Barrier Island morphology trajectories using OCS Sand vs. Nearshore Sand

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Barrier Island morphology trajectories using OCS Sand vs. Nearshore Sand

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THE UNIVERSITY of NEW ORLEANS

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BOEM Bureau of Ocean Energy Management

MISSISSIPPI STATE UNIVERSITY

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Curlew Island 2009 – Chandeleur Island Chain, Louisiana

Outline

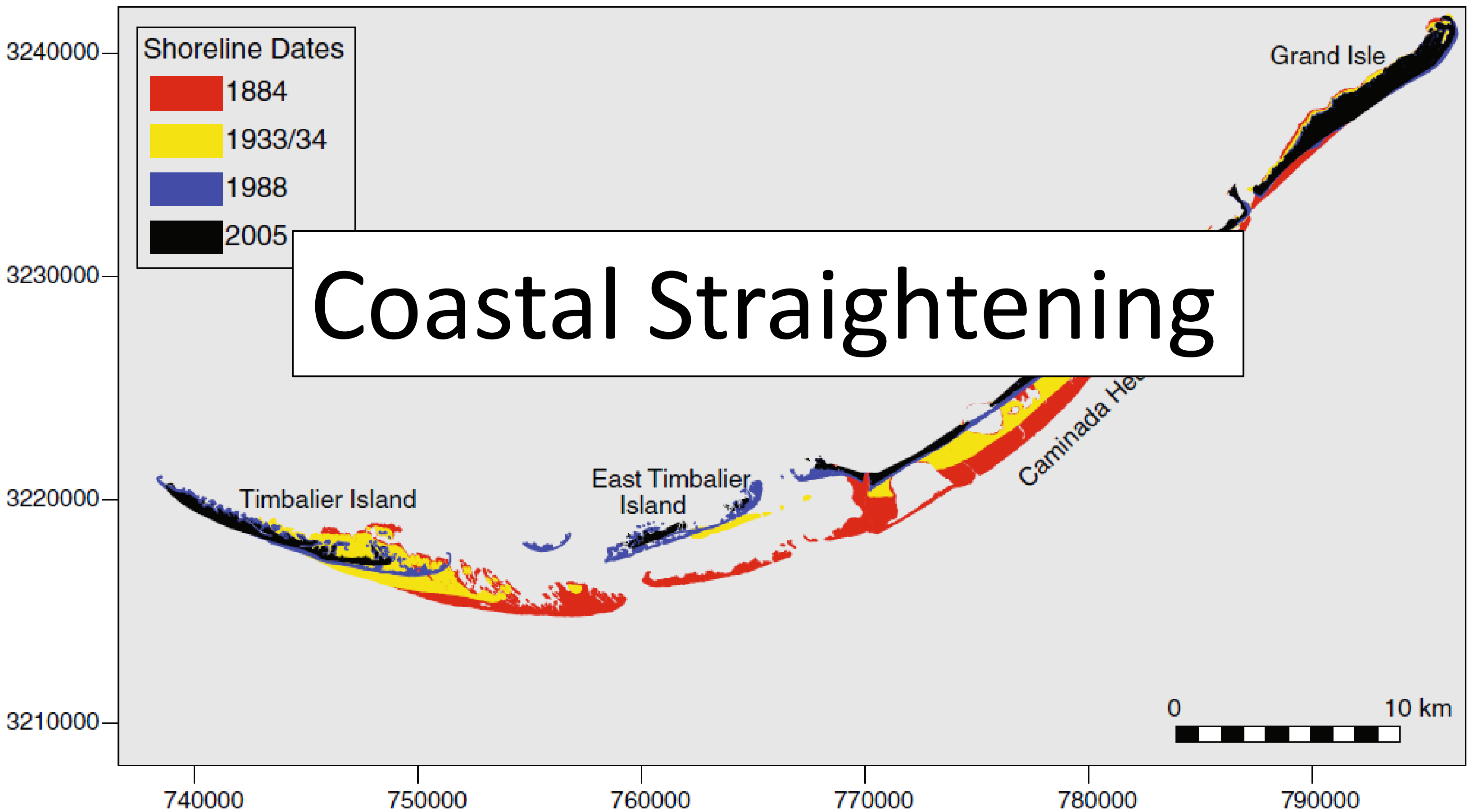
Regional Processes driving Barrier Island morphology change

Evidence of regional change from Louisiana

Problem setup and conceptual framework

Update on ongoing/future numerical experiments

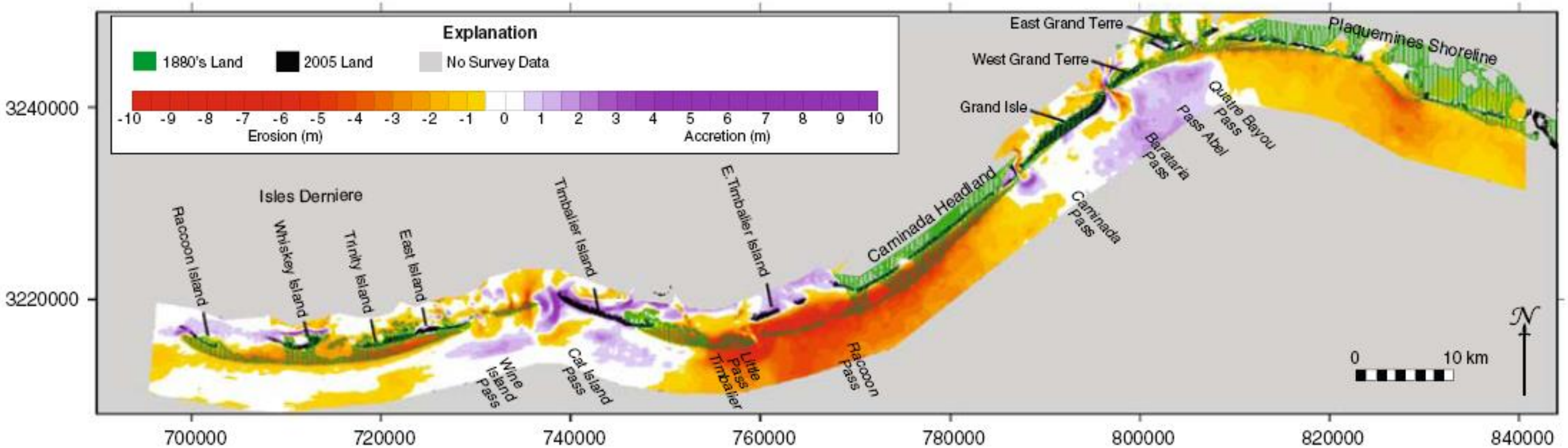
Motivation and relevance



Coastal Straightening

Miner et al. (2009); shorelines from Martinez et al (2009)

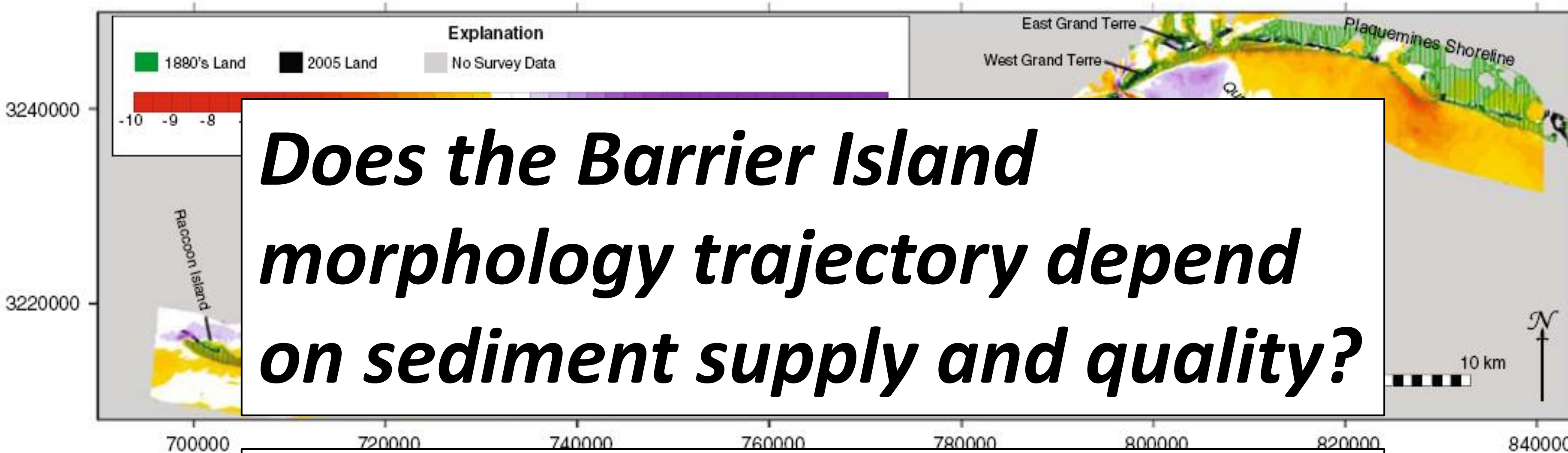
Motivation/questions



From Miner et al., 2009; shorelines from image below from Martinez et al (2009)

- Large-scale coastal degradation (***storms?*** *Sea-level rise? Day-to-day?* ***Paucity of sand?***)
- Coastal straightening, ***widespread barrier transgression***
- How much/what type of sediment is being lost, and what are the governing processes?
- How do we ***define Sediment pathways*** (present and future?)
- Can we ***enhance barrier longevity*** by introducing ***new high quality sediment***? (Is it economically feasible? see next talk)

Motivation/questions



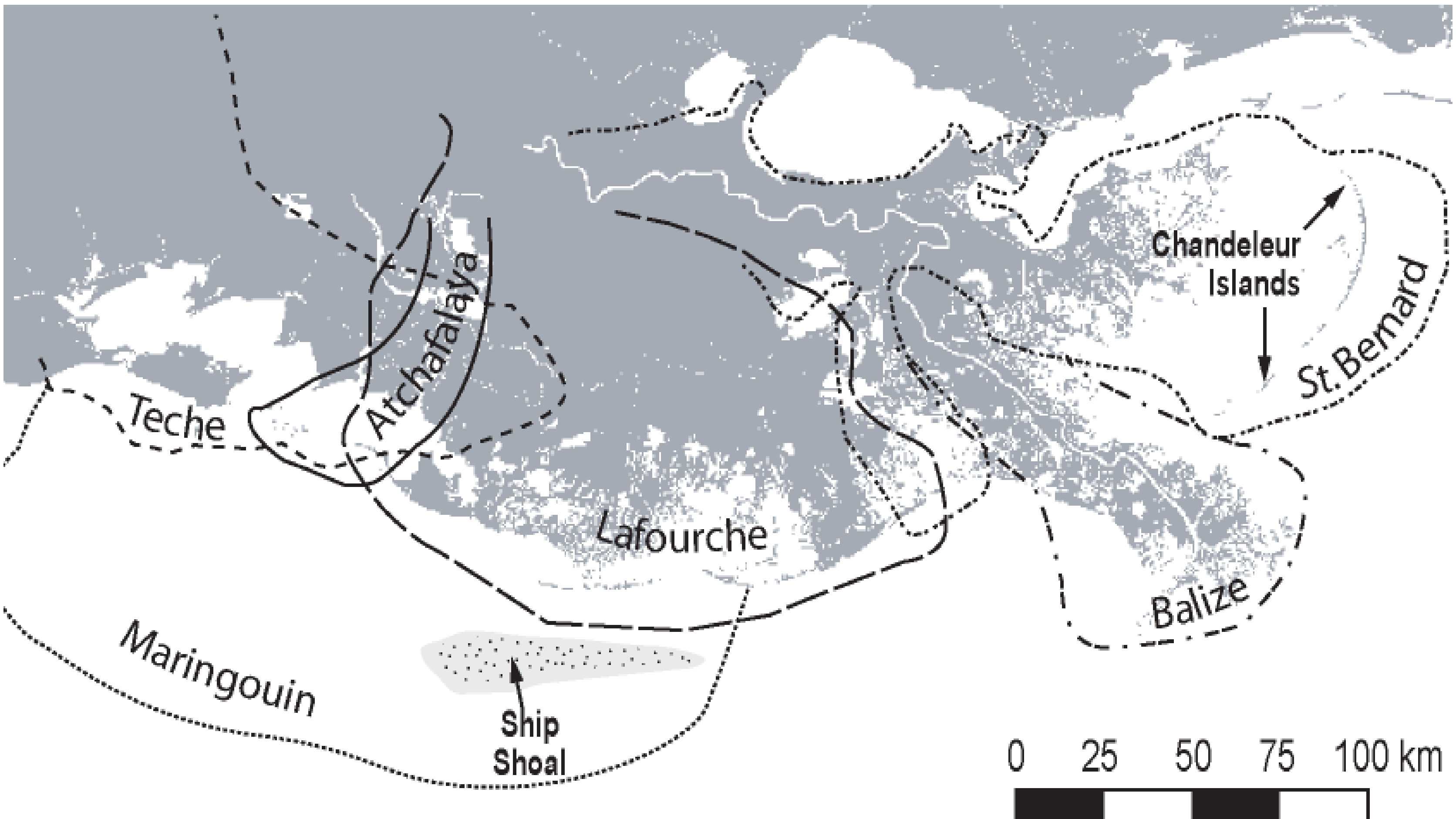
Does the Barrier Island morphology trajectory depend on sediment supply and quality?

ez et al (2009)

To some extend we know the answer, but quantitative data to understand system response and drive economic assessments are still lacking

- Large-sc ... *day?* ***Paucity***
- Coastal
- How mu ... e governi
- How do
- Can we ... ***ity sediment***? (cost implications? See next talk)

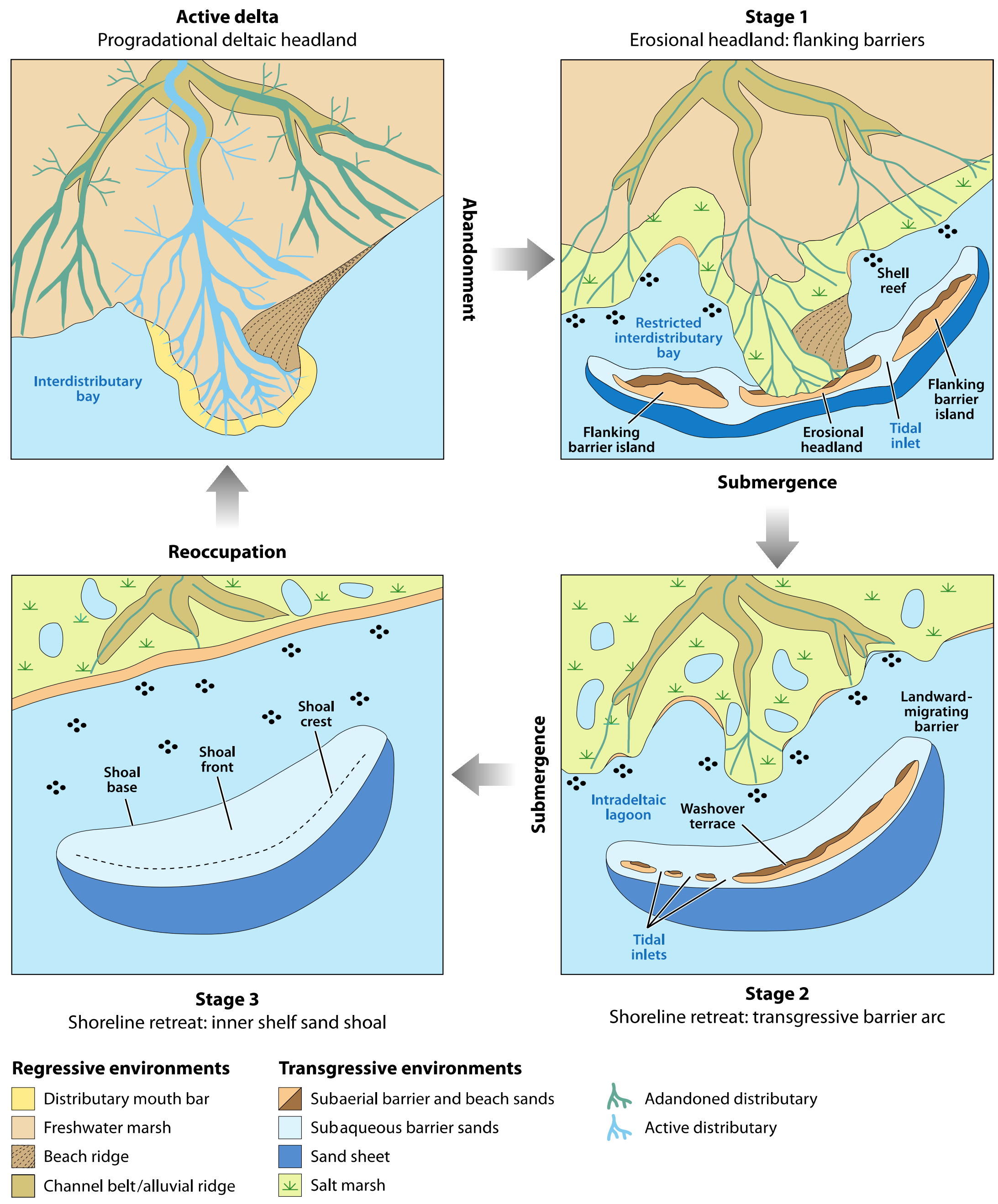
Origin of Deltaic Barriers - Holocene Delta Complexes



Maringouin-Teche (7,500 – 3,800 yrs BP)
St. Bernard (4,000 – 1,800 yrs BP)
Lafourche (2,500 – 400 yrs BP)
Balize (1,000 yrs BP – present)
Atchafalaya (400 yrs BP – present)

Adapted from Fisk (1944), Kolb and van Lopik (1958), Frazier (1967), Penland et al. (1988), Tornqvist et al. (1996), Roberts (1997), and Kulp et al. (2005).

