

Human alterations of channel characteristics in the Delta and effects on hydrodynamics and sediment transport

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Outline

- **Background on human alterations to the Delta channels**
- **Methods of data collection and measuring changes in hydrodynamics and sediment transport**
- **Results**
 - **Effects of flooded islands**
 - **Effects of changes in channel geometry**
 - **Sediment deposition in the Delta**
- **Conclusions**

Background

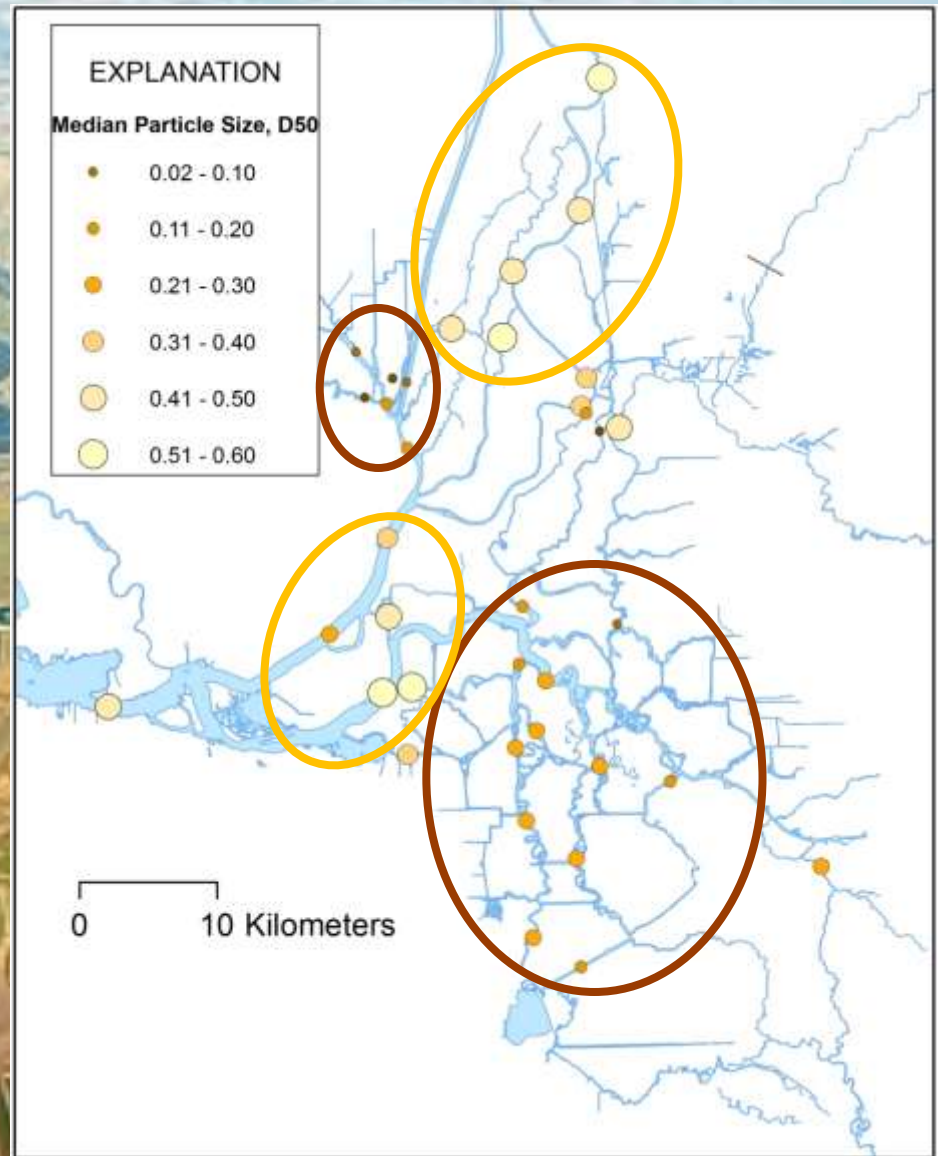
- **U.S. Bureau of Reclamation is working to develop hydrodynamic and sediment transport models for the purpose of evaluating management effects on endangered species in the Delta.**
- **USGS is currently supporting the development of these models by collecting field data on bed-material as well as investigating changes in sediment dynamics**
- **Why is it important?**
 - Bed-material size and characteristics can affect turbidity, which is particularly important for Delta Smelt
 - Sediment supply to the Bay has been decreasing
 - Channel and shear velocity affect sediment transport and can play an important role in shaping ecosystem characteristics.

