Salt wedge controlled sediment dynamics of the Brazos River, TX: Storage in the lower river, transport to the shelf

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ABSTRACT: The purpose of this study is to determine the role that salt wedge dynamics plays in controlling both short-term storage of sediment in a lower river mouth during low flow conditions and in the deposition of sediment on the shelf during higher flow conditions for a wide, low gradient, passive margin shelf. The Brazos River is being used as the natural laboratory to conduct this on-going study. The Brazos River is located along the northwestern Gulf of Mexico, is the 11th longest in the USA, flows primarily along the coastal plain, and empties onto a shelf that is 100-150 km wide and the prodelta has a slope of approximately 0.1o. A series of stations have been established every 0.5 km from the mouth of the river and extending 15 km upstream and also every 0.5 km from the mouth of the river and extending 7 km across the shelf, perpendicular from shore. A time series has been conducted sporadically for each of these stations where profiles of water column salinity, temperature and turbidity for each sampling event. Additionally, surface sediment grab samples and/or 30 cm long gravity cores were collected at each station along with surface and bottom water samples. For select sampling event, ultra high resolution swath bathymetry was also conducted to detect changes in bathymetry, using a Benthos® C3D® bathymetric side scan sonar system. Results to-date reveal that during low flow conditions (~50-150 m3s-1), a well stratified salt wedge extends 1-8 km up river from the river mouth and the suspended sediment is trapped upstream of the salt wedge as ephemeral layers decimeters thick. During a moderate river flow survey of 340 m3s-1 (Oct. 17, 2007), the salt wedge was pushed to the seaward side of the river mouth bar and the suspended sediment was trapped near the seabed, across the mouth bar landward of the salt wedge, with no hypopycnal turbidity plume. During the one high discharge event (2040 m3s-1) sampled (July 12, 2007) 10 days after peak discharge (2190 m3s-1), the shelf waters seaward of the seabed intersection of salt wedge (null point) were well stratified, with a highly turbid fresh water hypopycnal plume and a highly turbid bottom boundary layer both extending ~5 km offshore. Our interpretation of the highly turbid bottom layer is that it was a wave supported boundary layer of recently deposited flood sediments, deposited when the salt wedge was displaced further offshore during peak discharge. Results to-date suggests that the salt wedge provides a highly effective trap of suspended sediment. The initial placement offshore flood deposition of the Brazos River's suspended load is controlled by the offshore displacement of the salt wedge. Future work will focus on quantifying the amount of sediment stored in the lower river between flood events, the amount and initial position of sediment deposited within the river and on the shelf for various flood discharge rates, quantify the partitioning of the hypopycnal plume and near bed and use these observations to reconstruct the history of river discharge events for the existing hydrographic record of the river.

Methodology:
Cruise Dates
- **July 12, 2007 (Offshore)**
- **October 13, 2007 (Offshore/River)**
- **May 28, 2008 (Offshore)**
- **June 16, 2009 (Offshore)**
- **February 17, 2010 (Offshore)**
- **May 17, 2010 (River)**
- **June 28, 2010 (River)**
- **July 4, 2010 (River)**
- **July 17, 2010 (River)**
- **January 10, 2011 (River)**

Data Collection
- **CTD casts 0.5 km frequency for Temperature, Salinity, Optical Backscatter (OBS-suspended sediment)**
- **Surface and bottom water samples**
- **Surface sediment grab samples/ 3 cm diameter ~30 cm length gravity cores**
- **Side scan sonar/bathymetric surveys (Teledyne Benthos® C3D-LPM)**
- **Discharge data from USGS station #08116650 at Rosharon, TX.**

Figure 1: R/V Cavalla during survey (above) Teledyne Benthos® C3D-LPM transducer pod. Brazos River river sampling stations.