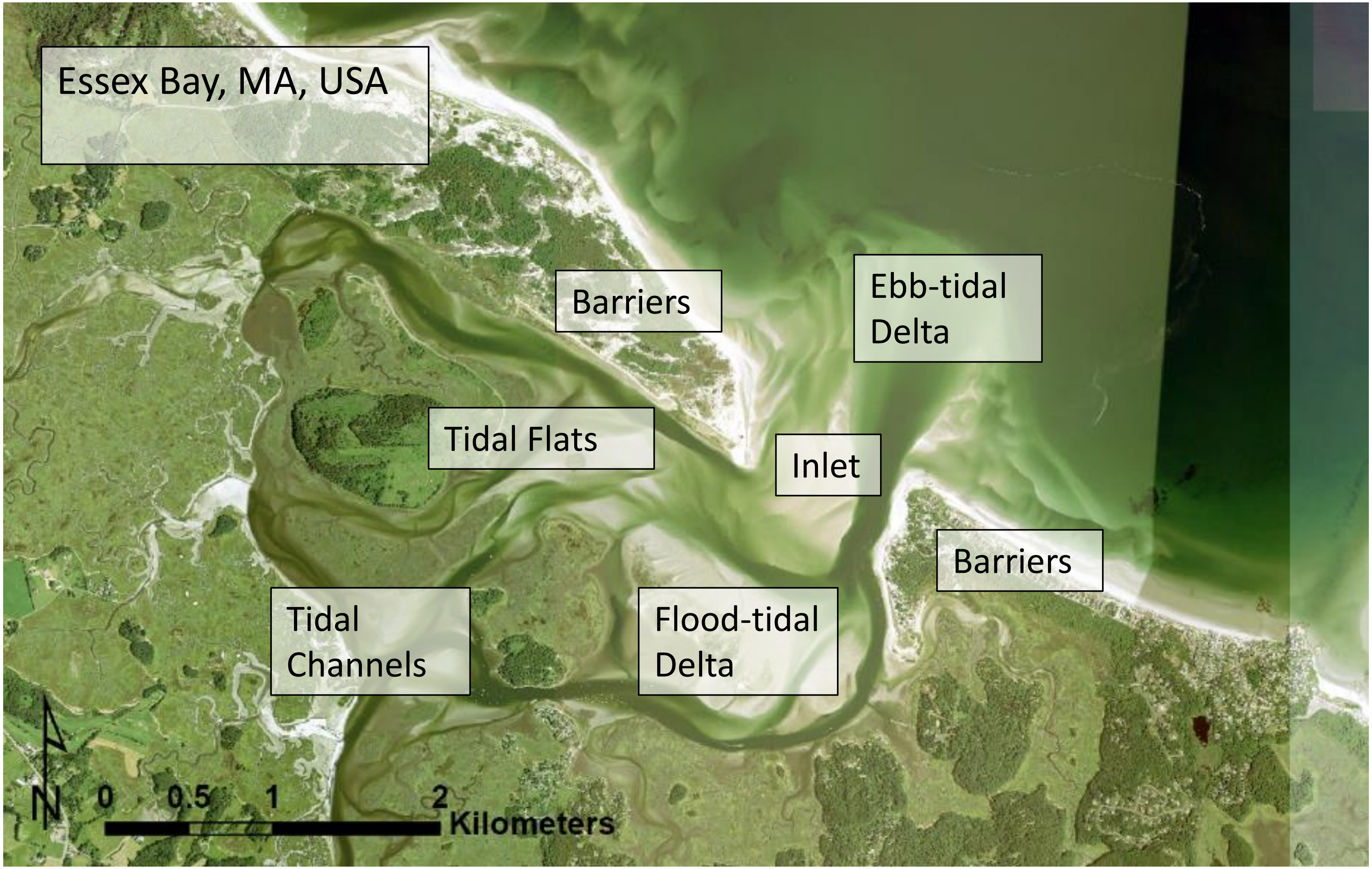
Deltaic headland evolution and the Penland Model



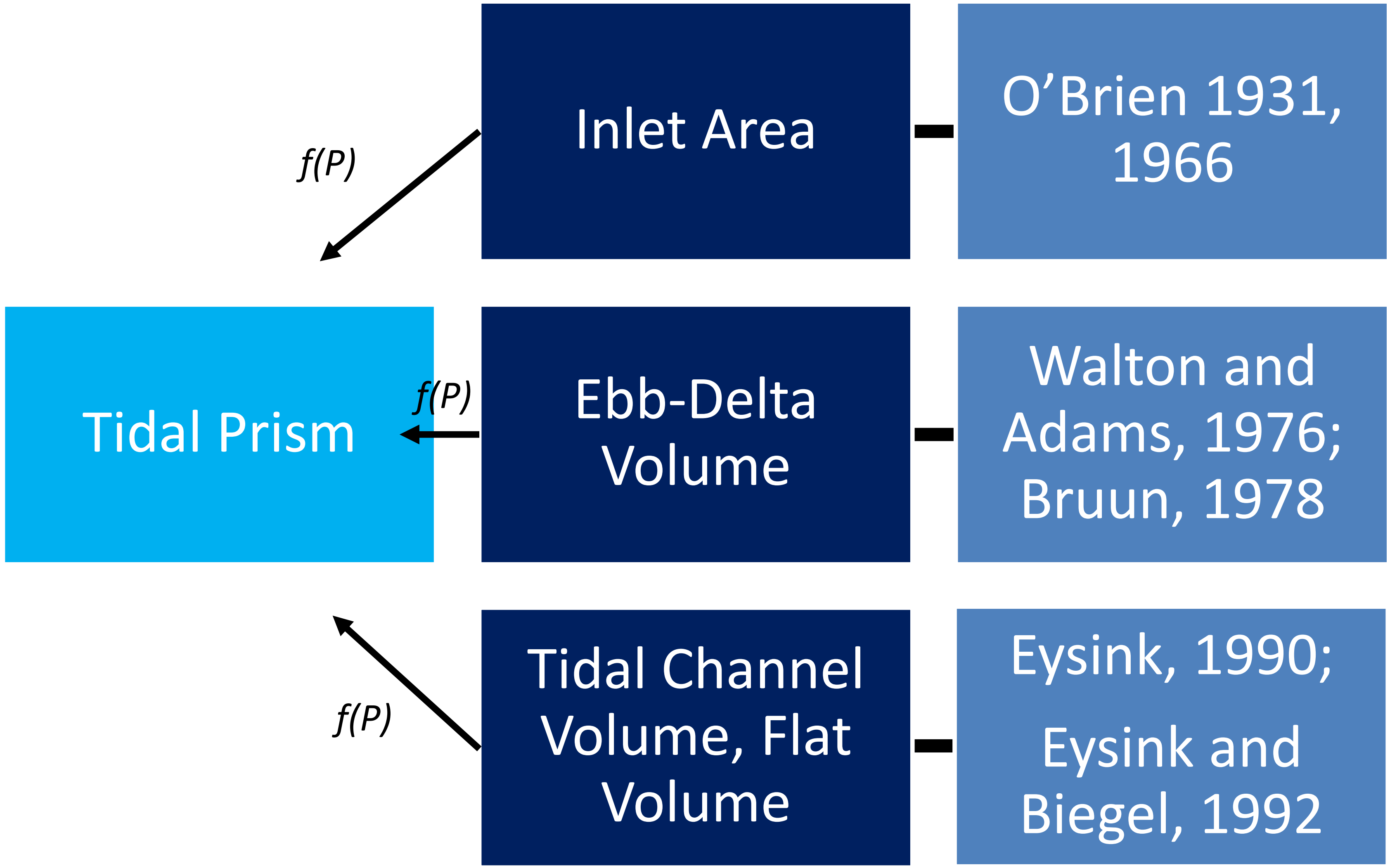
From Blum and Roberts, 2012, modified from Penland et al. (1988)

BARRIER GEOMORPHOLOGY

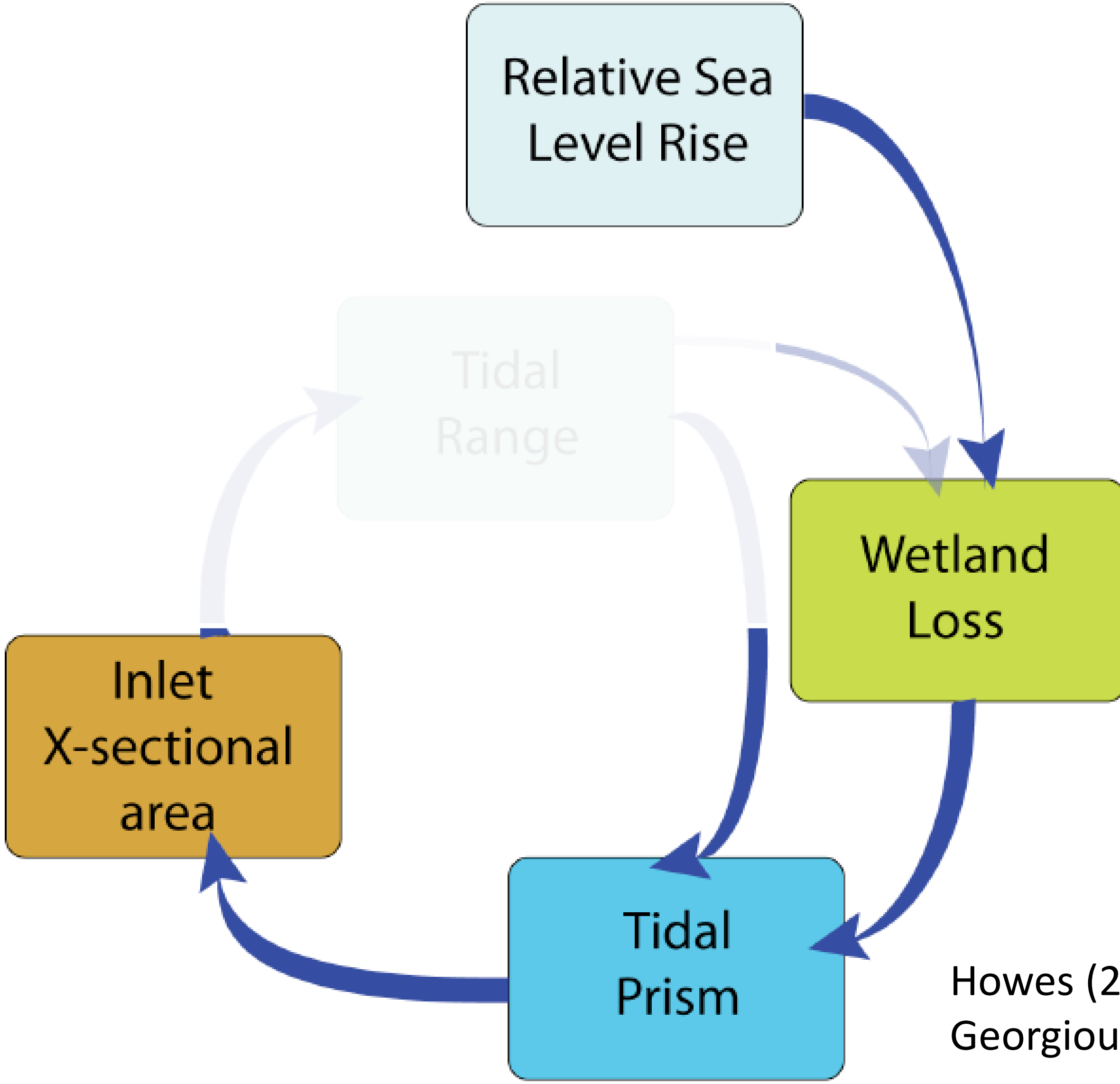
Barrier geomorphology and feedbacks



Geomorphic units and feedbacks



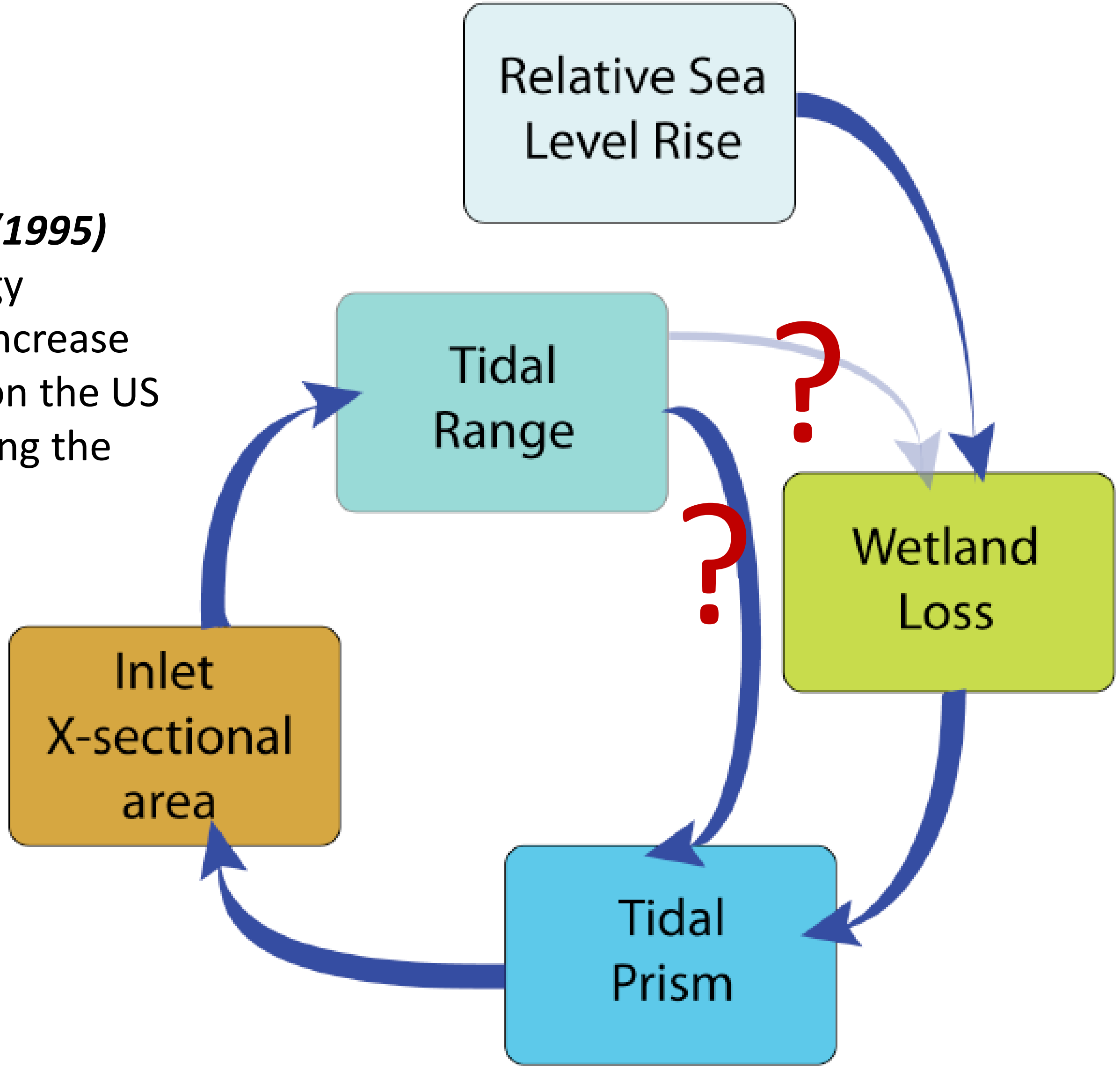
Disclaimer – not an exhaustive list of citations