Background

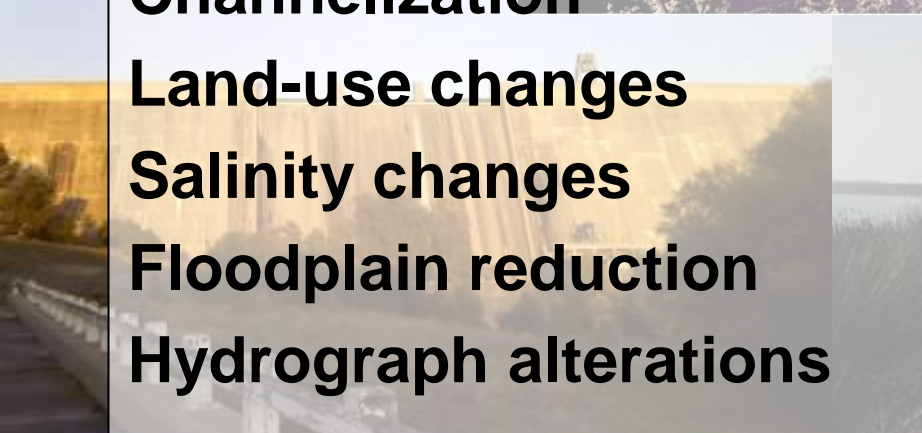
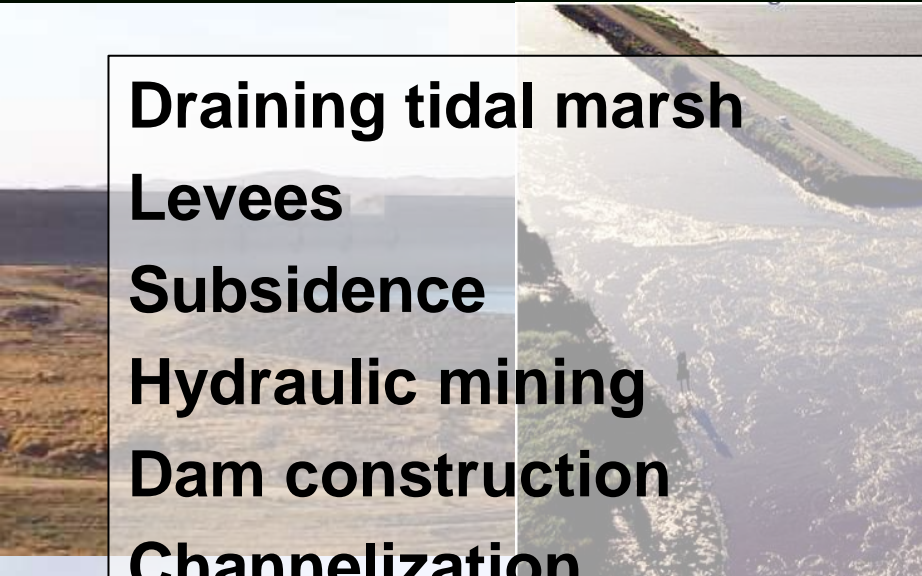
Results from USGS bed-material sampling

Summary of previous findings:

- Coarse material found in North Delta, and near confluence
 - Fine material found in South Delta and Cache Slough complex
-
- Unclear why certain bed materials were found in some locations and not in others.
 - Warranted further investigation.



Historical changes to the Delta and watershed...



Draining tidal marsh
Levees
Subsidence
Hydraulic mining
Dam construction
Channelization
Land-use changes
Salinity changes
Floodplain reduction
Hydrograph alterations



Bank stabilization
Flooded islands
Man-made channels
Channel widening
Channel dredging