Study Area:

Brazos River

- **118,000 square kilometers**
- **39 metric tons per square kilometer sediment yield**
- **11th longest river in the US**
- **Only river on the Texas Coast that drains into the Gulf**

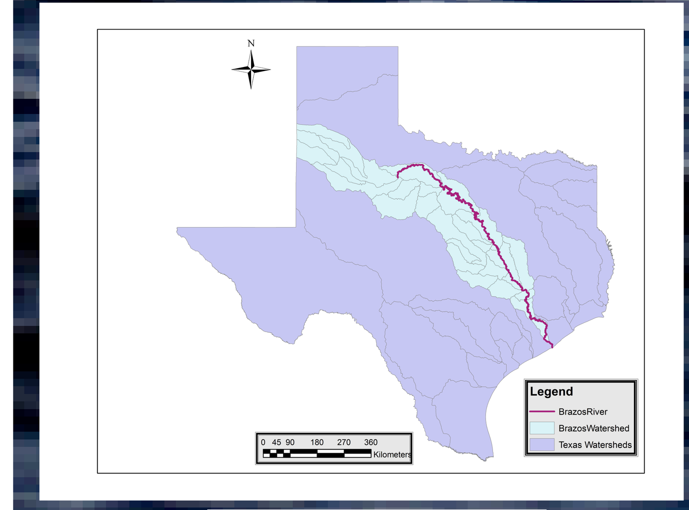

Figure 2: Brazos River watershed.

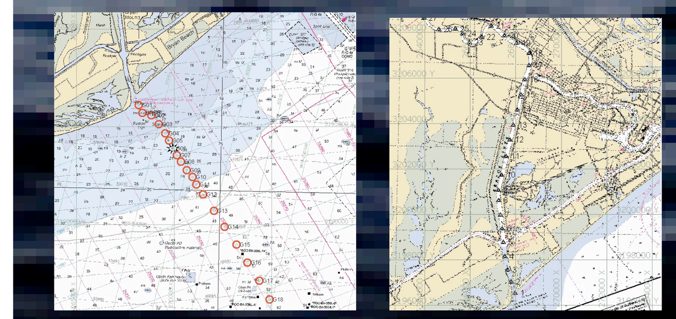

Figure 3: Study area sampling stations, offshore (left) and river (right).

MAJOR FLOOD EVENT

July, 12 2007
Discharge: 1750 m^3/s

Figure 4: Picture of Brazos River flood plume during July 13, 2007 research cruise.

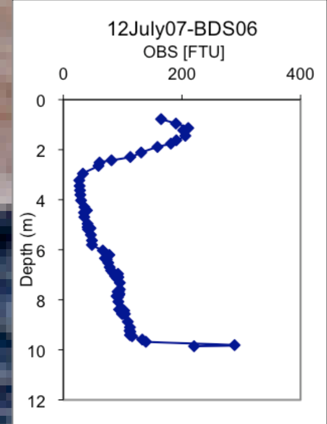

Figure 5: Plot of CTD profile from July 13, 2007 showing OBS from station BRD06. The highly turbid hypopycnal surface plume and bottom boundary layer are evident.