Howes (2009)
Georgiou et al (2013)

Conceptual model of the processes and feedbacks

Gehrels et al. (1995)
Marine Geology
Documented increase
In tidal range on the US
East coast during the
Holocene



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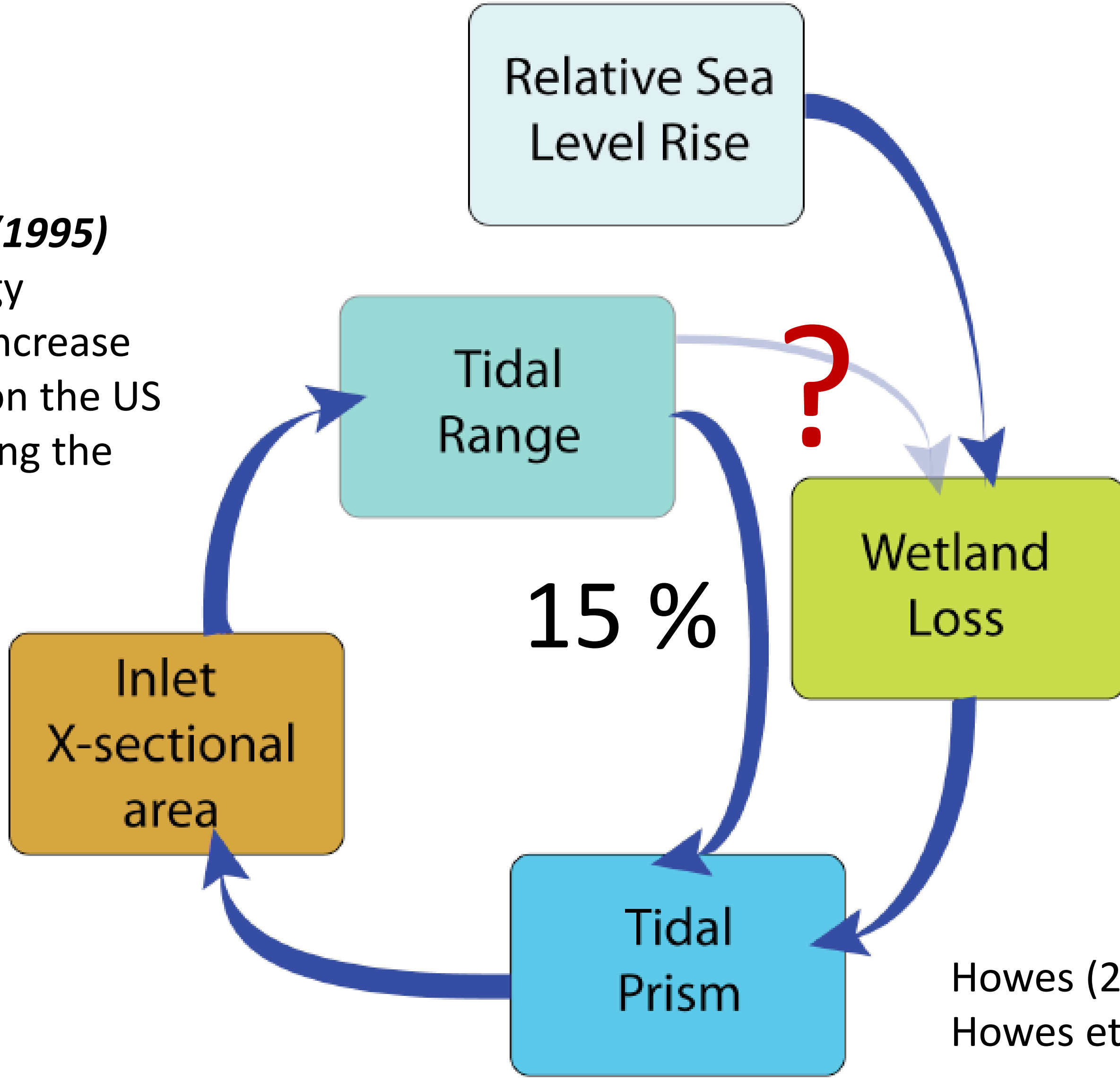
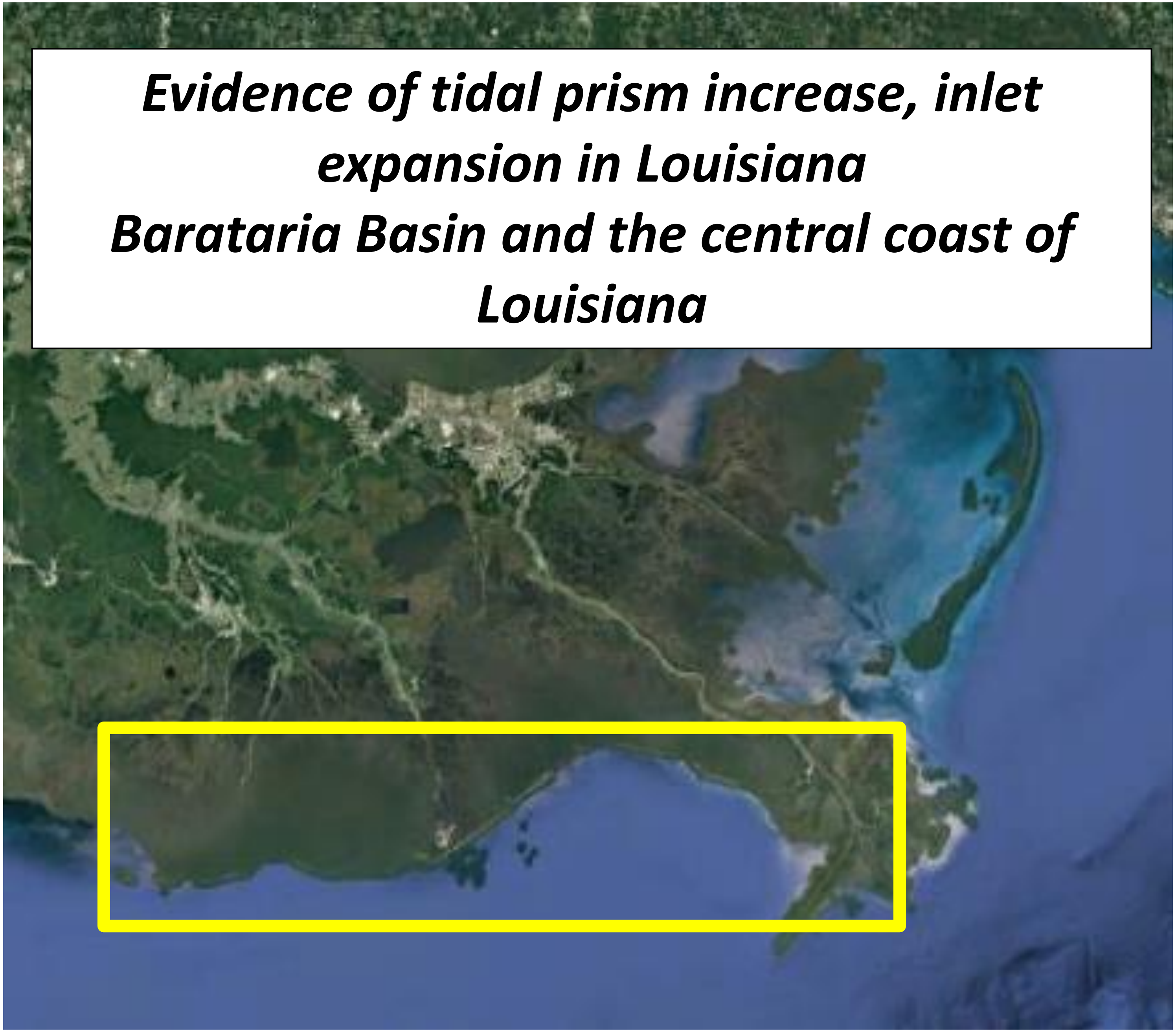


Howes (2009)
Howes et al. (2014)

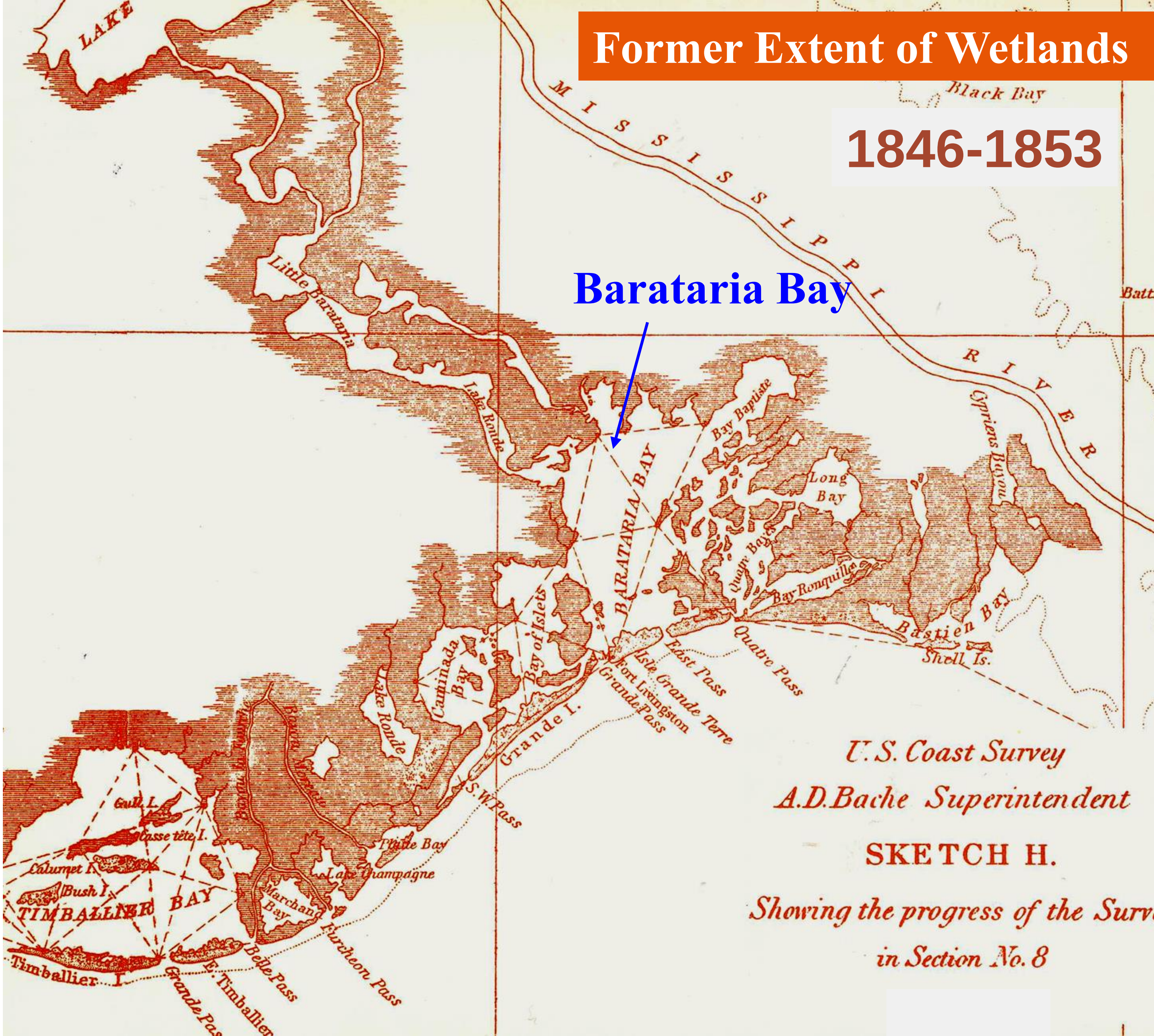
Conceptual model of the processes and feedbacks

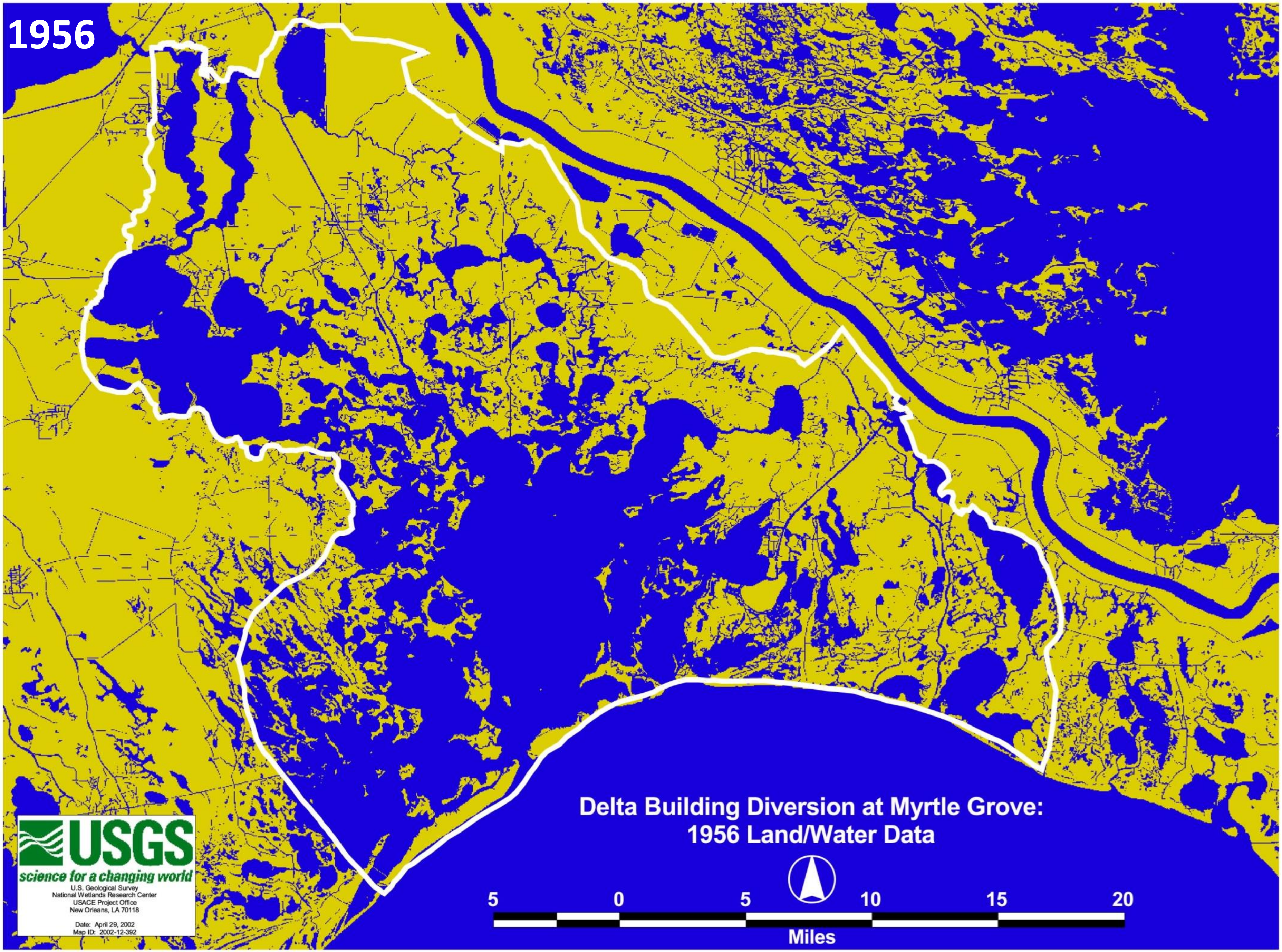
Evidence of tidal prism increase, inlet expansion in Louisiana
Barataria Basin and the central coast of Louisiana



