Screening Simulations for Sediment Diversions: AdH/SEDLIB

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Chronic Stresses on Coastal Wetlands in Louisiana

Although there are multiple causes of land loss in the Mississippi Delta, several of the most significant are also the least likely to change in the future

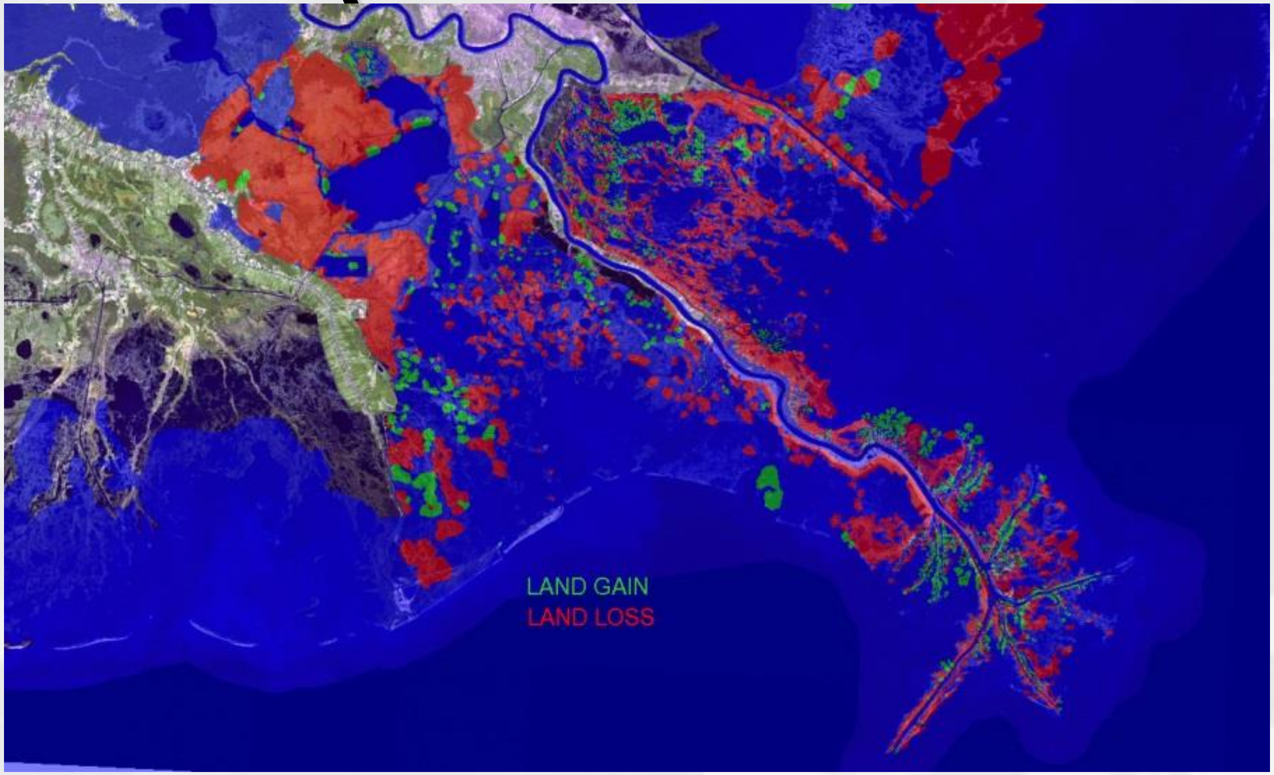
- The dramatic reduction in fine sediment (mud) transported by the river to the delta (e.g., Tweel and Turner, 2012)
- The 1.25 M cfs statutory limit on water discharge passing new Orleans, which limits the stream power available to deliver sand to the wetlands (most of the sand settles in the riverbed)
- Very high rates of subsidence (~5-25 mm /yr) provide a continuous stress on the existing wetlands

Chronic Stresses on Coastal Wetlands in Louisiana

As a result, it is very likely that significant land loss will persist in Coastal Louisiana, irrespective of other factors.

Therefore, the Diversions discussed here, along with other restoration efforts, are intended to mitigate, not reverse, coastal land loss. The degree to which they succeed, and some other impacts, are discussed here.

Modeled Land Loss in 2070 (without Diversions)

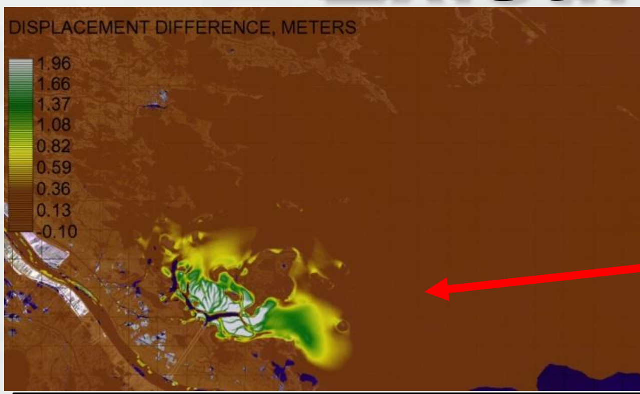


This land loss is primarily a consequence of

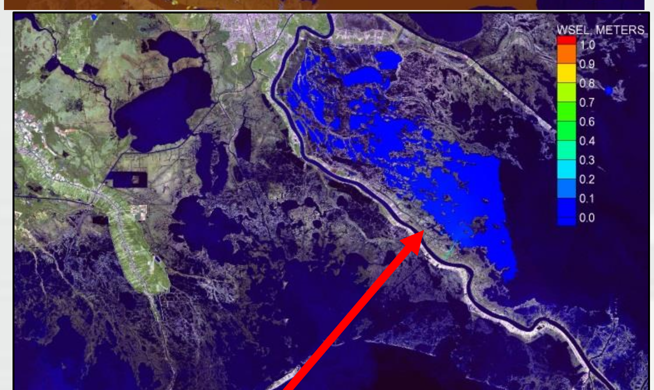
- the inability of the organic production of the existing marshes to keep pace with the stress of relative sea level rise
- the ongoing contraction of the Birdsfoot Delta due to a lack of sufficient sediment and water to sustain the existing marshes.