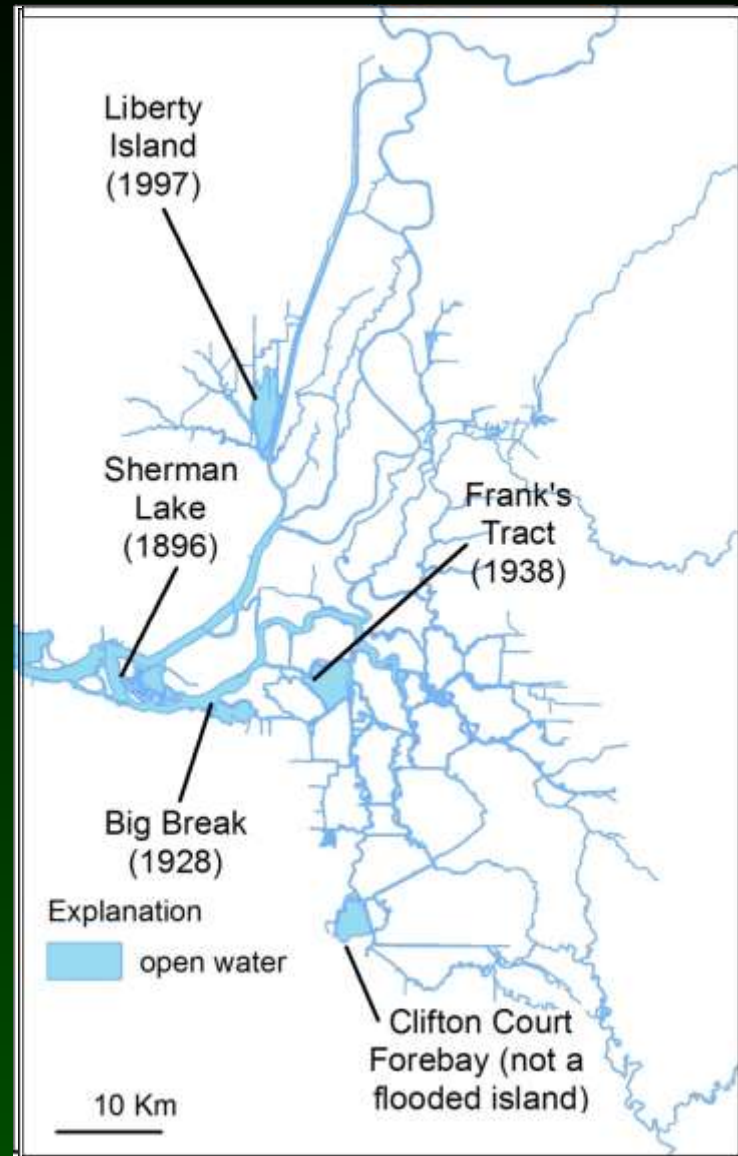
Photo: CA DWR



Historical Changes continued...

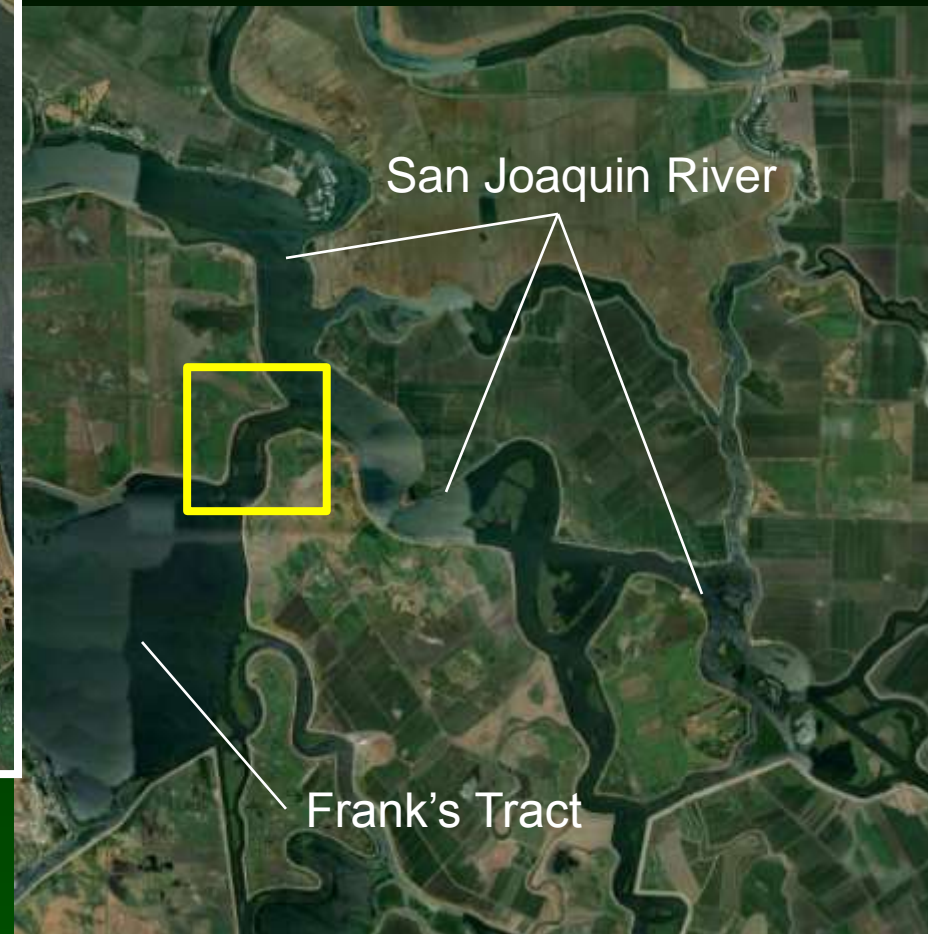
1800s through 1900s
State of the Delta early 1800s