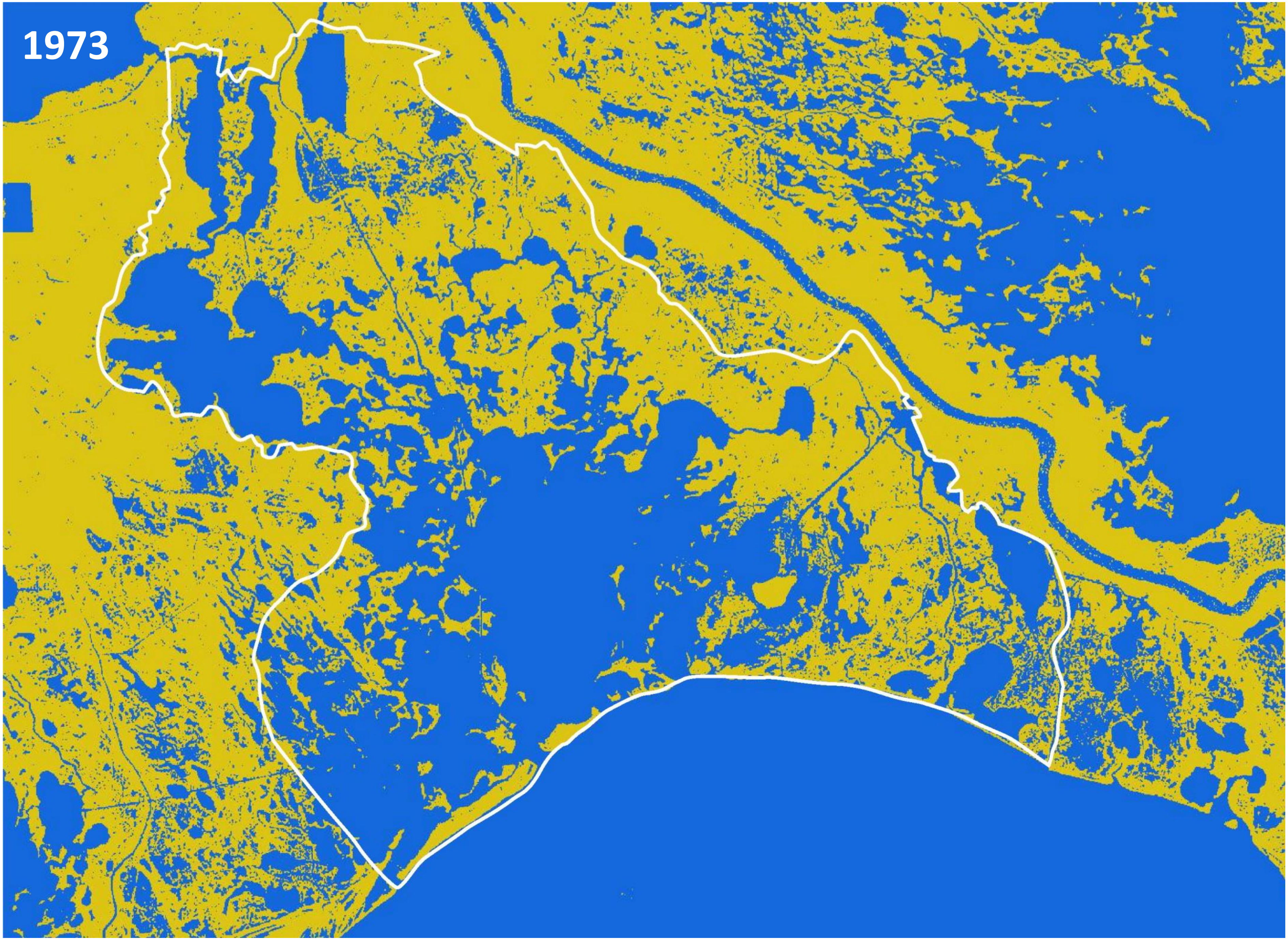
Former Extent of Wetlands

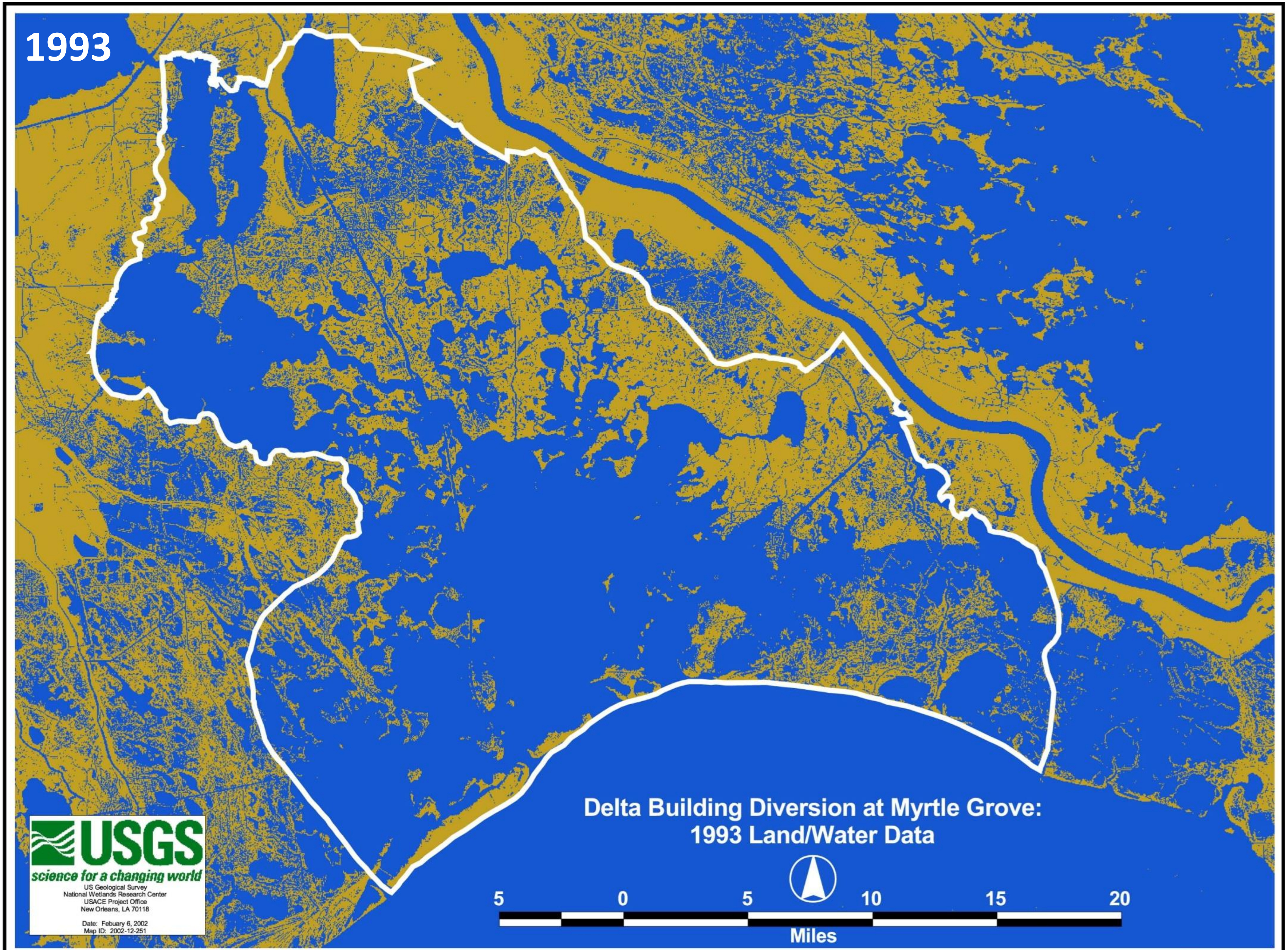
1846-1853





1956
Delta Building Diversion at Myrtle Grove:
1956 Land/Water Data
5
0
5
10
15
20
Miles
USGS
science for a changing world
U.S. Geological Survey
National Wetlands Research Center
USACE Project Office
New Orleans, LA 70118
Date: April 29, 2002
Map ID: 2002-12-392


1973


1993
Delta Building Diversion at Myrtle Grove:
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5
0
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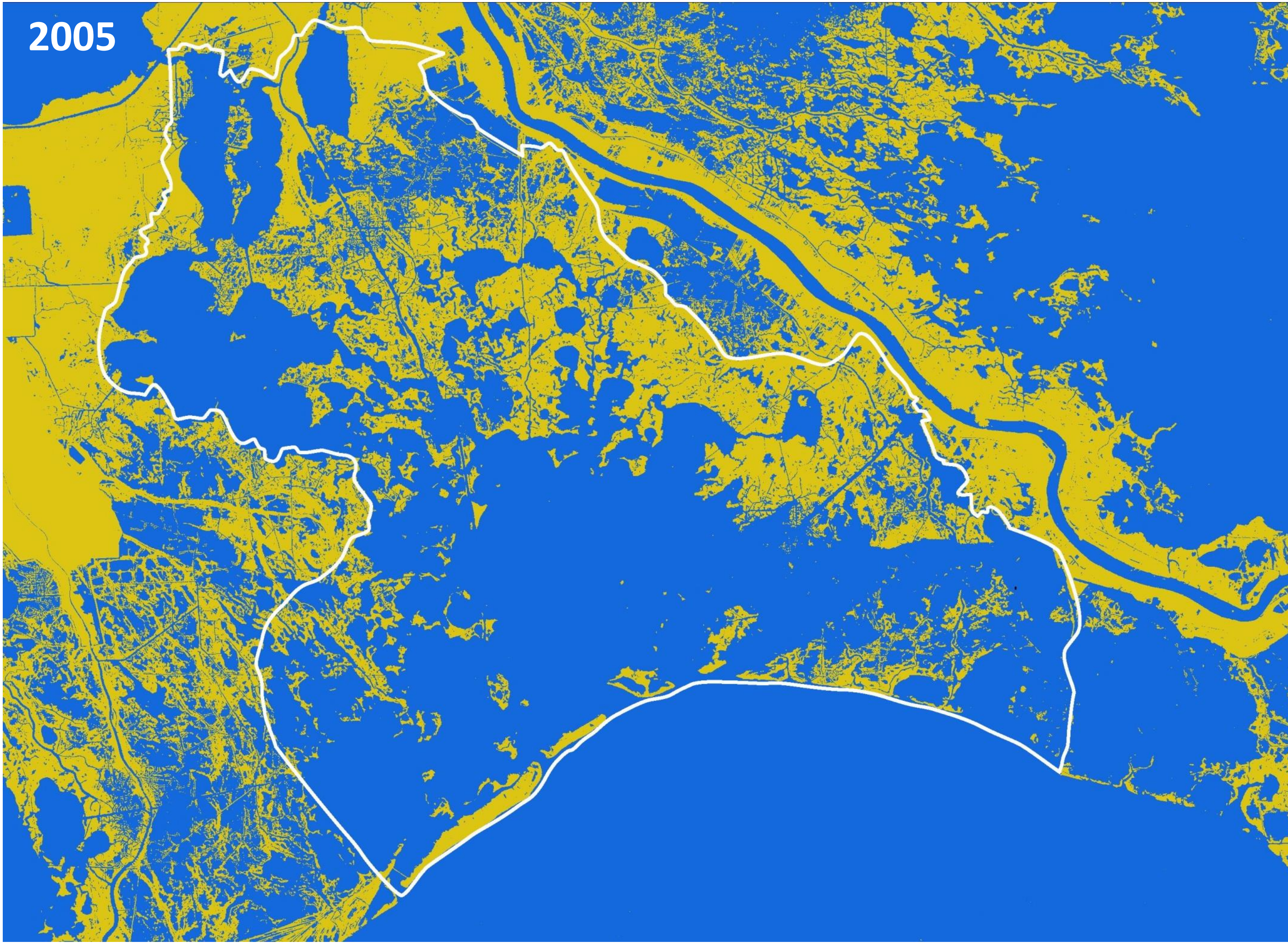
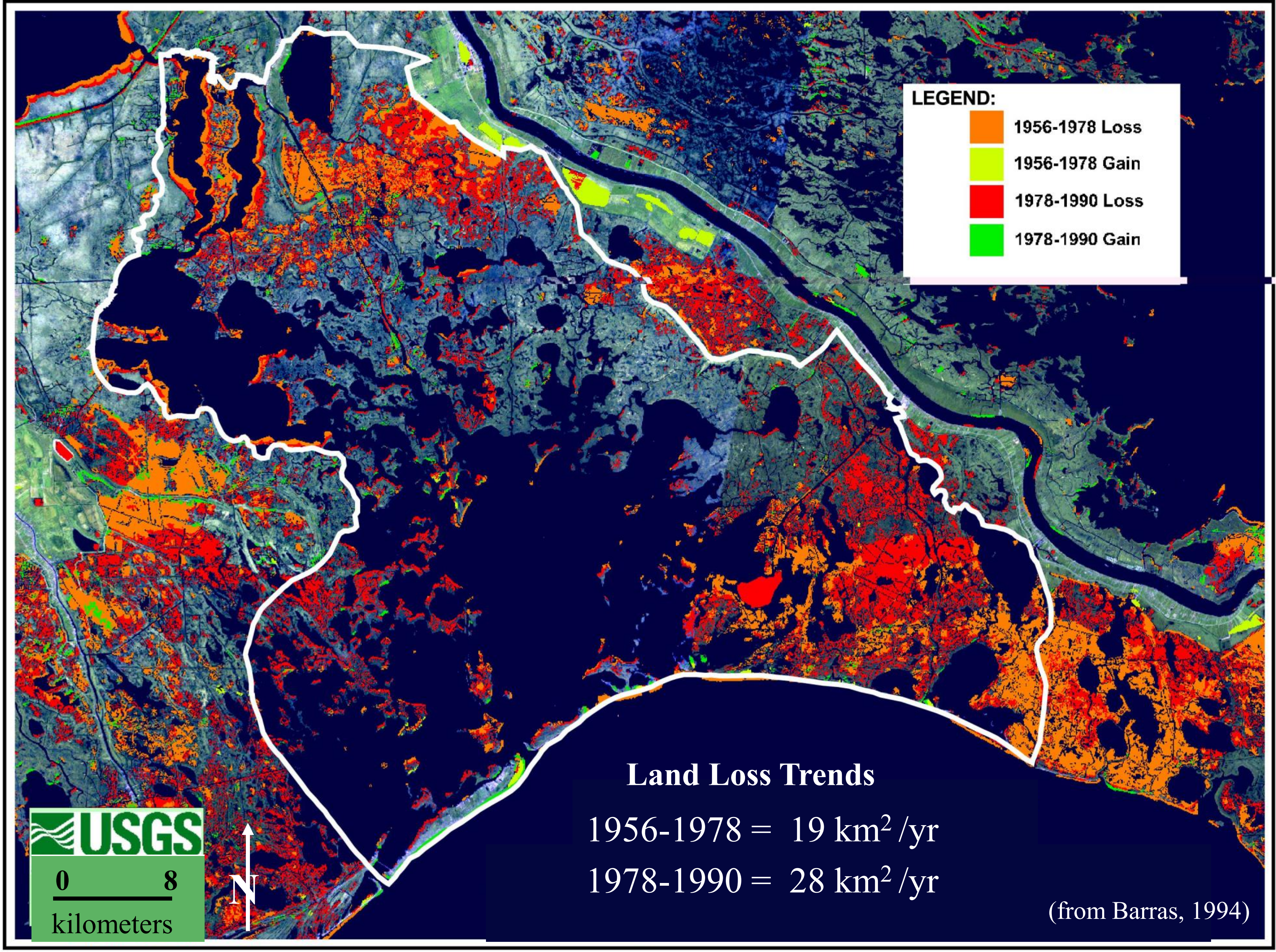
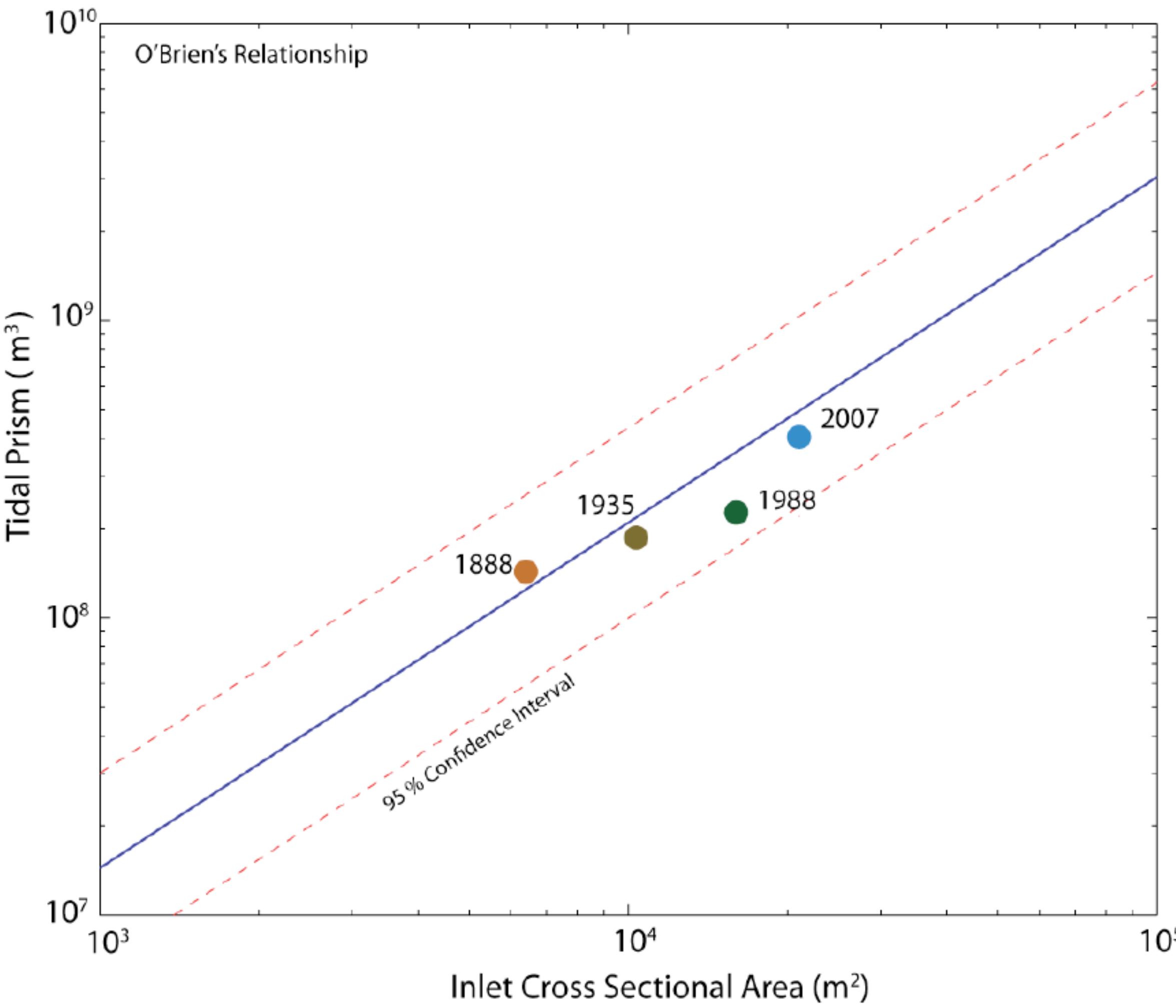
Miles
USGS
science for a changing world
US Geological Survey
National Wetlands Research Center
USACE Project Office
New Orleans, LA 70118
Date: Febuary 6, 2002
Map ID: 2002-12-251