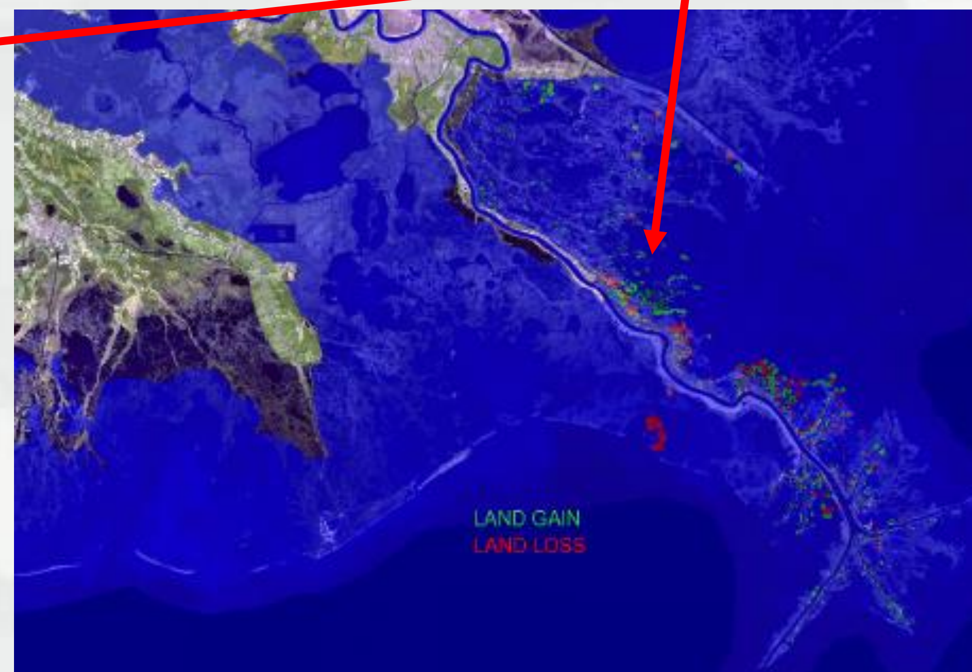
Note: this model simulation assumes that the eustatic sea level rise follows the NRC1 curve (i.e. 0.5 m of ESLR by 2100). Subsidence is spatially varying and is based on a synthesis of observed data (MRHDMS PDT, 2015))

The Lower Breton Diversion: Created Wetlands and Impacts to Existing Wetlands



Minimal land gain, largely because land doesn't emerge until ~25 years after the onset of diversion operations (diversion outfall in 1.5-2 m deep water)



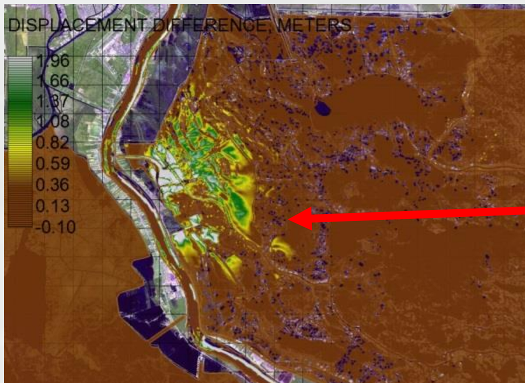


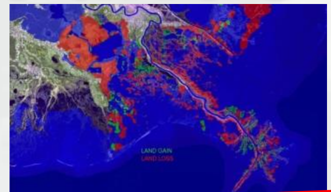
Negligible water surface elevation impact (diversion outfall in 1.5-2 m deep water)

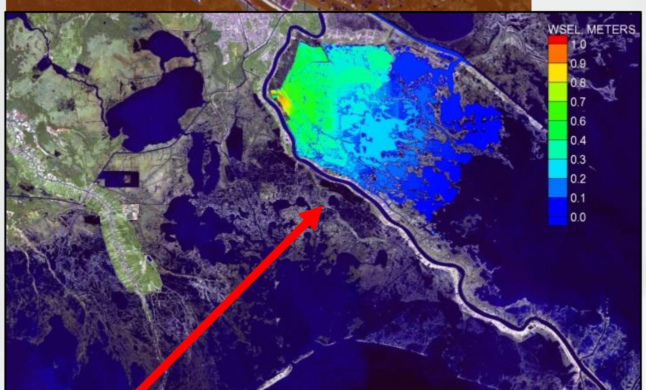
The Mid- Breton Diversion: Created Wetlands and Impacts to Existing Wetlands

Significant land building, but also significant loss of existing marsh due to inundation stress