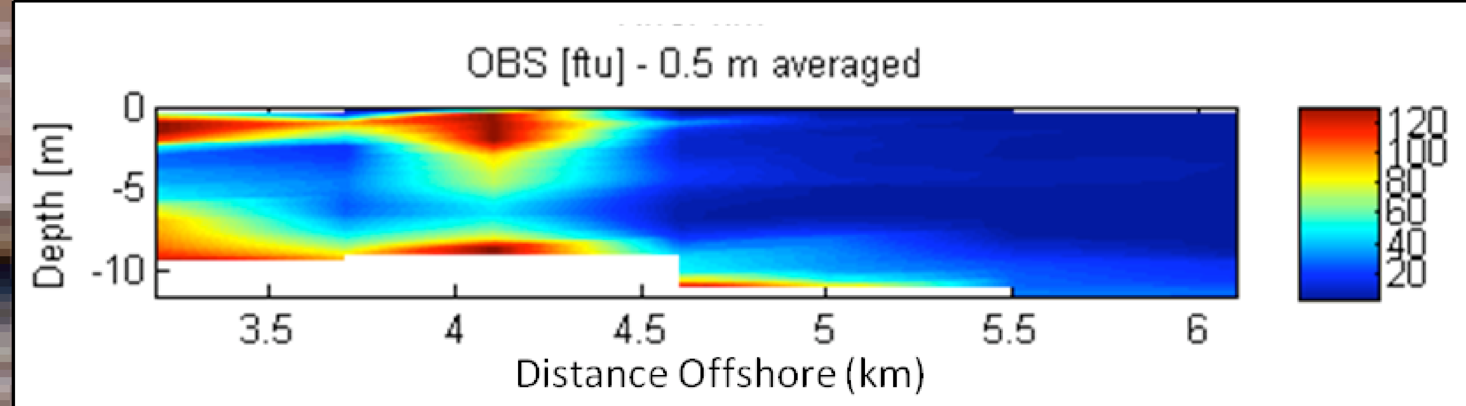

Figure 6: Plot of offshore transect showing OBS with depth from July 13, 2007.

FLOOD WATERS RETREAT

October 13, 2007
Discharge: 260 m^3/s

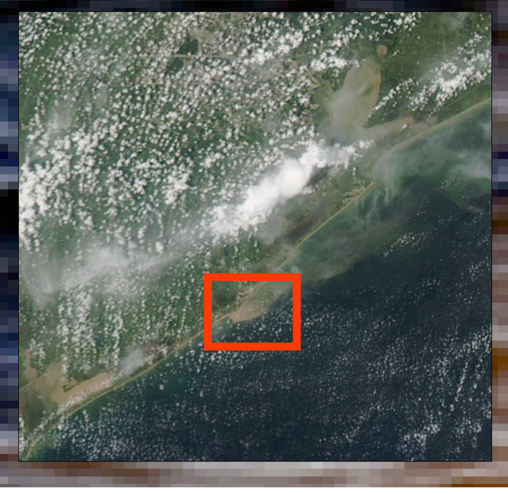

Figure 7: NASA satellite image of Brazos River plume (red box).

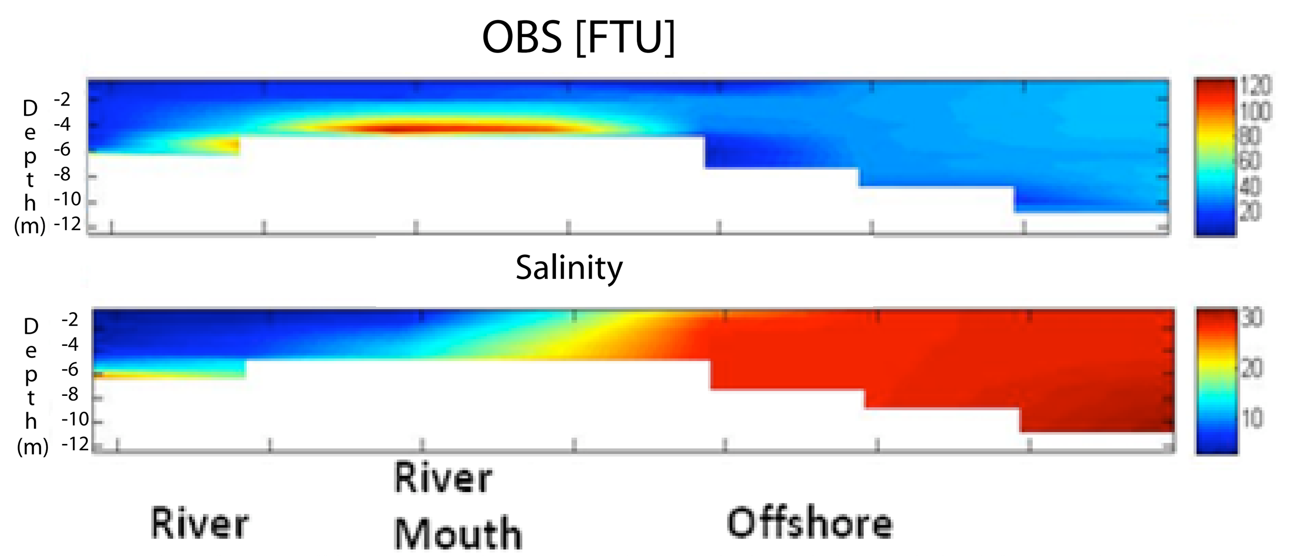

Figure 8: Plots of river to offshore transect showing OBS (above) and salinity (below) with depth from October 13, 2007.