- Marshes were drained
- Complex network of channels with large expanse of tidal and freshwater wetlands
- New channels were constructed
- Deep-water shipping channels
- Leveed islands subsided and flooded (some permanently)



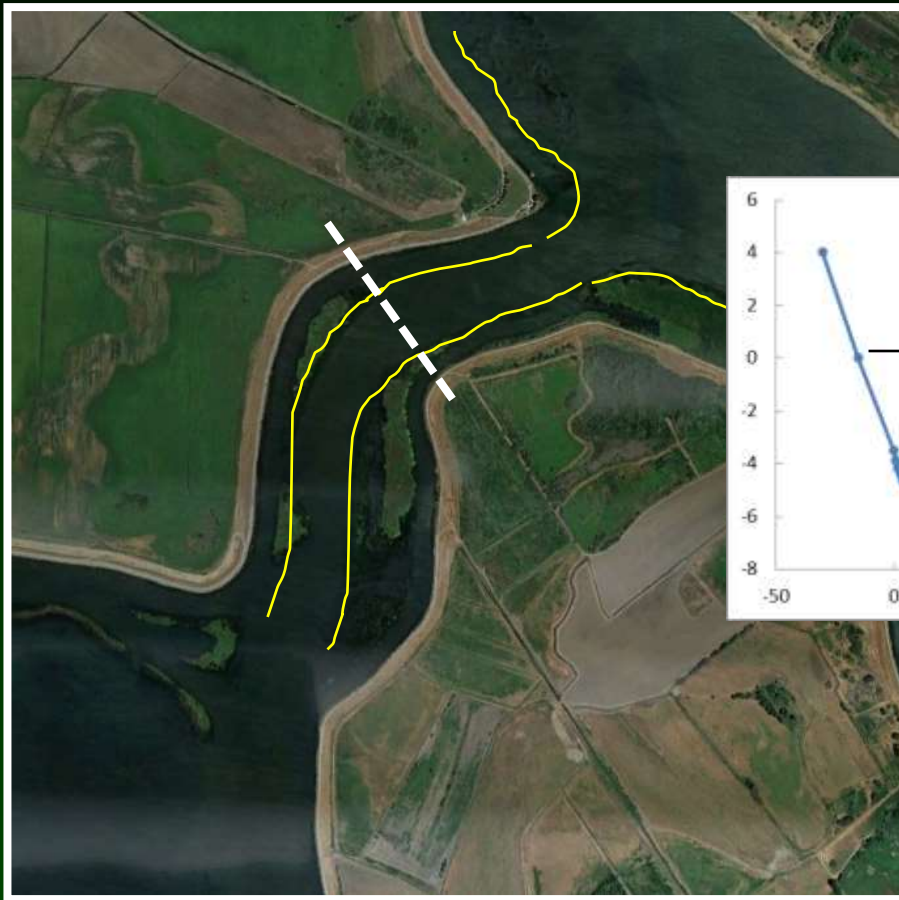
Historical Changes continued...