Also, outfall will likely require some dredging to maintain diversion capacity

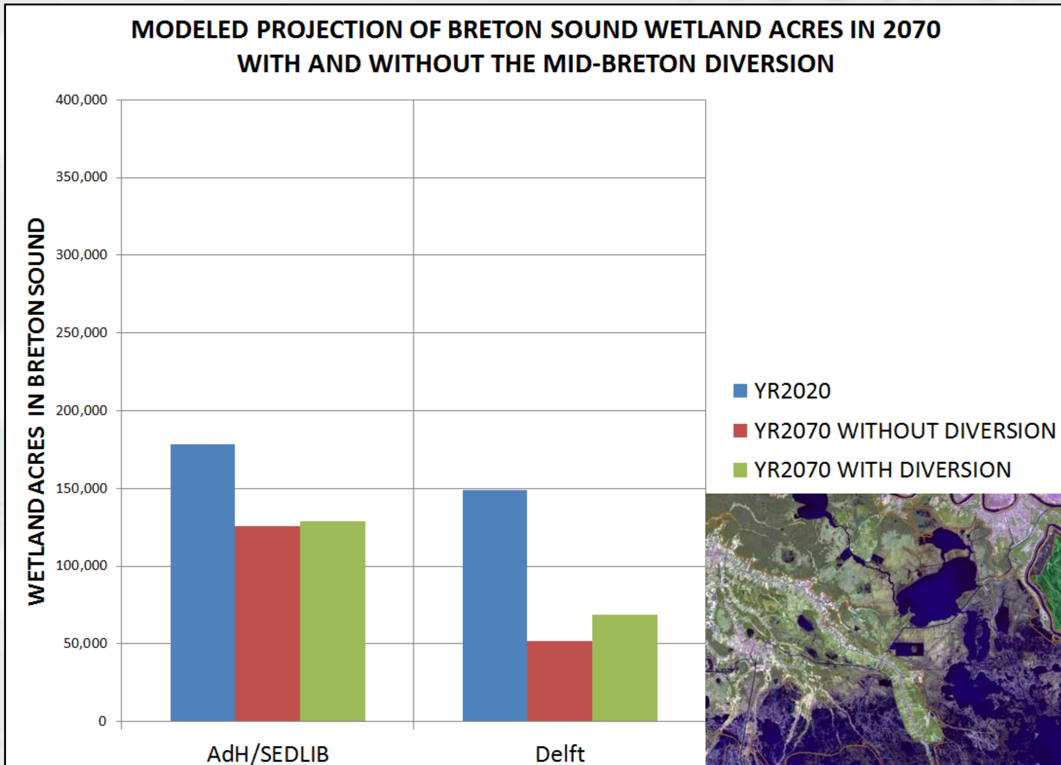






Significant water surface elevation impacts (diversion outfall in ~0.5m deep existing wetland)

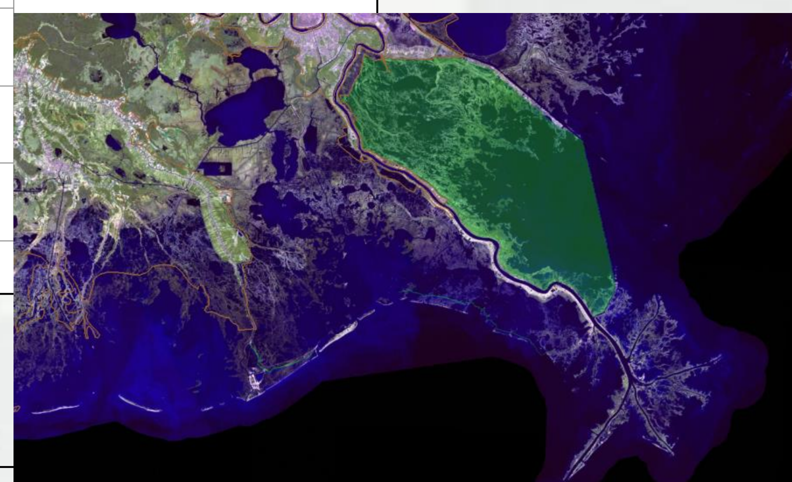
The Mid- Breton Diversion: Comparing AdH/SEDLIB and Delft Results



Both models show significant losses of wetlands with or without the diversion

The Delft simulation shows much greater mitigation of land loss than does the AdH/SEDLIB simulation

This is primarily due to differences in the way wetland vegetation is simulated in the two models.

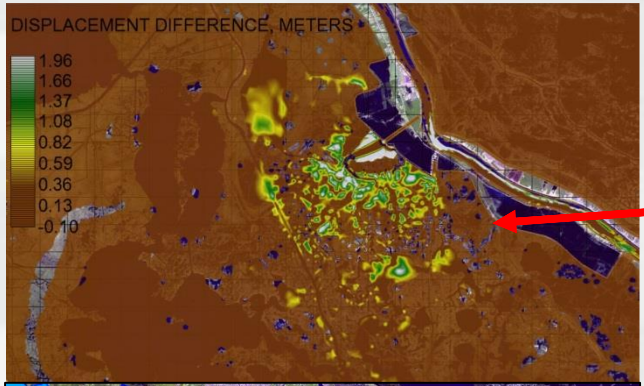


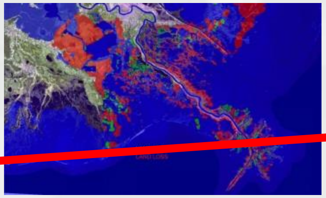
AdH/SEDLIB and Delft Vegetation Models

	AdH/SEDLIB	Delft
Number of plant species modeled	1	Multiple
Transition between species (habitat switching)	No	Yes
Influence of inundation	The growth rate of marsh vegetation is linearly, inversely dependent on the local instantaneous depth (i.e. any increase in depth results in a corresponding decrease in growth rate	For a given species, the growth rate is independent of the local depth, unless a critical submergence is achieved (~0.8 meters for most species)
Influence of salinity/nutrients	No	Yes
Frequency of bed elevation update	10 minutes	10 years

- In Adh/SEDLIB, the growth rate is very sensitive to inundation, and AdH/SEDLIB does not allow more flood tolerant species to replace existing species
- In Delft, the growth rate of a given species is generally insensitive to inundation, and Delft does allow more flood tolerant species to replace existing species
- Hence, it is assumed that these two approaches roughly bracket the range of uncertainty associated with inundation effects on vegetation
- This range of uncertainty can only be narrowed with some clarification and/or consensus building within the wetland research community of scientists.