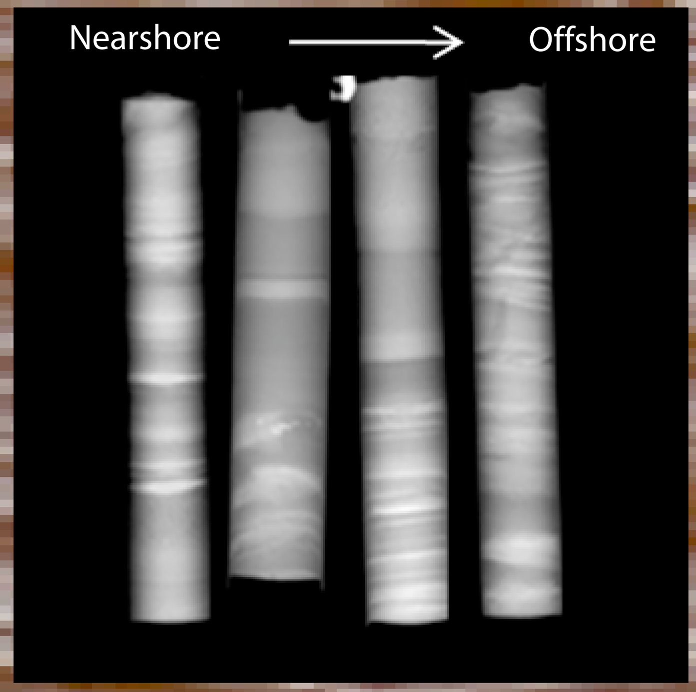

Figure 9: X-radiographs of gravity cores from October 13, 2007 offshore transect. From left to right cores are from station BRD04 (nearshore), BRD06, BRD08, BRD12 (offshore). Evidence of the summer floods is preserved in cores and decreases in thickness toward BRD12.

