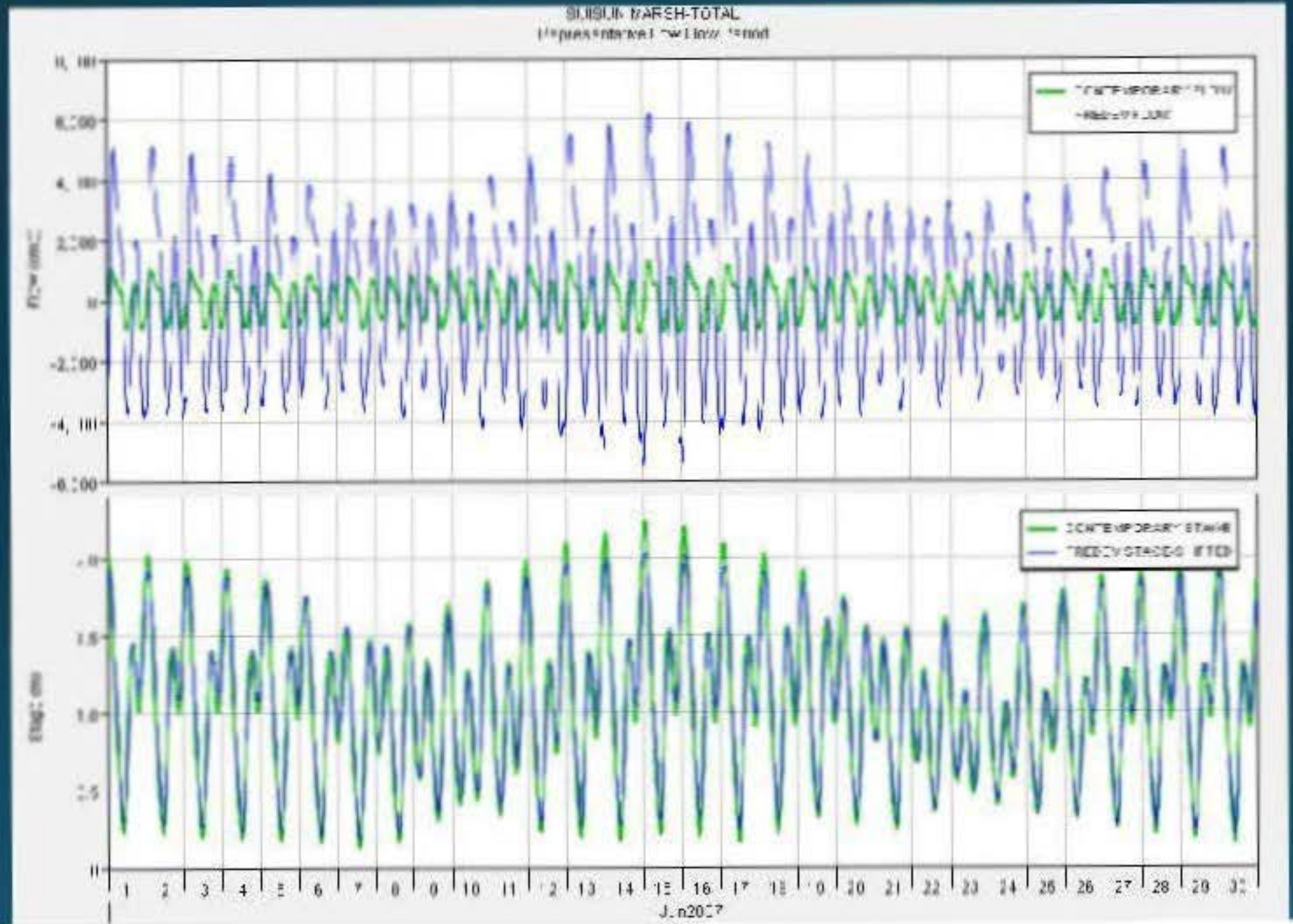
Modeling salt intrusion in the San Francisco Estuary prior to anthropogenic influence

Roughly 20% of tidal energy -> Suisun Marsh





Questions?