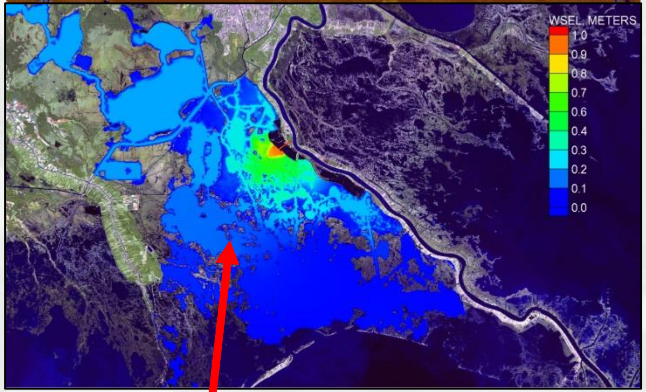
The Mid- Barataria Diversion: Created Wetlands and Impacts to Existing Wetlands

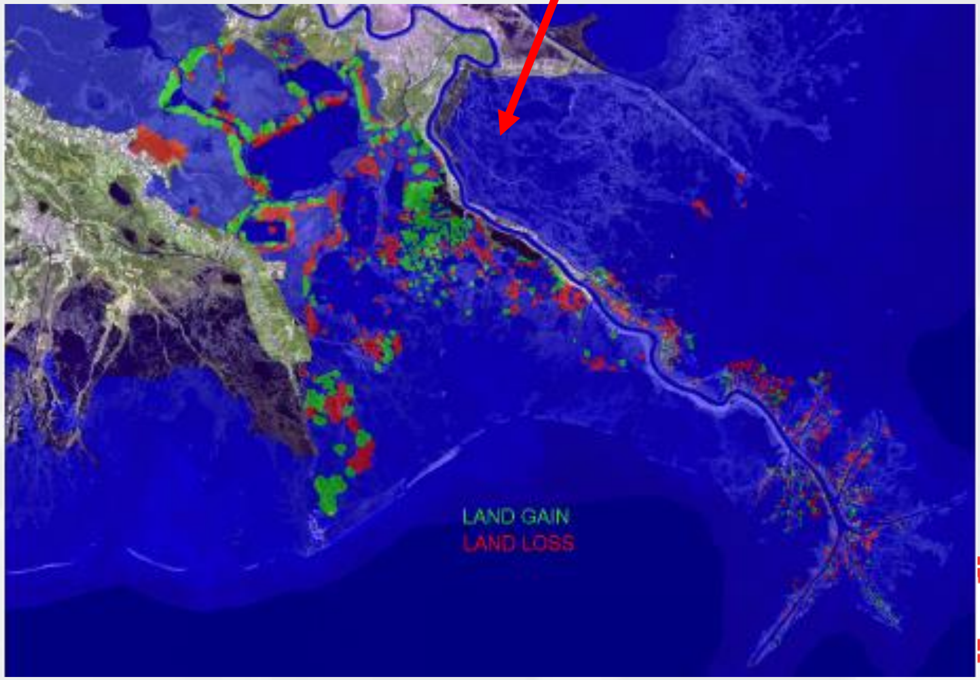




Sediment tends to settle in marshes, but also to flow though existing channels into shallow lakes

Wide ranging inundation impacts on vegetation (both beneficial and detrimental)





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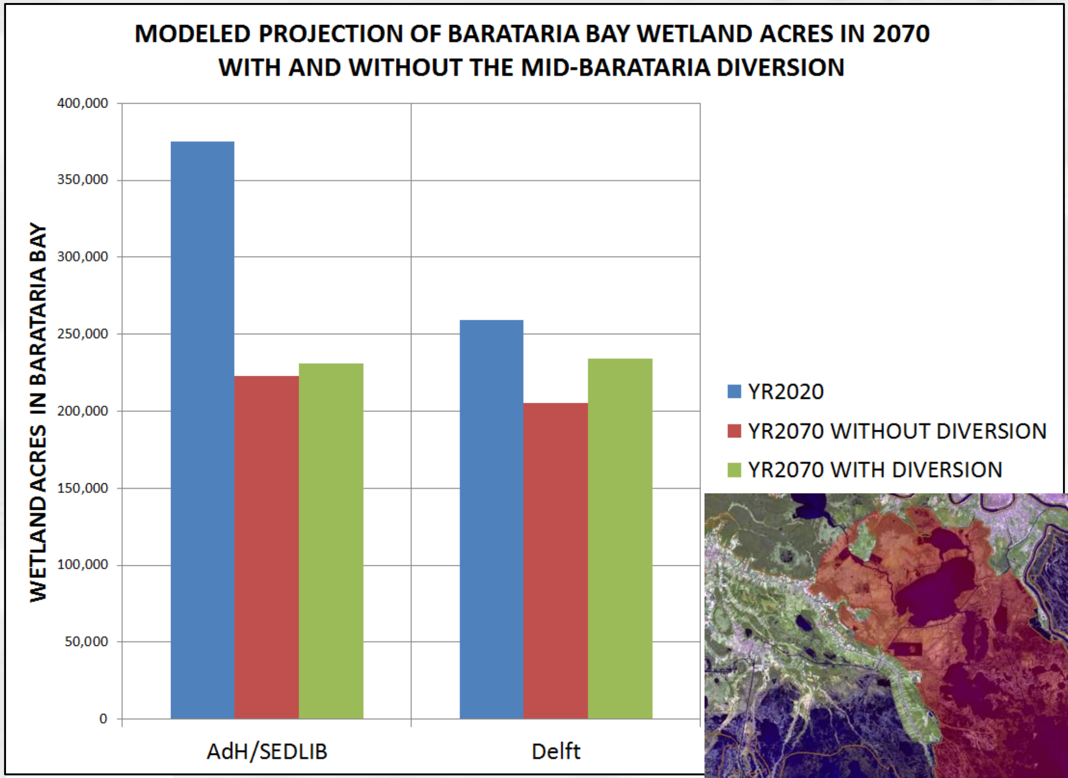
Widespread inundation impacts