AVERAGE DISCHARGE

May 17, 2010
Discharge: 220 m^3/s

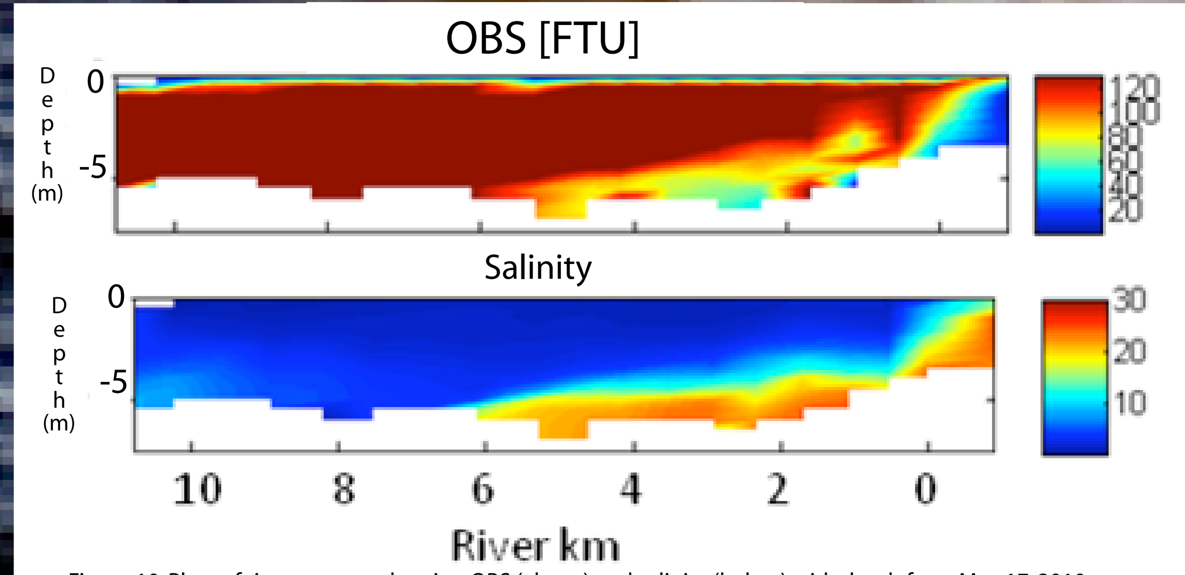

Figure 10: Plots of river transect showing OBS (above) and salinity (below) with depth from May 17, 2010.

HIGH DISCHARGE EVENT

July 4, 2010
Discharge: 690 m^3/s

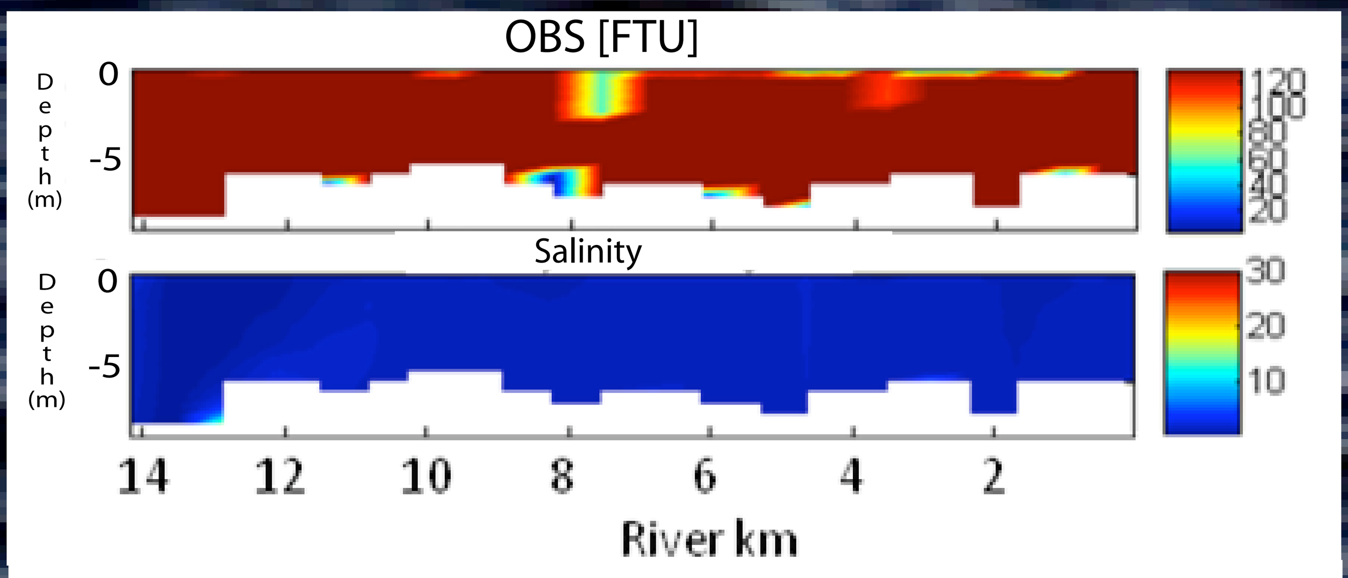

Figure 11: Plots of river transect showing OBS (above) and salinity (below) with depth from July 4, 2010.

Figure 12: Side scan survey mosaic of the Brazos River from June 28, 2010 showing changes in dominant bottom sediment type. Mud area indicates the extent at which the null point migrates as the salt wedge moves with changes in river discharge.