2005


LEGEND:
1956-1978 Loss
1956-1978 Gain
1978-1990 Loss
1978-1990 Gain
Land Loss Trends
1956-1978 = 19 km^2 /yr
1978-1990 = 28 km^2 /yr
(from Barras, 1994)
USGS
0
8
kilometers
N

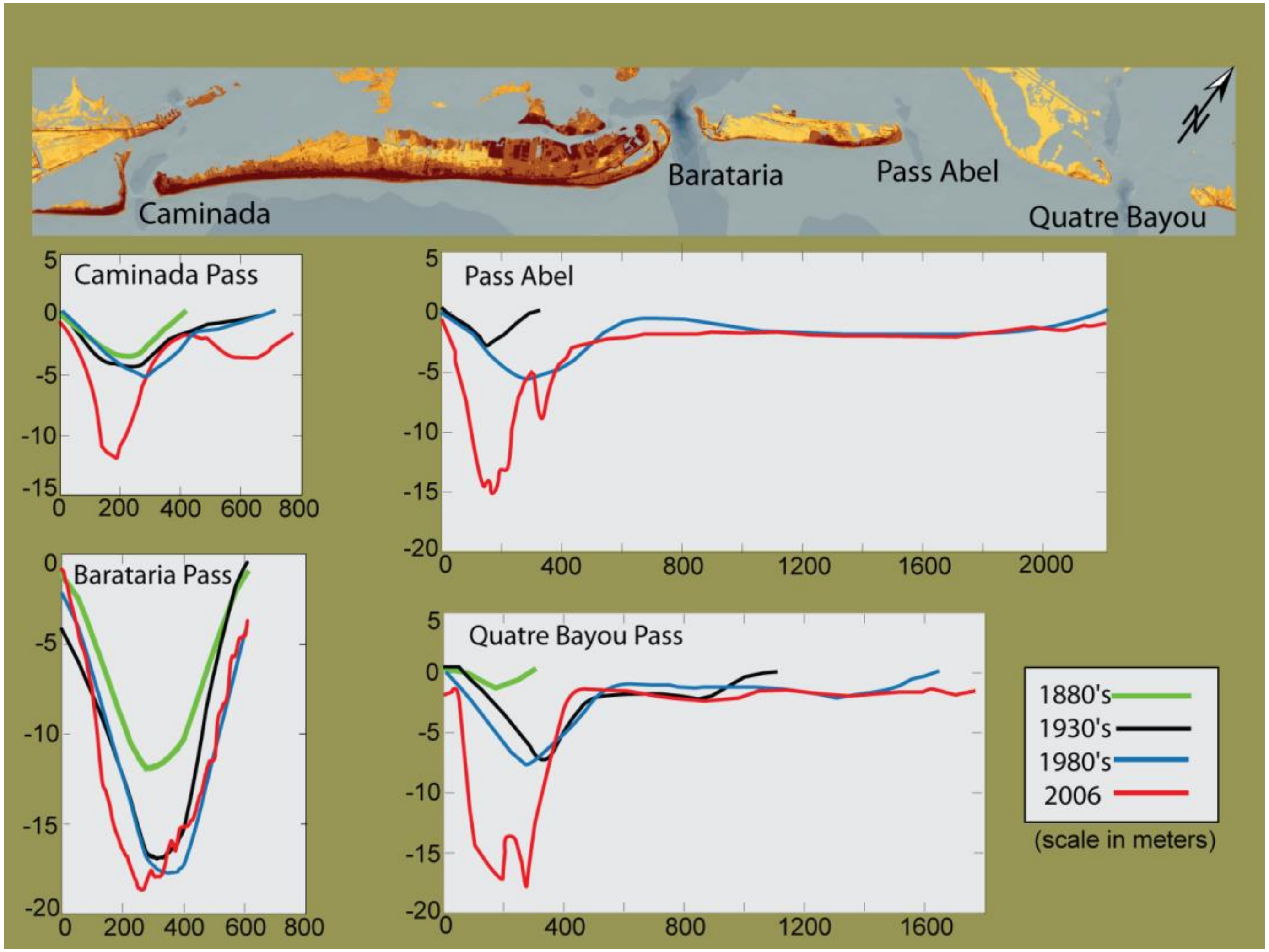
Enlargement of tidal prism and inlet area



The historical increase in tidal prism and cumulative area for the Barataria Basin Inlets.

(from Howes, 2009 and Miner et al., 2009; tidal prism data for 1888-1988 from List (1997) & Suhayda (1997)

Enlargement of inlet cross sectional area

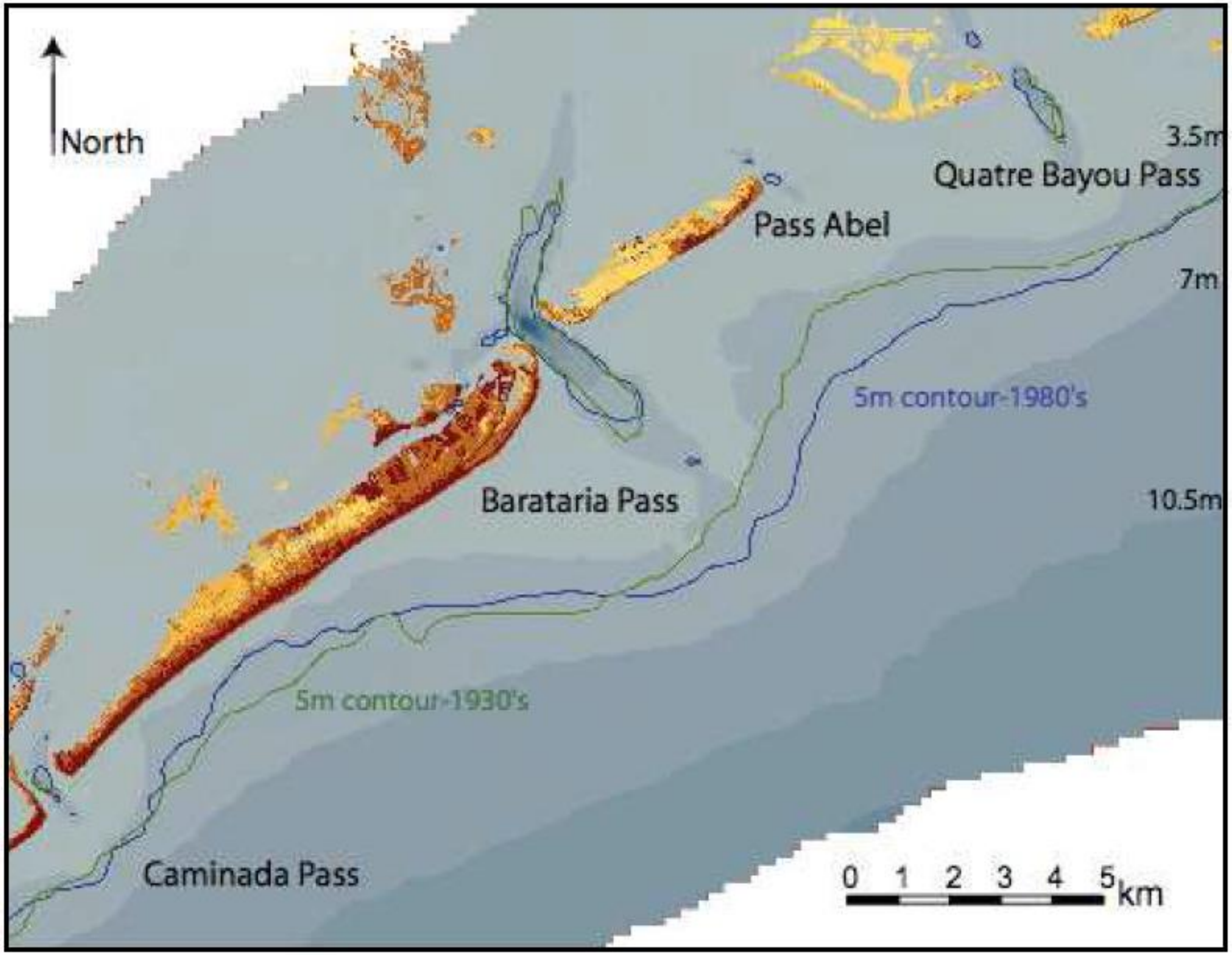


Historical morphological changes in tidal inlet throat morphology between 1880 and 2006.

(FitzGerald et al, 2007,
Howes 2009,
Miner et al 2009
Howes et al., 2014;

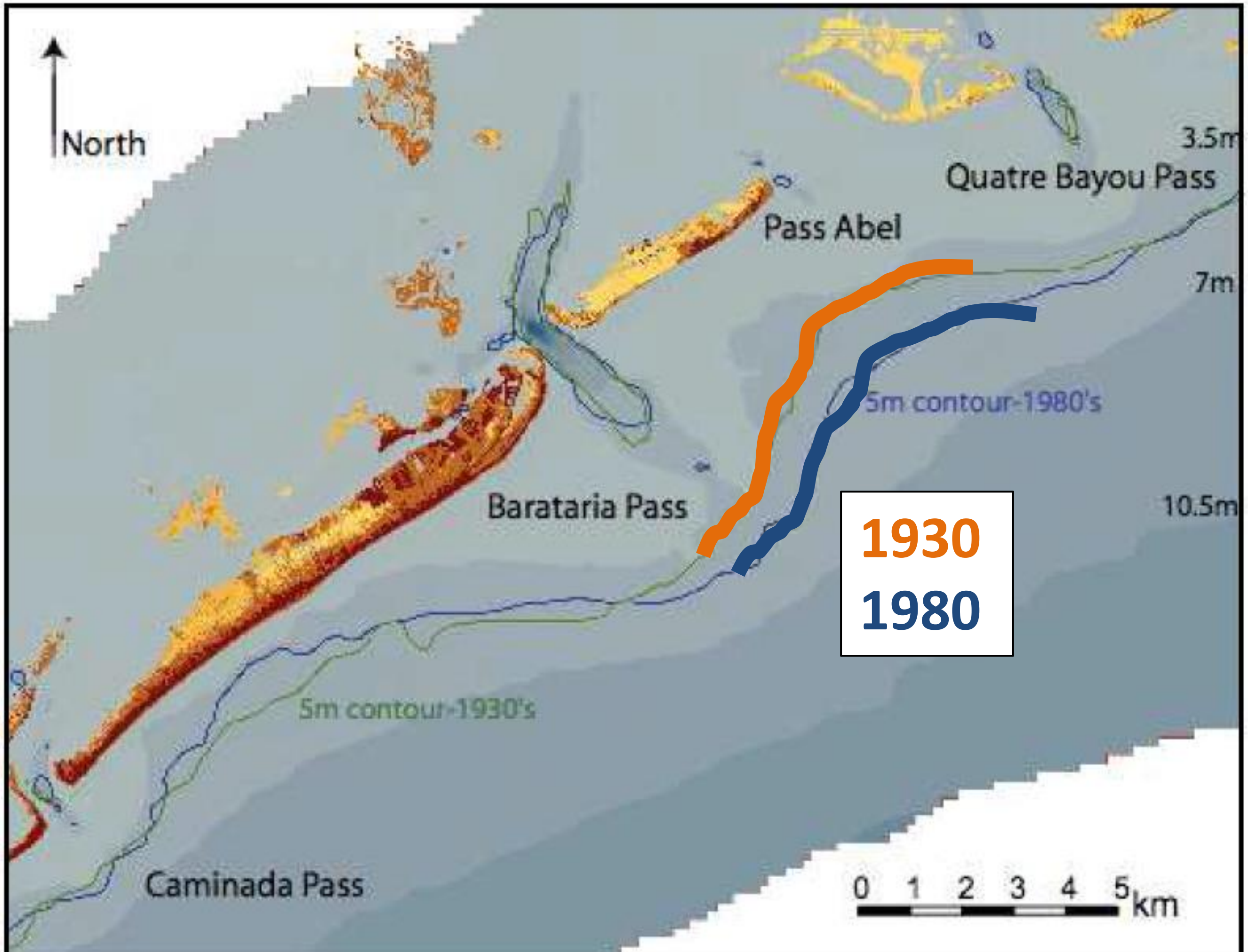
data for 1880 – 1980 from List et al., 1994
Data for 2006 from Miner et al., 2009)