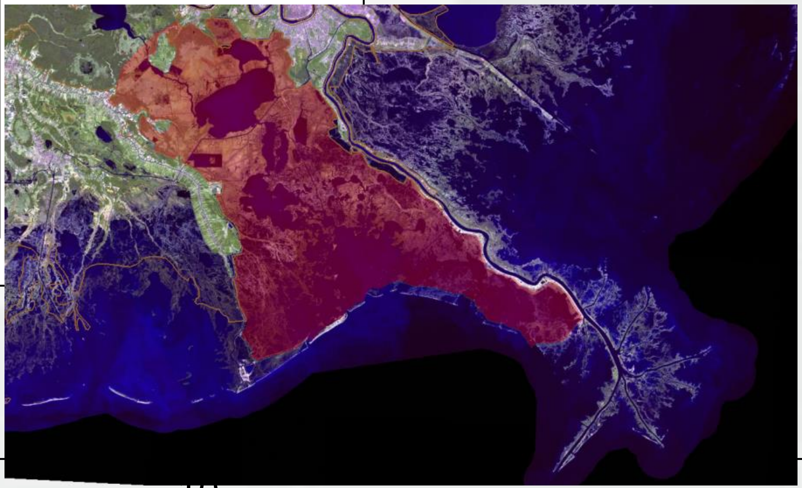
The Mid- Barataria Diversion: Comparing AdH/SEDLIB and Delft Results



Both models show significant losses of wetlands with or without the diversion

The Delft simulation shows much greater mitigation of land loss than does the AdH/SEDLIB simulation

One significant reason for these differences is due to differences in the way wetland vegetation is simulated in the two models.



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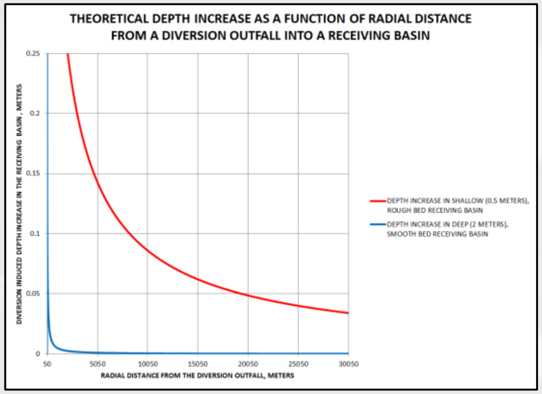
Discussion: Why some Diversions behave differently than Crevasse Splays

Diversions are often characterized as analogs to the naturally occurring land building that arises from the development of crevasse splays

However, depending on how they are designed, diversions may or may not mimic the behavior of crevasse splays

- Crevasse splays typically develop in open water bodies that are relatively deep (~2m) (Wells and Coleman, 1987). Examples of modern diversions that mimic this are Wax Lake and West Bay, and the proposed Lower Breton Diversion
- Hence, diversions designed to empty into shallow, vegetated receiving basins are **not** strictly analogous to crevasse splays. These include the proposed Mid-Breton and Mid-Barataria diversions
- Therefore, we can expect some differences between how these diversions will function and how crevasse splays typically function.