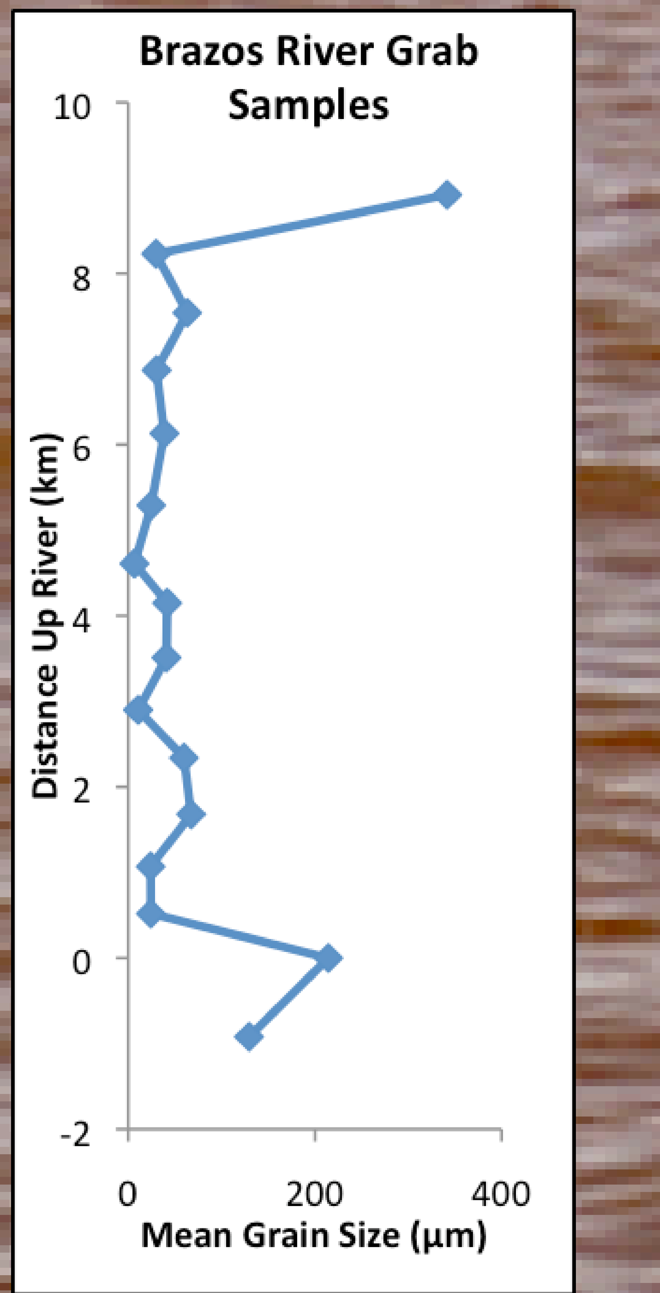

Figure 13: Plot of mean grain size of surface sediment grab samples from the river sampling stations showing distinction between marine sands, mud and riverine sands areas.

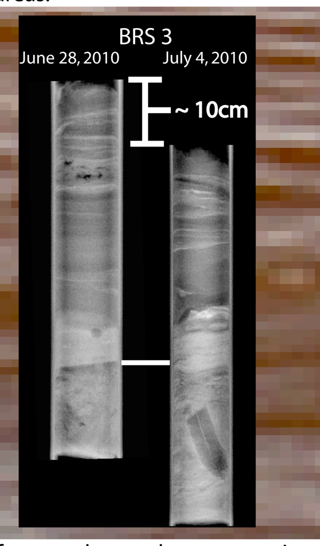

Figure 15: Xradiographs of cores taken at the same station in the lower one week apart showing an aproximate 10 cm erosion following a high discharge event. Core location is shown in Figure12.