Enlargement of ebb-tidal delta



FitzGerald et al., 2004 (sedimentology); FitzGerald et al., 2007 (*Coastal Sediments)*

Enlargement of ebb-tidal delta

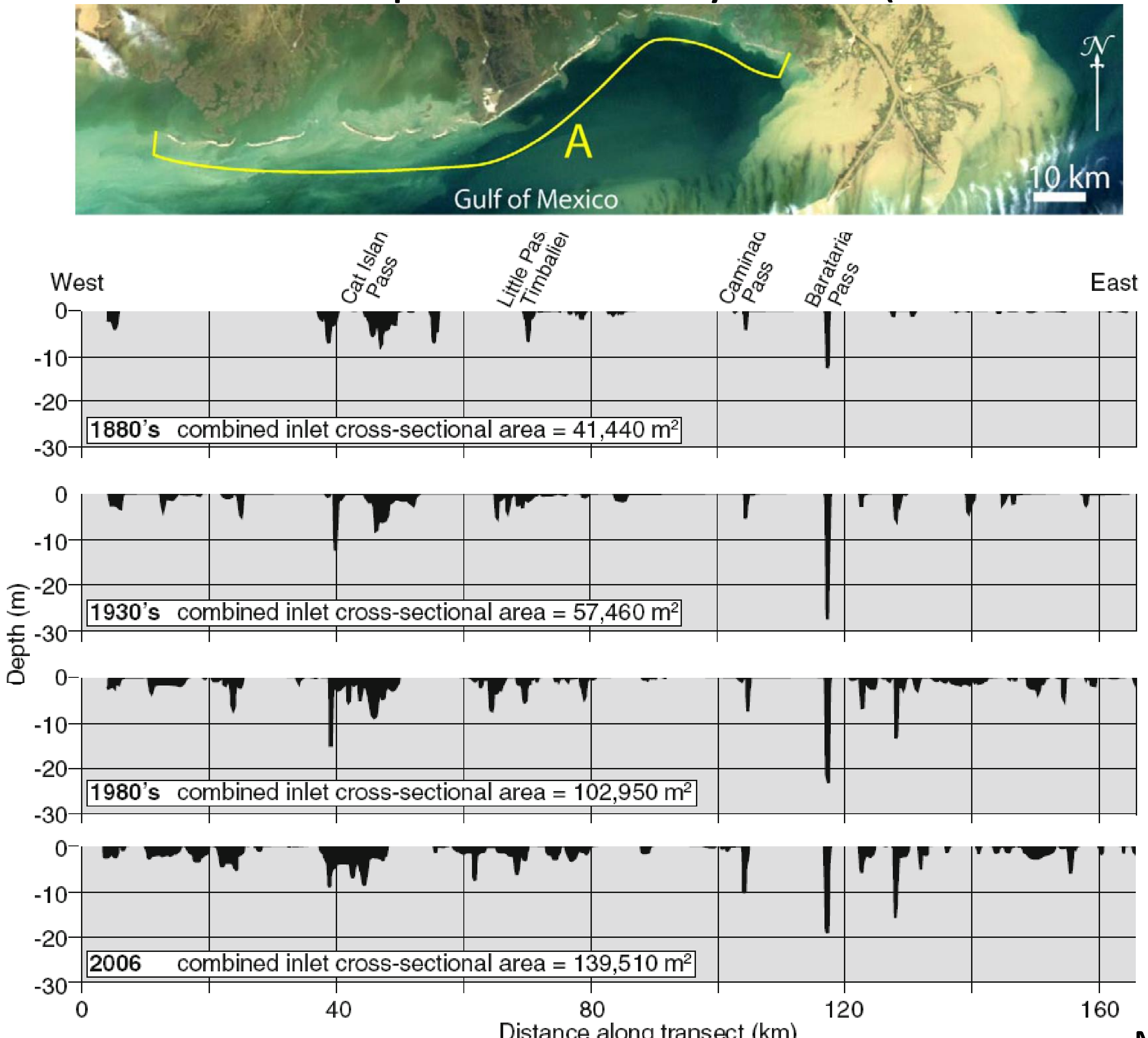


FitzGerald et al., 2004 (sedimentology); FitzGerald et al., 2007 (*Coastal Sediments)*

REGIONAL TRENDS

Regional trends in tidal inlet expansion

for Raccoon point to Sandy Point (1880-2006)

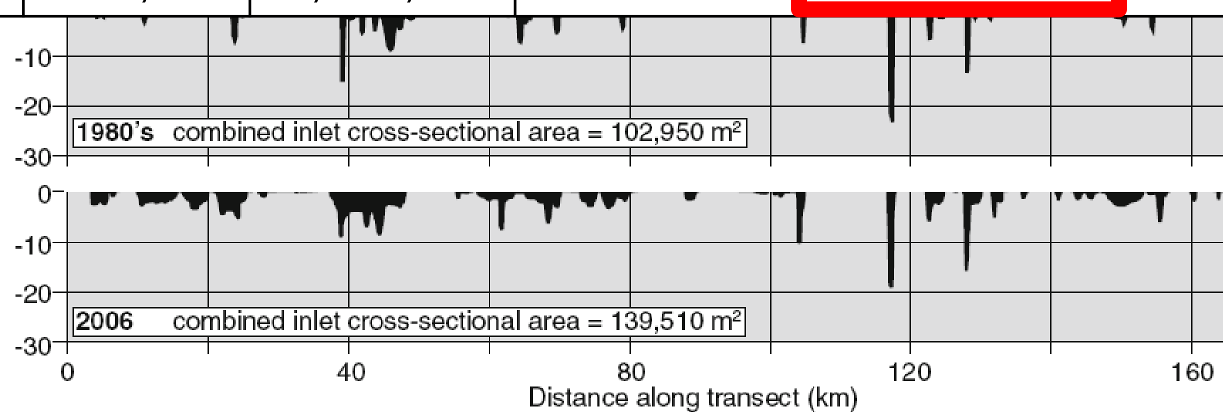


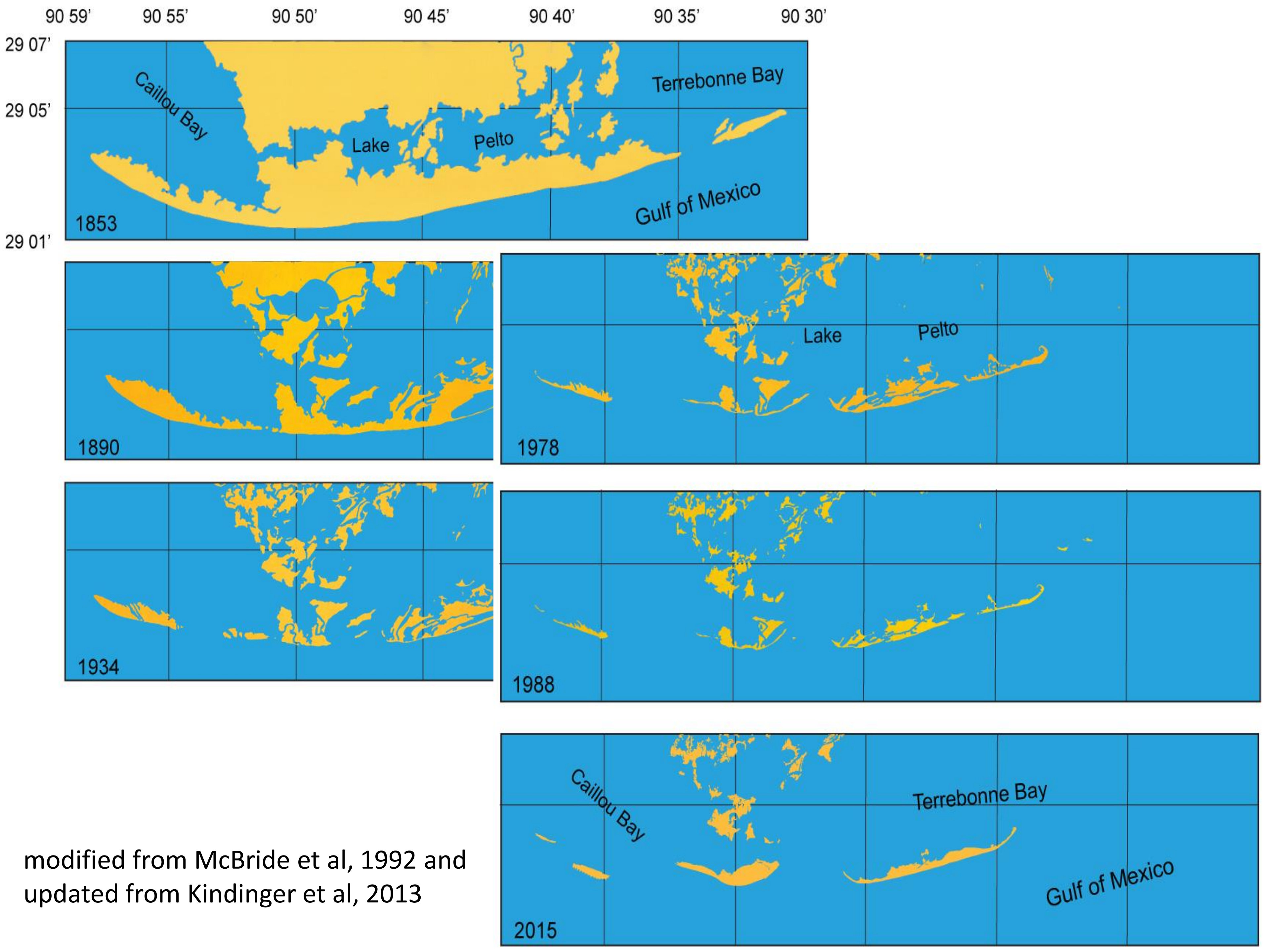
Miner et al. (2009)

Regional trends in tidal inlet expansion

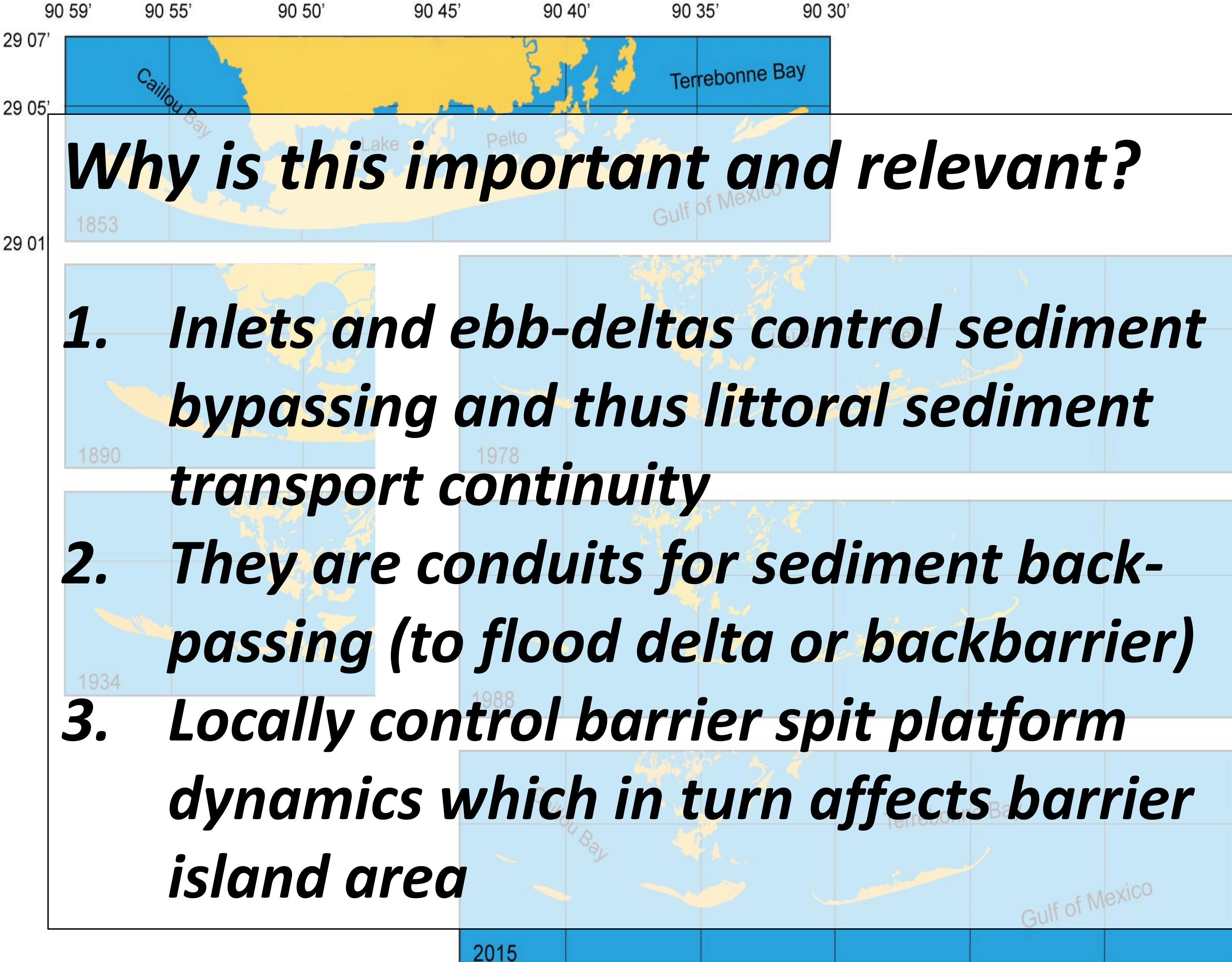
for Raccoon point to Sandy Point (1880-2006)

YEAR	A (m^2)	A (ft^3)	Annual (%) increase	Cumulative increase (%)	P (ft^3)
1880	41,440	1,463,440			117,509,158
1930	57,460	2,029,181	32.0	32.0	155,140,686
1980	102,950	3,635,645	69.2	116.7	254,681,458
2006	139,510	4,926,749	29.5	180.6	329,745,947





modified from McBride et al, 1992 and updated from Kindinger et al, 2013

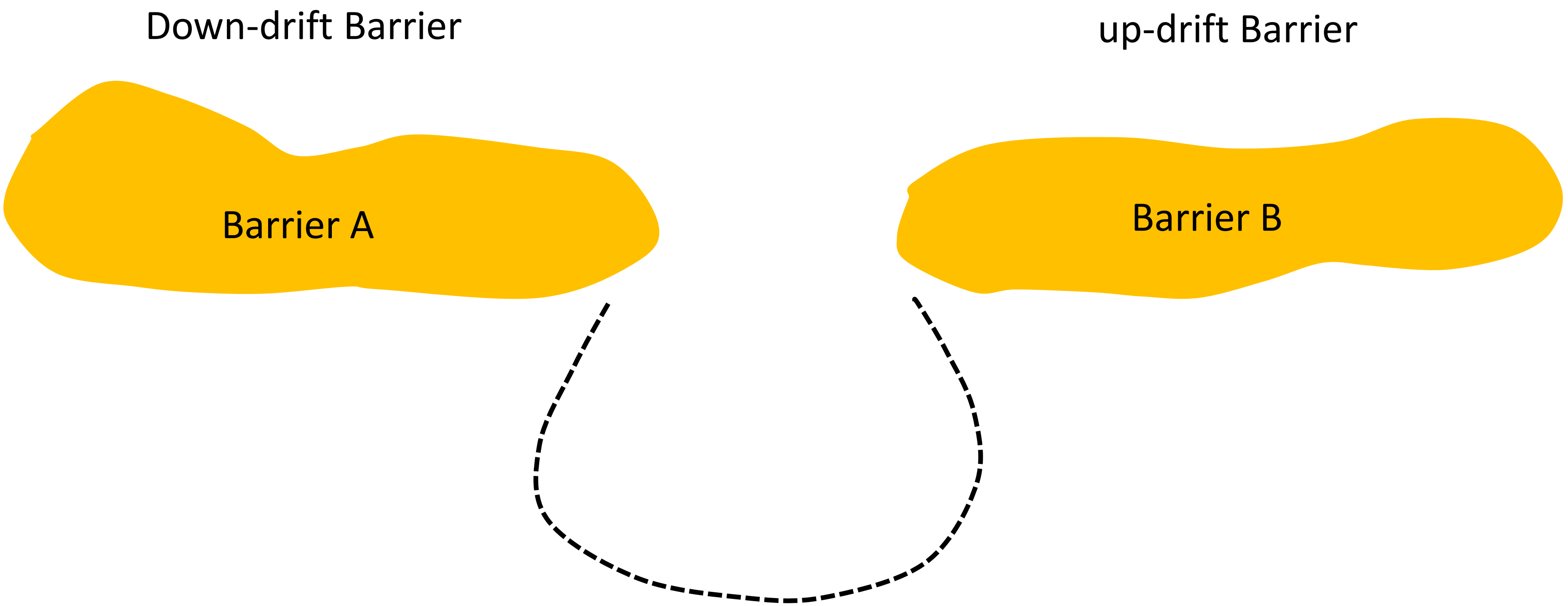


Why is this important and relevant?