Many channels were widened
Example: Old River near Frank's Tract

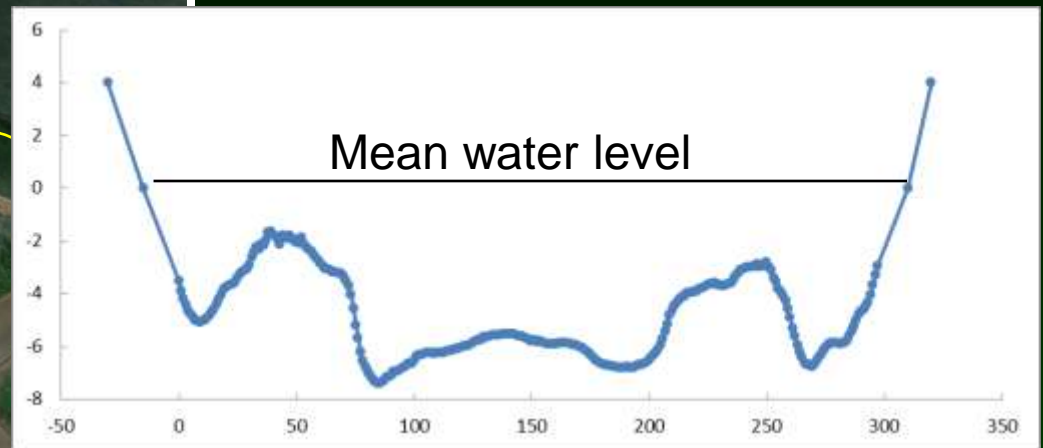


Historical Changes continued...

Many channels were widened
Example: Old River near Frank's Tract



Channel cross-section



Original channel width?

Flooded islands



Methods

Bed shear velocity and critical shear velocity

Shear velocity, u_* (Keulegan, 1938)

$$\frac{U}{u_*} = \frac{1}{\kappa} \ln \left(11 \frac{H}{k_s} \right)$$

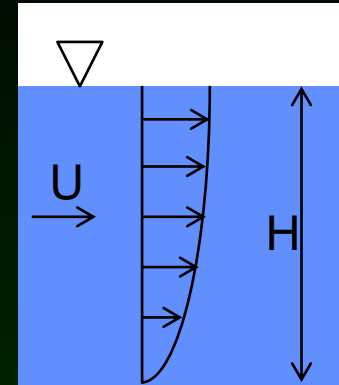
Known:

H = depth

$\kappa = 0.41$ (von Karmon coefficient)

U = average velocity

k_s = roughness coefficient
= $3 \cdot D_{90}$ (van Rijn, 1984)



Critical shear stress, τ_{cr} (Brownlie, 1981)

$$\frac{\tau_{cr}}{\rho g R D} = 0.22 R_{ep}^{-0.6} + 0.06 e^{(-17.77 R_{ep}^{-0.6})}$$

$$\text{where } R_{ep} = \frac{\sqrt{g R D D}}{\nu}$$

Known:

$\rho = 1000 \text{ kg/m}^3$ density of H_2O

$g = 9.81 \text{ m/s}^2$ (gravity)

$R = 1.65$ (submerged specific weight)

D = particle size, D_{50}

$\nu = 1\text{E-}6 \text{ m}^2/\text{s}$, (kinematic viscosity)