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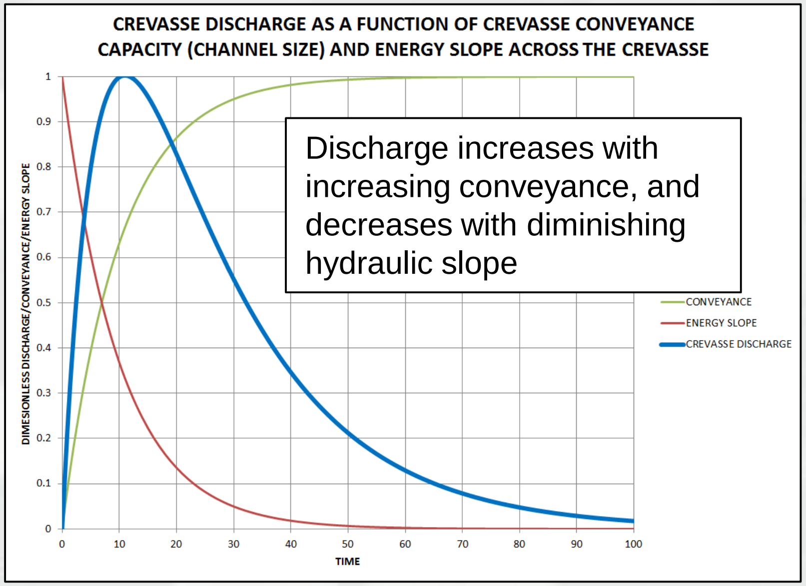
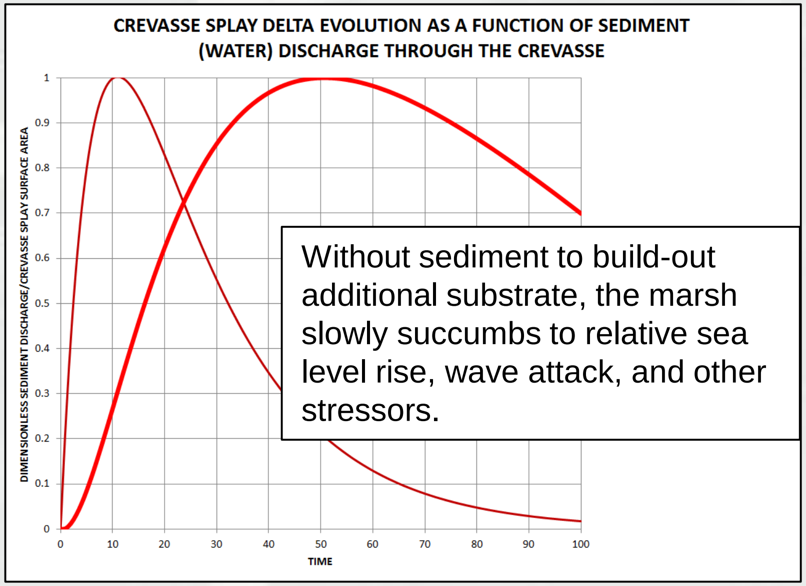
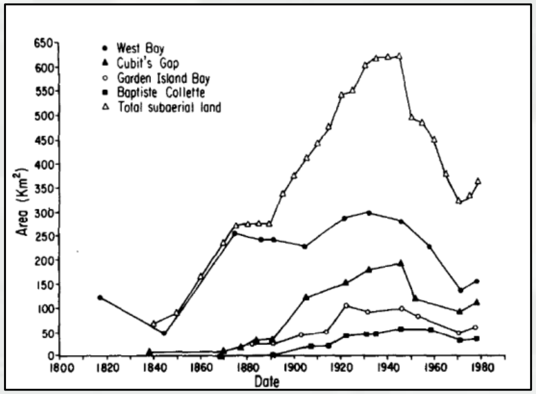
How Energy Principles Influence the Crevasse Splay Delta Life Cycle





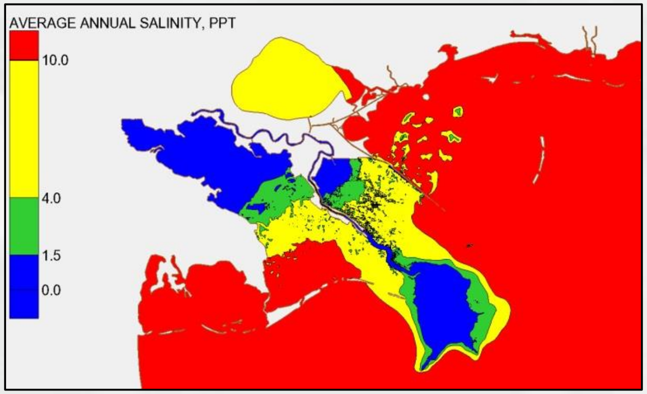


This general process is described by several researchers. A schematic presentation is given in Coleman et. al. (2011). Observations of the life cycles of deltas in the Mississippi River Bird's Foot are given in Wells and Coleman, 1987 (at left)

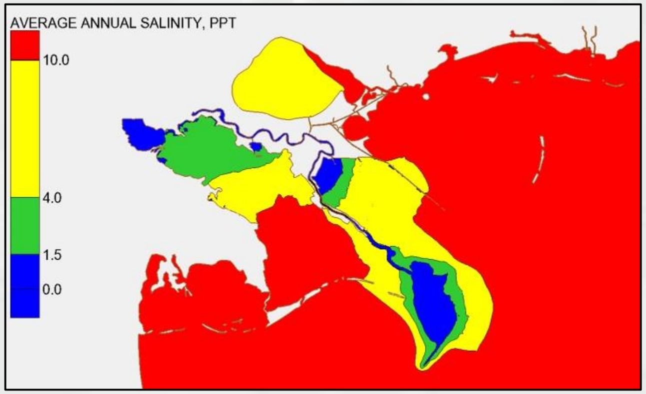
Physics as a constraint on Diversion Operations

- Large Diversions maximize the emergent footprint of the diversion deposit.
  - However, they also increase inundation in the outfall (magnitude and extent).
- Sediment (sand) rich diversions maximize land building potential and minimize potential downstream deposition in the river.
  - However, they also require a (hydraulically) steeper channel to convey the sediment to the receiving basin.
  - Also, the deposited sediment will more rapidly increase the downstream water level (due to backwater effects), eventually resulting in a loss of capacity to divert the design discharge
- Diversions into shallow receiving basins hasten emergence and maximize the emergent footprint.
  - However, shallow basins induce greater inundation (magnitude and extent) for a given design discharge