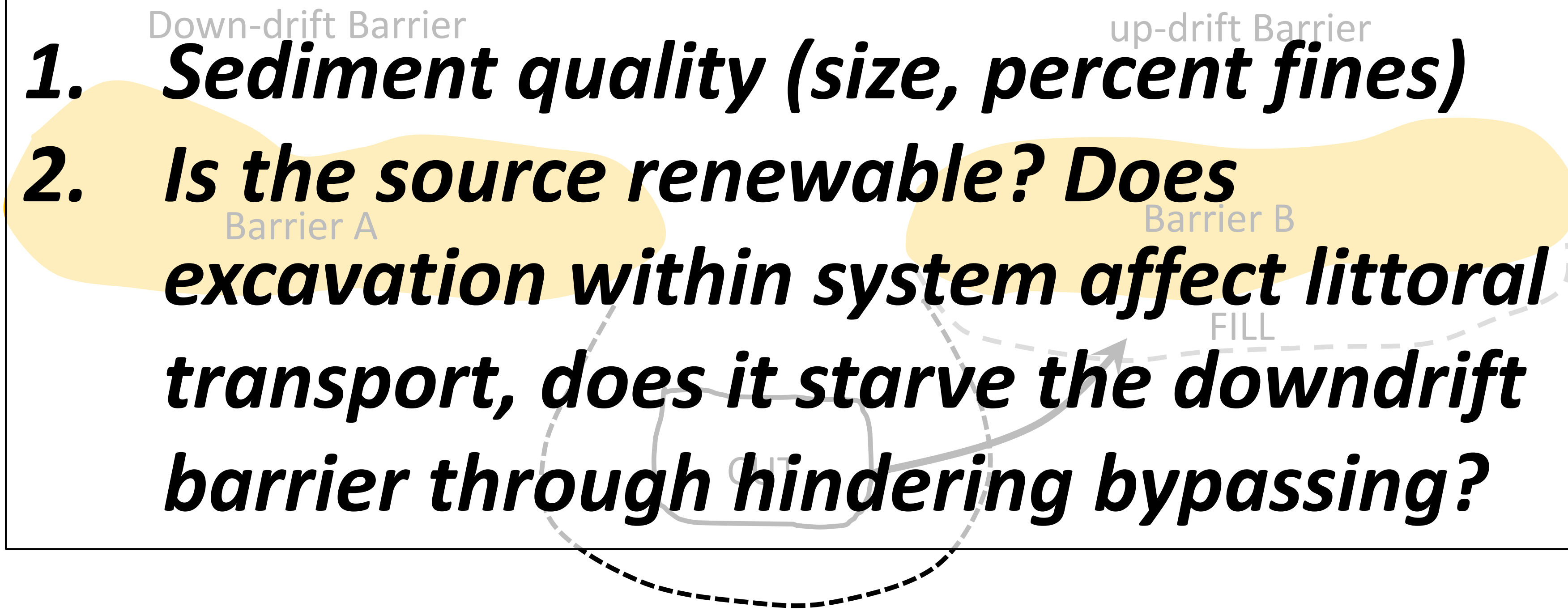
1. ***Inlets and ebb-deltas control sediment bypassing and thus littoral sediment transport continuity***
2. ***They are conduits for sediment back-passing (to flood delta or backbarrier)***
3. ***Locally control barrier spit platform dynamics which in turn affects barrier island area***

CONCEPTUAL FRAMEWORK

Scenario 0 or reference
No action No nourishment/restoration



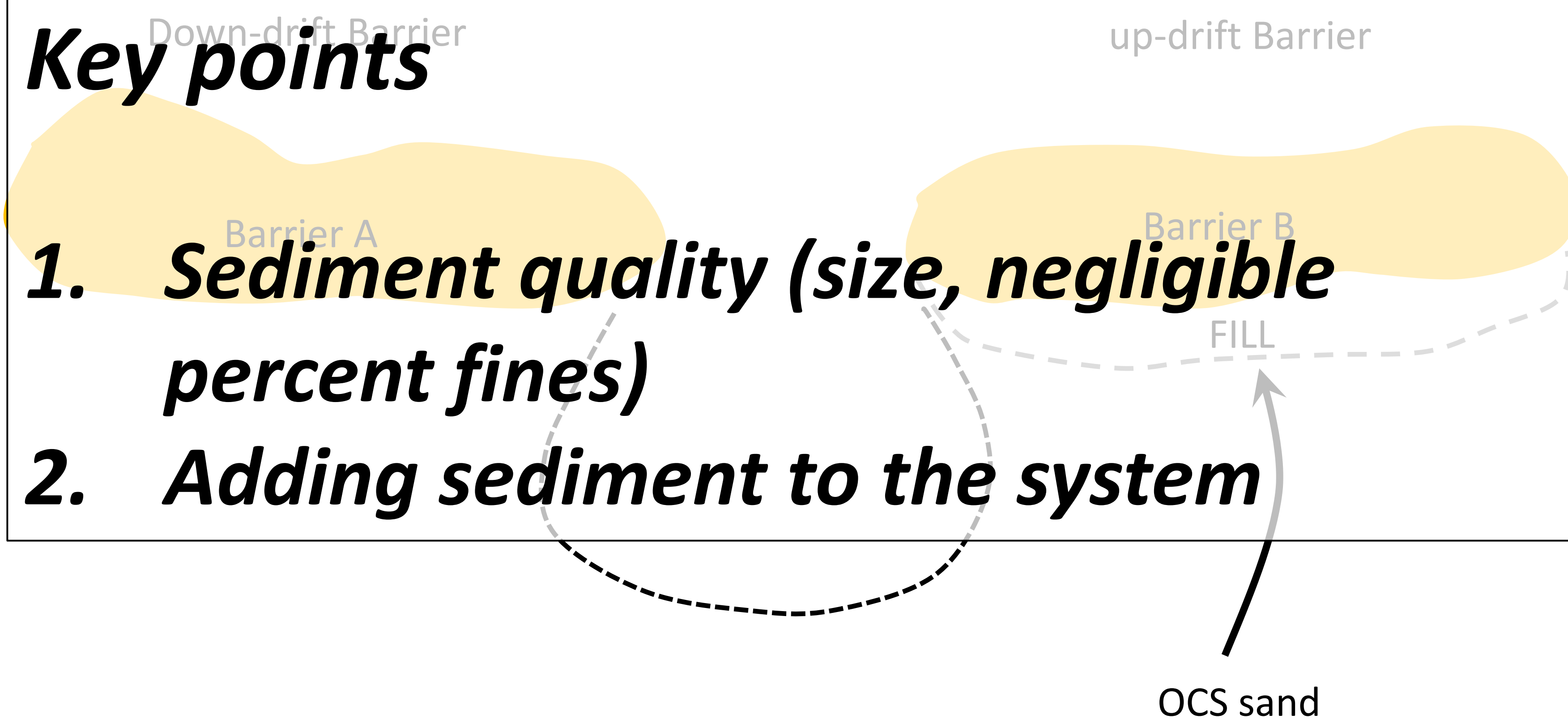
Scenario 1 – Borrow within the system



Key points

1. ***Sediment quality (size, percent fines)***
2. ***Is the source renewable? Does excavation within system affect littoral transport, does it starve the downdrift barrier through hindering bypassing?***

Scenario 2 – OCS sand; outside the system



Key points

1. ***Sediment quality (size, negligible percent fines)***
2. ***Adding sediment to the system***

Conceptual Barrier trajectories
(informed by observations in Louisiana)

Scenario 0 - no action		
Time	Area/Site A (Volume yd^3)	Area/Site B (Volume yd^3)
0	1,057,000	5,551,000
5	313,000	3,436,000
10	[illegible]	[illegible]
15	350,000	3,926,000
20	55,000	3,431,000

Scenario 1 - within system updrift island downdrift excavation		
Time	Area/Site A (Volume yd^3)	Area/Site B (Volume yd^3)
0	1,057,000	8,585,000
5	340,000	6,433,000
10	[illegible]	[illegible]
15	363,500	6,608,000
20	100,500	6,142,000

Numbers are not terribly important!

These semi-empirical results are driving the early economic models

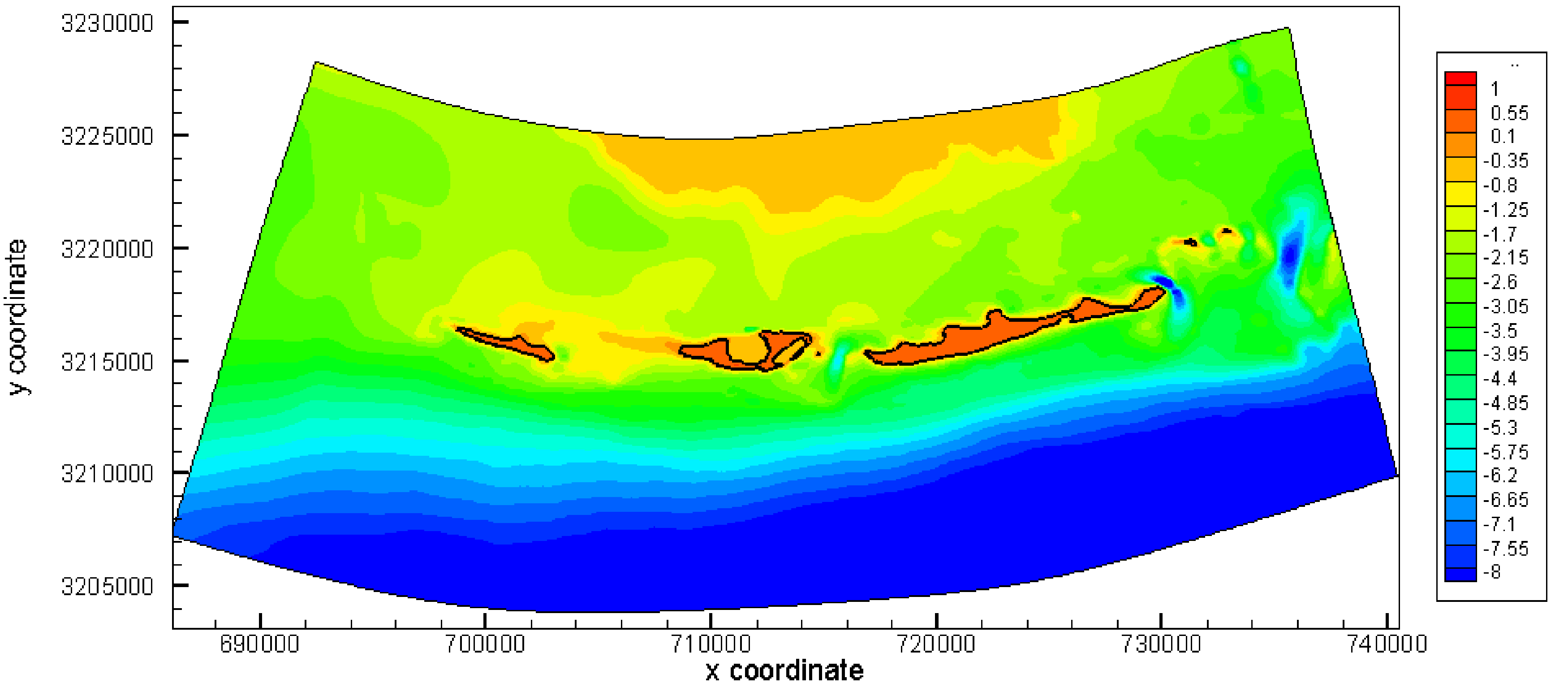
Scenario 2 - Offshore sand		
Time	Area/Site A (Volume yd^3)	Area/Site B (Volume yd^3)
0	1,057,000	8,585,000
5	[illegible]	6,433,000
10	299,000	3,602,083
15	377,000	7,268,800
20	146,000	7,293,625

MODELING FRAMEWORK

Model description

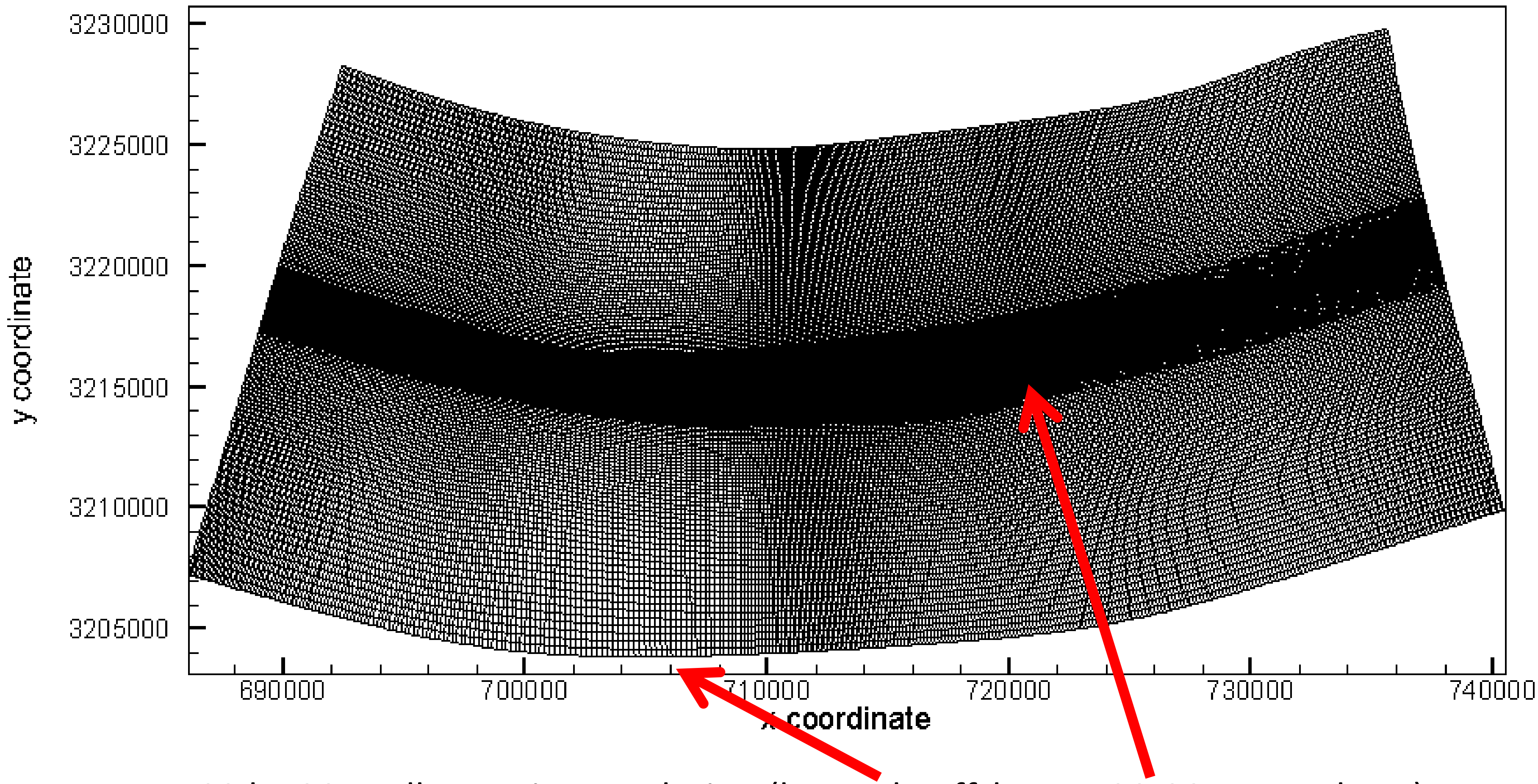
- Selected Delft Suite (with couple waves-tides-storms, sediment transport and morphology)
- Used in Depth-averaged mode
- Transport Formula (due to waves and currents)
  - Van Rijn
- Sediment size classes:
  - 2 classes (Fine sand and a tracer class to track the fate of placed sediment)