Critical shear stress, τ_{cr}
converted to critical shear velocity, u_{cr}

$$u_{cr} = \sqrt{\frac{\tau_{cr}}{\rho}}$$

Methods

List of data sources used to create a sediment budget

Suspended

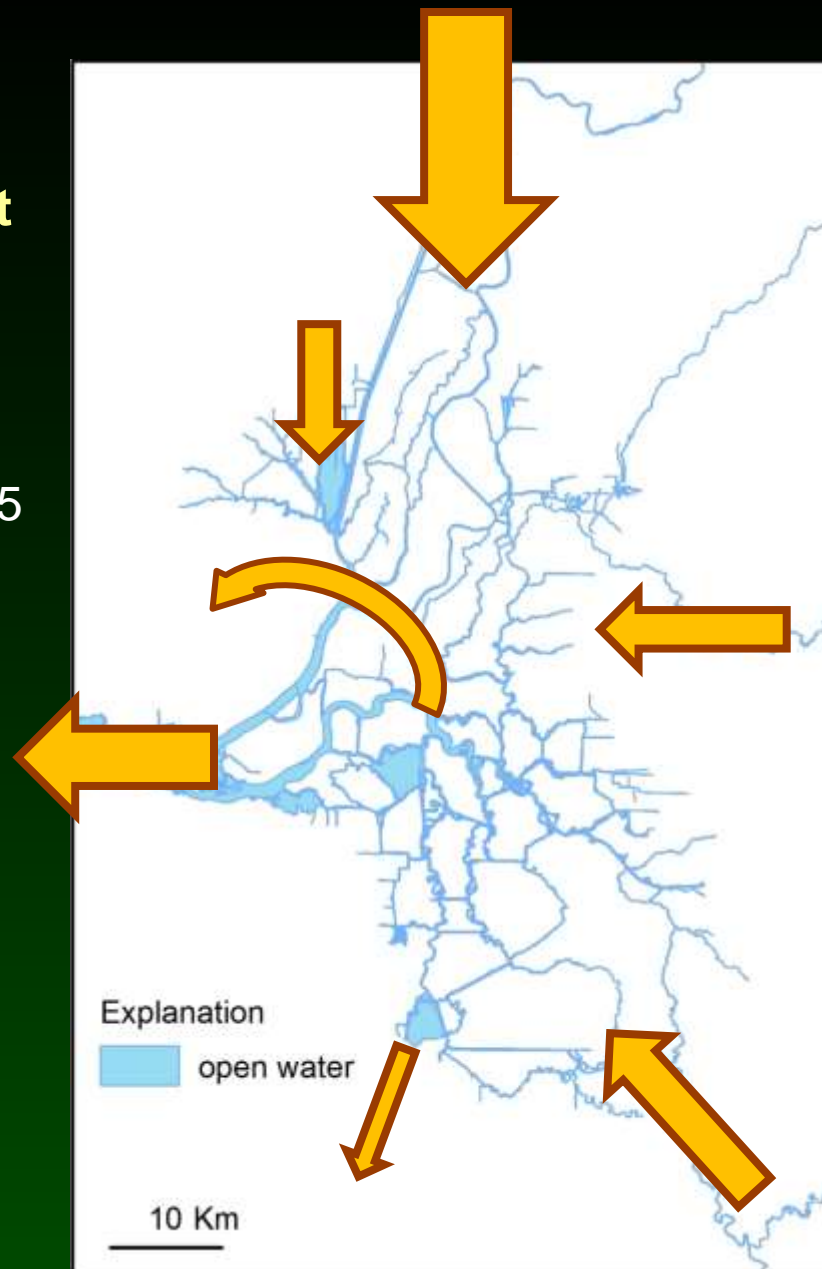
- USGS streamgages
- Wright and Schoellhamer 2005
- McKee et al 2013

Bedload estimates:

- Van Rijn 1984 method

Dredged material

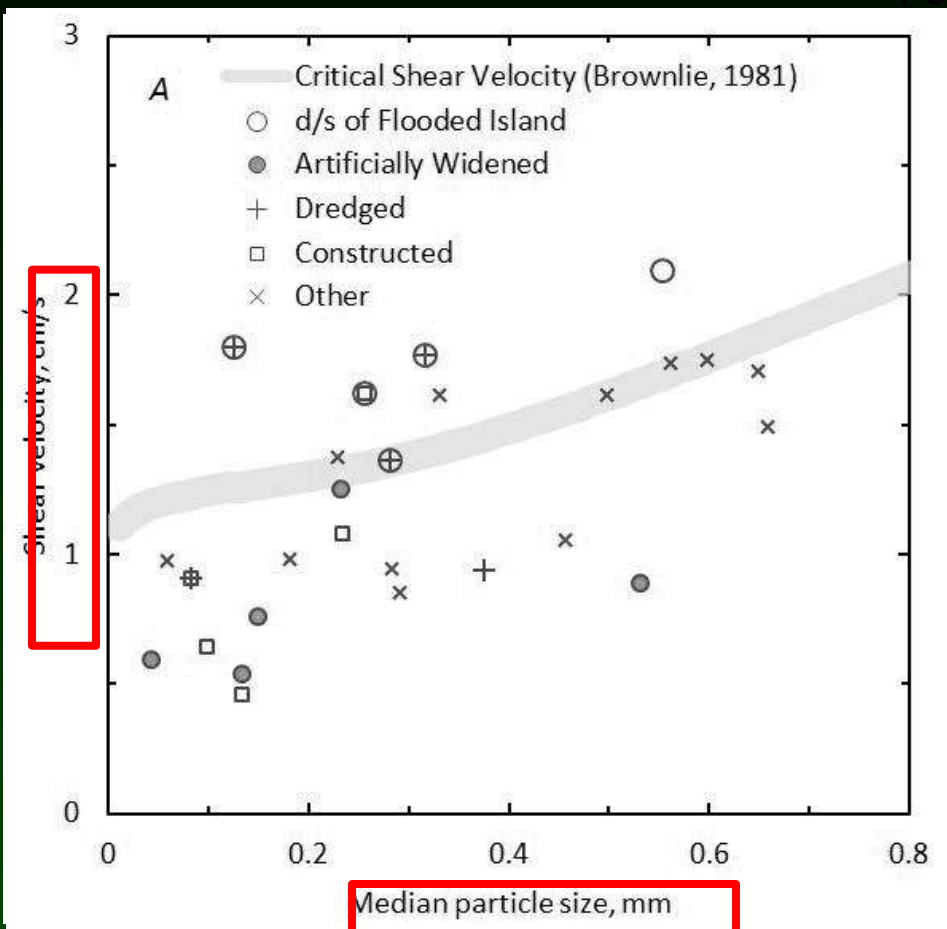
- USACE records



Results

Shear velocity vs critical shear velocity

Pearson's $r = 0.77$



↕ Erosional or transport reaches

← Critical shear velocity

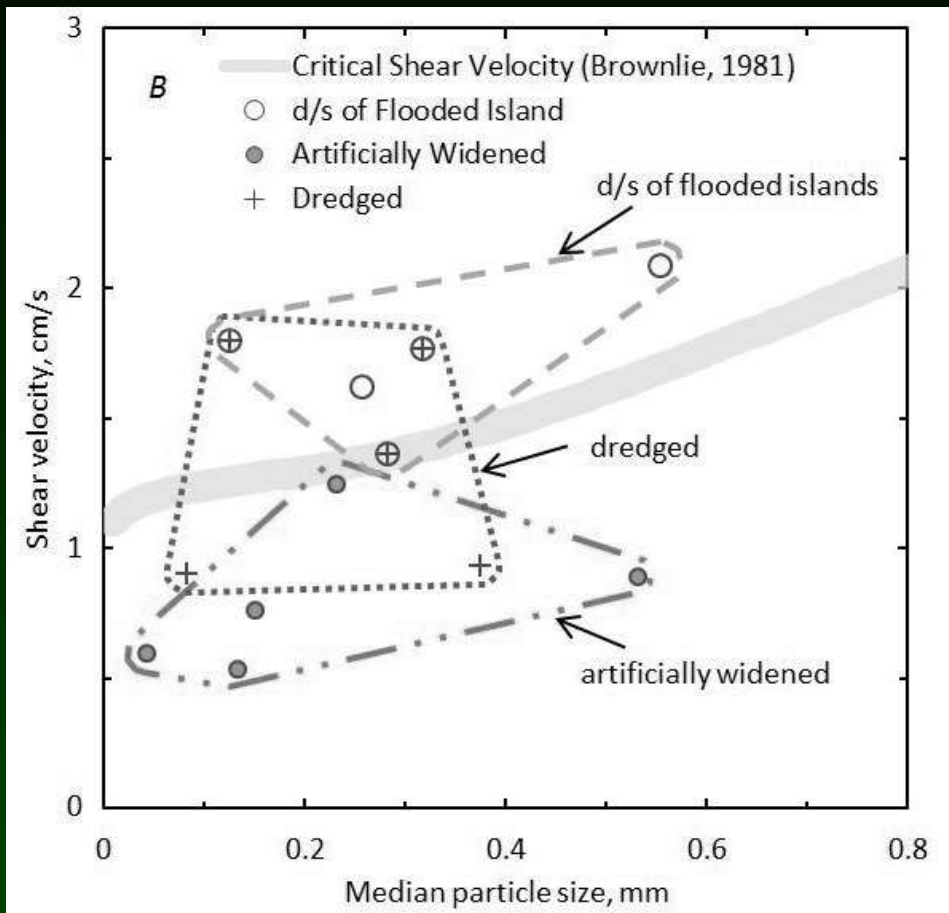
↕ Depositional

Sites were categorized based on characteristics (e.g. dredged, downstream of flooded island, etc.)