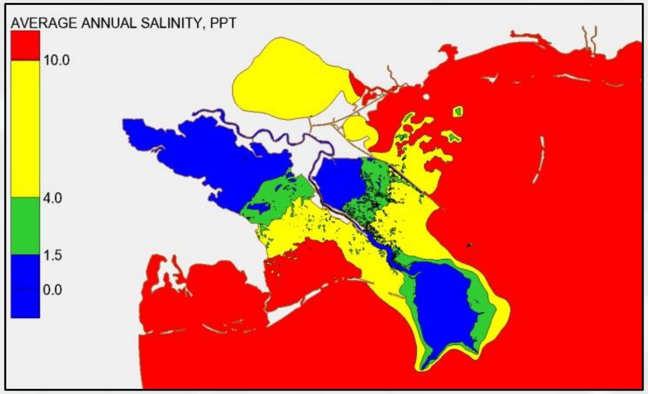
The Mid-Breton Diversion: Salinity Impacts



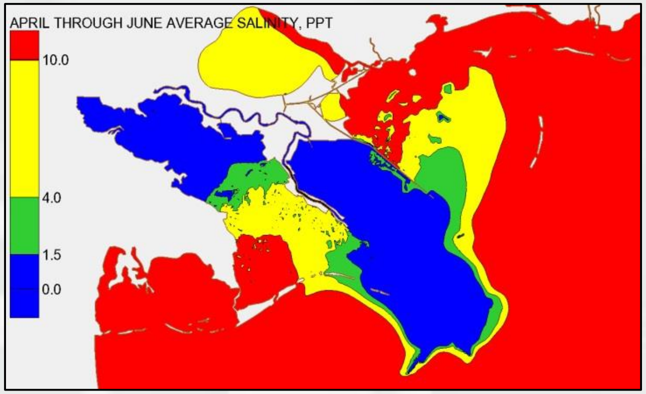
YR2020 ANNUAL AVERAGE WITHOUT DIVERSIONS



YR2070 ANNUAL AVERAGE WITHOUT DIVERSIONS

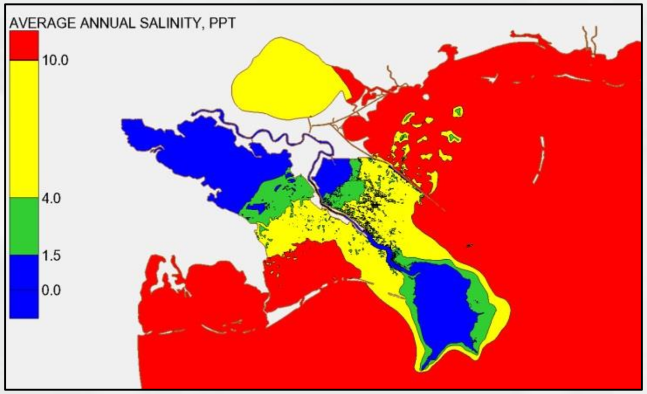


YR2020 ANNUAL AVERAGE
WITH MID-BRETON DIVERSION

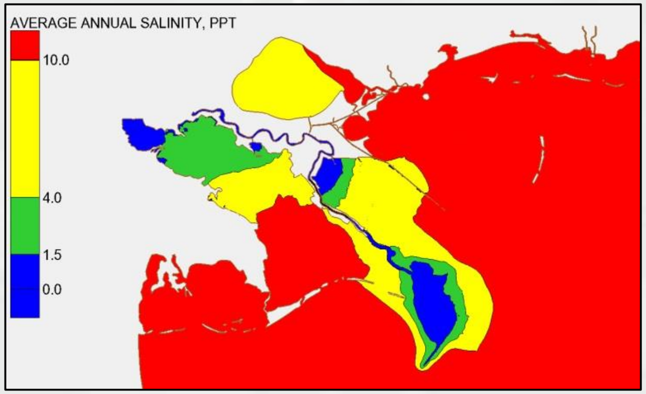


YR2020 APRIL-JUNE AVERAGE
WITH MID-BRETON DIVERSION

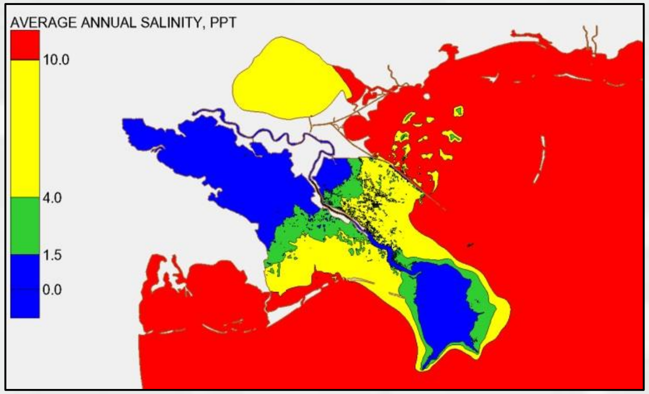
The Mid-Barataria Diversion: Salinity Impacts



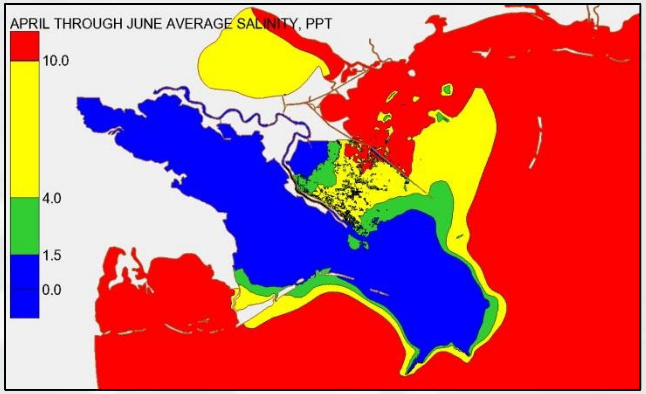
YR2020 ANNUAL AVERAGE WITHOUT DIVERSIONS