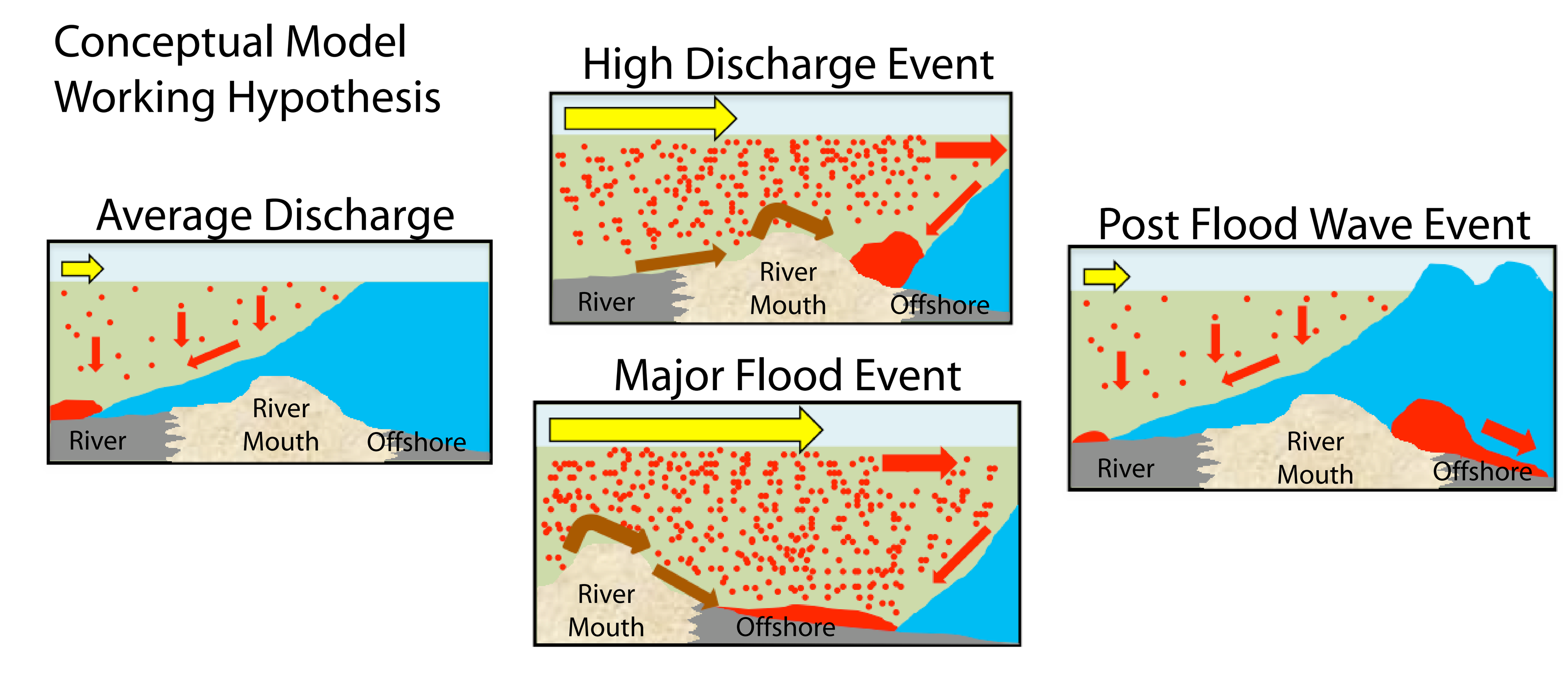

Figure 14: Conceptual model of salt wedge dynamics. Left panel shows average discharge where the salt wedge traps suspended sediment in lower river. Top center panel shows high discharge event (>1 yr frequency) where the salt wedge is displaced offshore of the river mouth and suspended sediment and bedload is transported to the shelf. Bottom center panel shows significant river flood event (3-5 yr frequency) where the salt wedge is displaced furthered offshore and sediment is deposited in a layer across the shelf. Right panel is post high discharge event where the salt wedge migrates back into the river, and wave action transports newly deposited sediment across the shelf.

Preliminary Conclusions:
- Salt wedge provides a highly effective suspended and bedload sediment trap
- Position of the salt wedge controls the foci of initial sediment deposition
- Only high discharge events displaces the salt wedge offshore allowing bedload transport to the shelf

Future Work:
- Understanding transport on the delta
- Quantify the amount of sediment stored in the lower river between events
- Quantify salt wedge position for varying discharge rates
- Reconstruct historical river discharge events