Some sites don't fit in any of these categories

Results

Shear velocity vs critical shear velocity



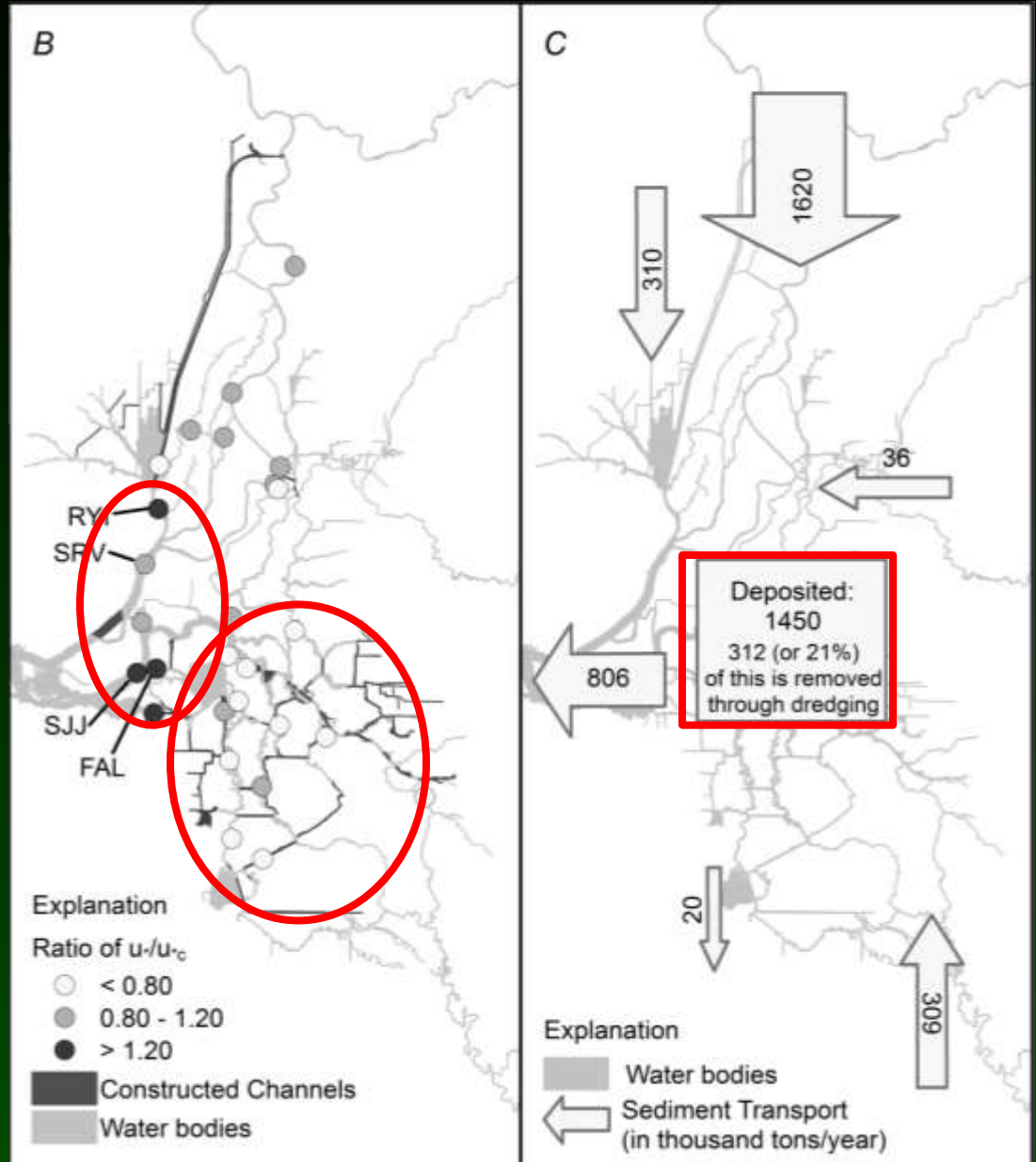
- Channels were widened during marsh reclamation (~late 1800s)
- Frank's Tract flooded in 1938

Generally, channels have not returned to an equilibrium state:

- Channels can not laterally adjust through erosion due to bank reinforcement
- Sediment supply is not sufficient for any significant accretion

Results

- Channels with highest shear velocity are all downstream of flooded islands
- Channels with lowest shear velocity are generally all artificially widened/deepened channels or are constructed channels
- On average, approximately 2/3rd of sediment (1997-2010) was deposited in the Delta
- Of the sediment deposited, about 20% was removed through dredging



Conclusions

- **Flooded islands increase the shear velocity of channels downstream**
 - May affect fish migration
 - Increased sediment transport and coarsened bed – possible impacts to food webs and aquatic wildlife
 - Additional future island flooding is possible (*e.g. Mount and Twiss, 2005*)
- **Deepened and widened channels decrease channel velocity**
 - Creates depositional environment
 - Prevents sediment from transporting downstream or to restoration areas
 - May increase vulnerability of channels to invasion by exotic weeds



Conclusions

- **1,450 tons/yr of sediment is deposited in the Delta**
 - Delta is a depositional environment, but today there may be too little sediment available for restoration or keep up with sea level rise
- **Approximately 20% of deposited sediment is removed through dredging**
 - Deep-water channels account for only 7% of the Delta by area, therefore a disproportionate amount of the deposition occurs in these areas



Questions?

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