YR2070 ANNUAL AVERAGE WITHOUT DIVERSIONS

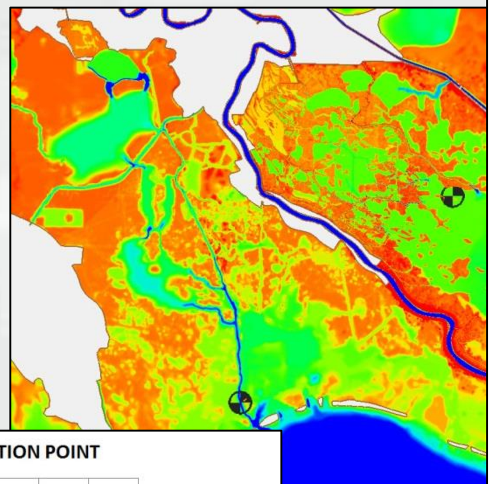


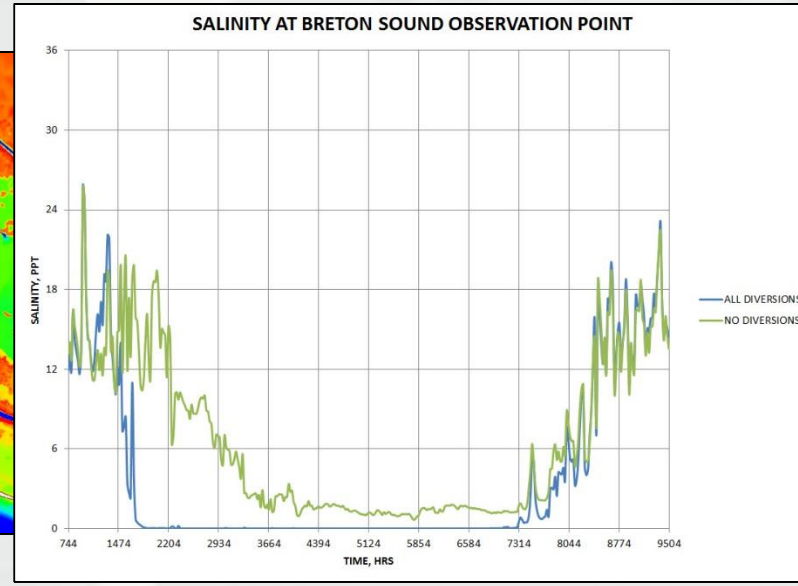
YR2020 ANNUAL AVERAGE
WITH MID-BARATARIA DIVERSION

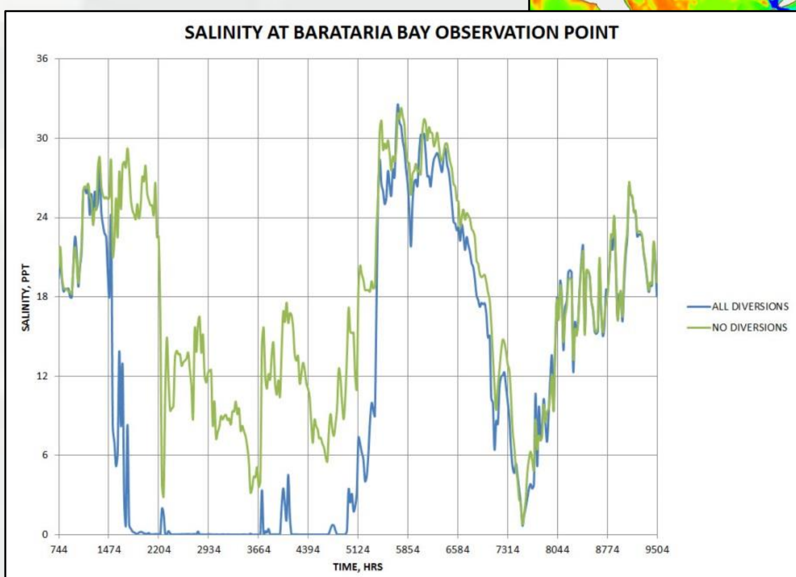


YR2020 APRIL-JUNE AVERAGE
WITH MID-BARATARIA DIVERSION

Time History Salinity Plots at Selected Observation Points







Results indicate that diversions tend to freshen the entire estuary, but when diversion operations cease, the salinity soon recovers to the without diversions conditions.

Summary of Results

- Significant land loss is expected to continue, with or without these diversions.
- The Mid-Breton Diversion builds significant land close to the diversion site. However, inundation effects are widespread, and the impact of this inundation in existing marsh is highly uncertain. Also, it is likely that some dredging of this diversion outfall will be required to maintain capacity.
- The Mid-Barataria Diversion also builds land locally, and also fills existing shallow lakes with sediment. However, inundation effects are widespread, and the impact of this inundation in existing marsh is highly uncertain.
- In order to reduce and eventually quantify the uncertainty in model predictions of land gain and loss, it is necessary to refine the relationship between existing wetlands and inundation This can only be accomplished with some clarification and/or consensus building within the wetland research community of scientists.
- Operation of the diversions tends to freshen the entire basin (Breton or Barataria) while they operate. However, once they cease operations, the salinity tends to recover relatively quickly to without project levels.