Modeling Bathymetry/coastline



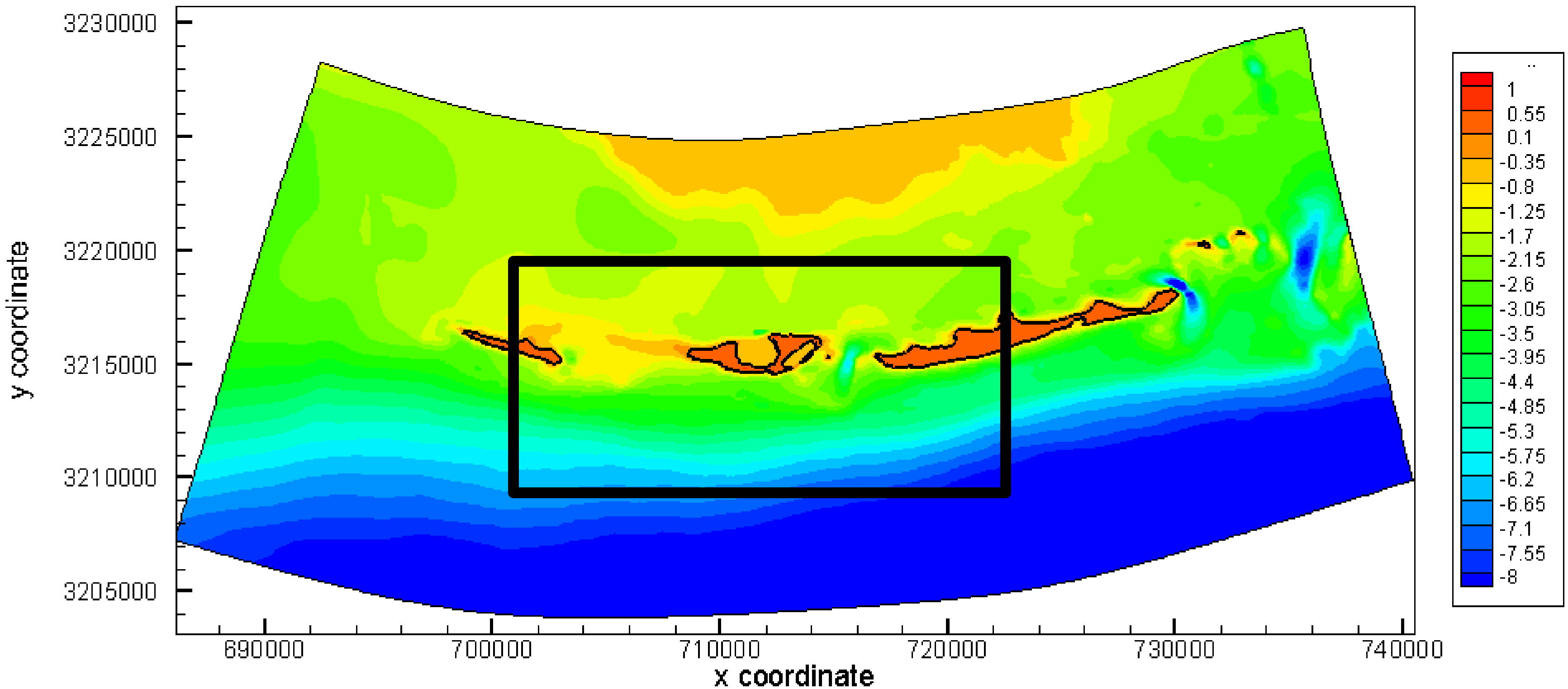
Used Isle Dernieres as proxy barrier system; used 1980s bathymetry (NOAA) when barriers were more rubust and exhibit important geomorphic features in a typical barrier chain

Modeling domain

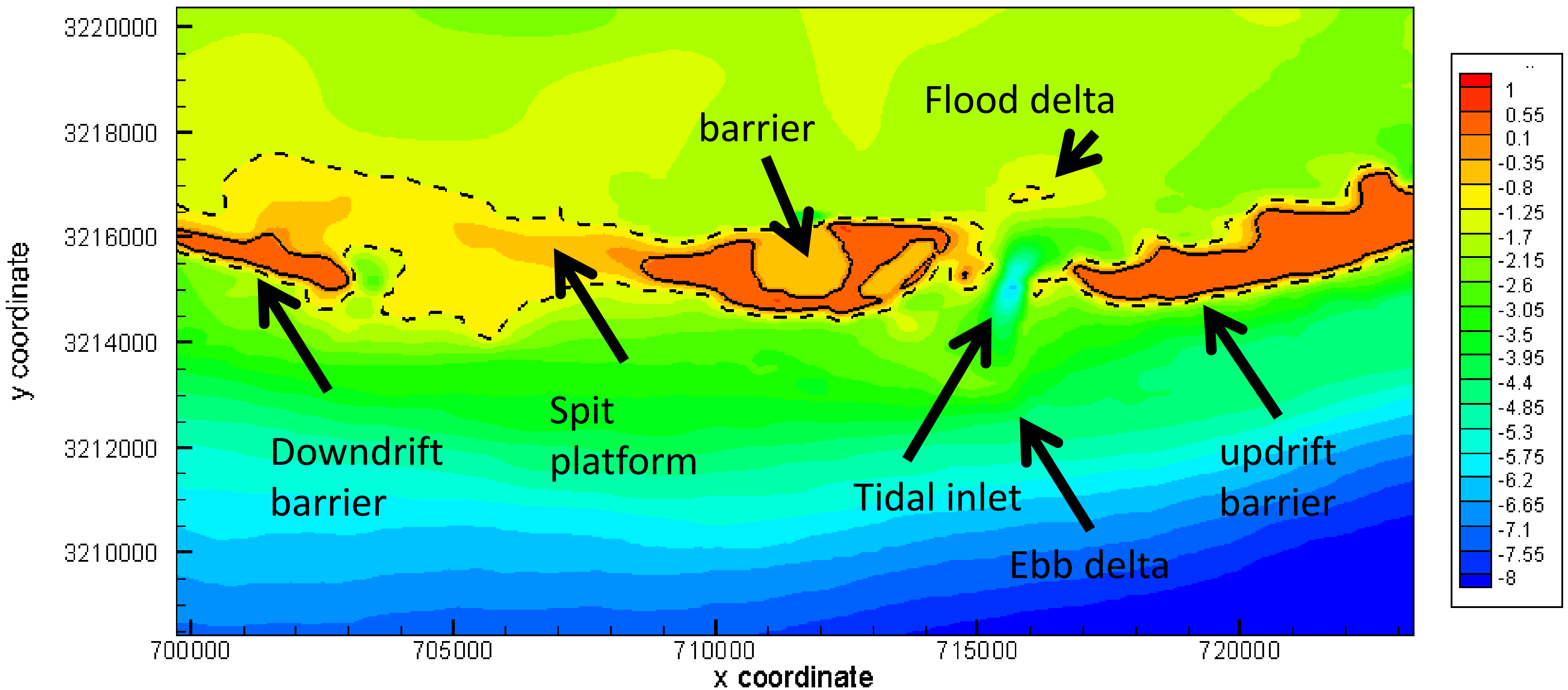


192 by 384 cells; varying resolution (km scale offshore, ~20-30m nearshore)

Modeling Bathymetry/coastline



Barrier SYSTEM components

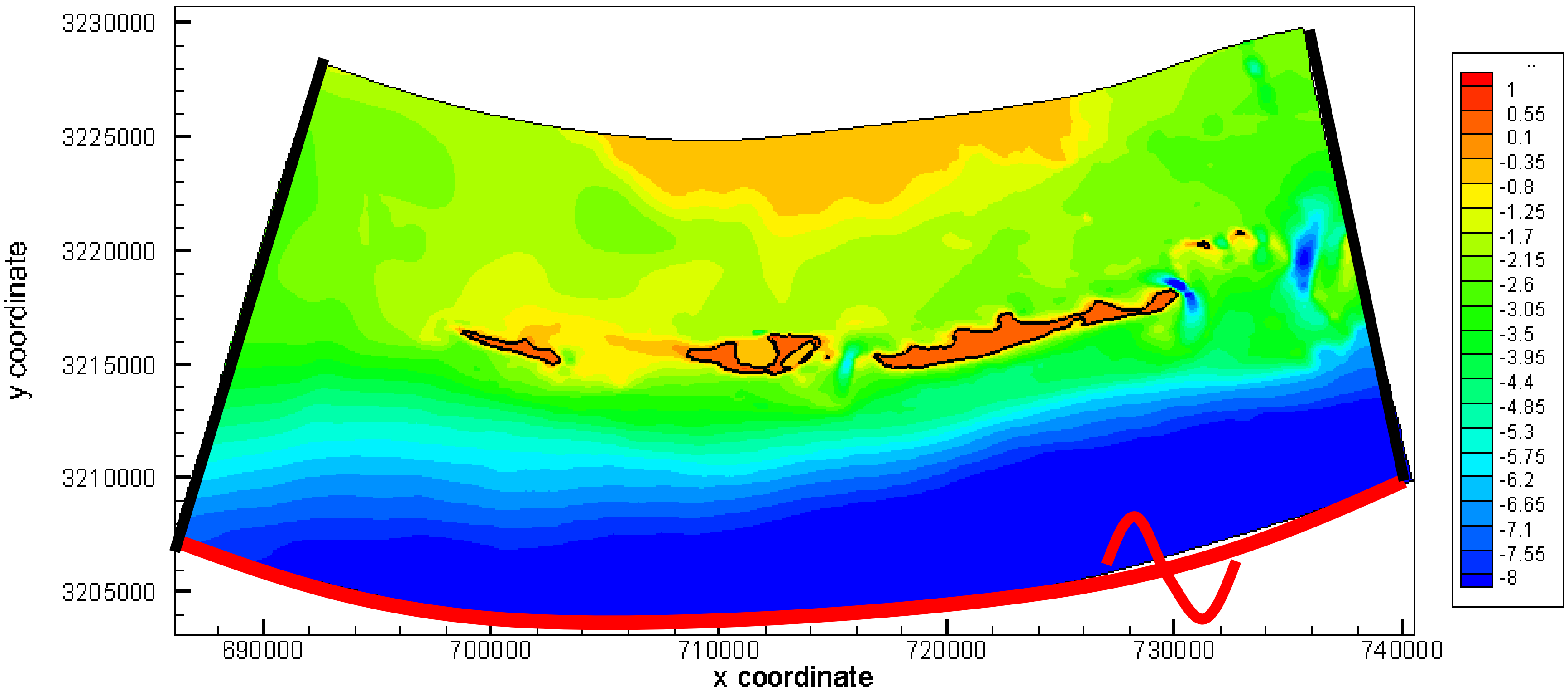


Barrier shorelines ~mean sea level (MSL)

Subaqueous barrier ~1.25 m depth below MSL

Model boundary conditions

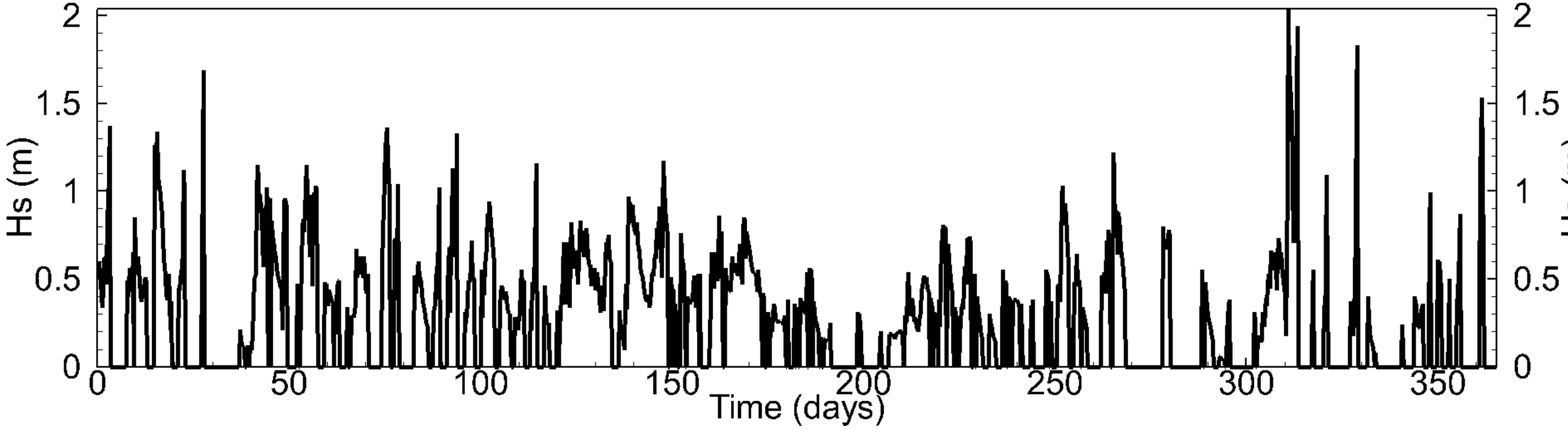
Offshore and Lateral Tides and waves [f(x,t)]

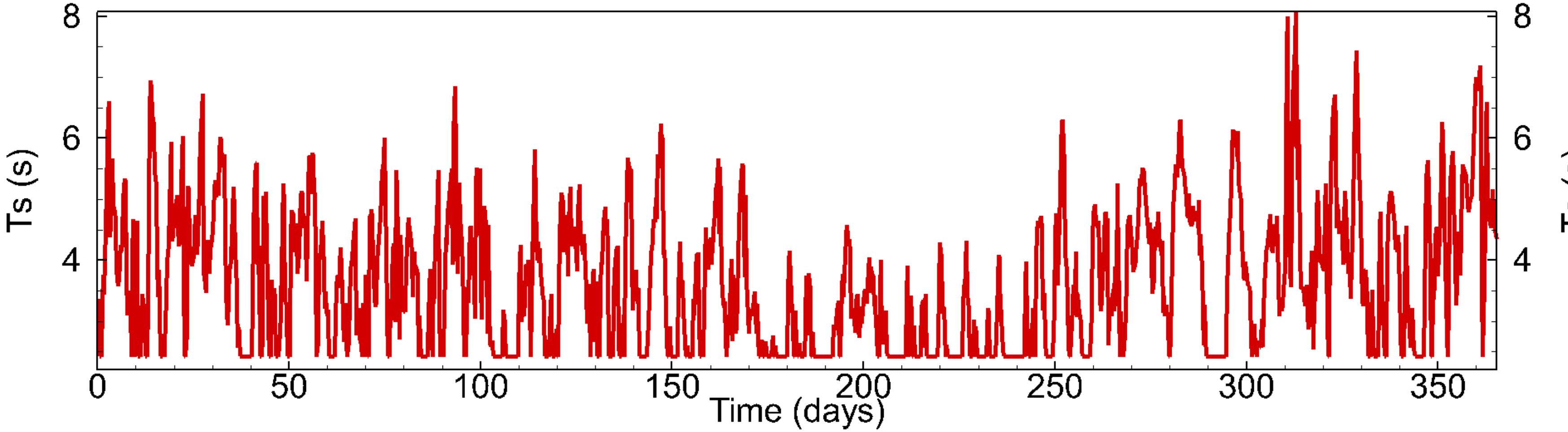


Tides, waves, subtidal [f(x,t)]

FLOW, WAVES (coupled every 3 hours), plus Sediment transport and morphology

Offshore wave forcing (typical year)





Offshore wave forcing (typical year)

Waves (every 3 hours)

Tides (astronomical forcing)

Sub-tidal (coastal stations – low pass)

Storm surge (nearby stations)

Wind stress (time-dependent, spatially constant)

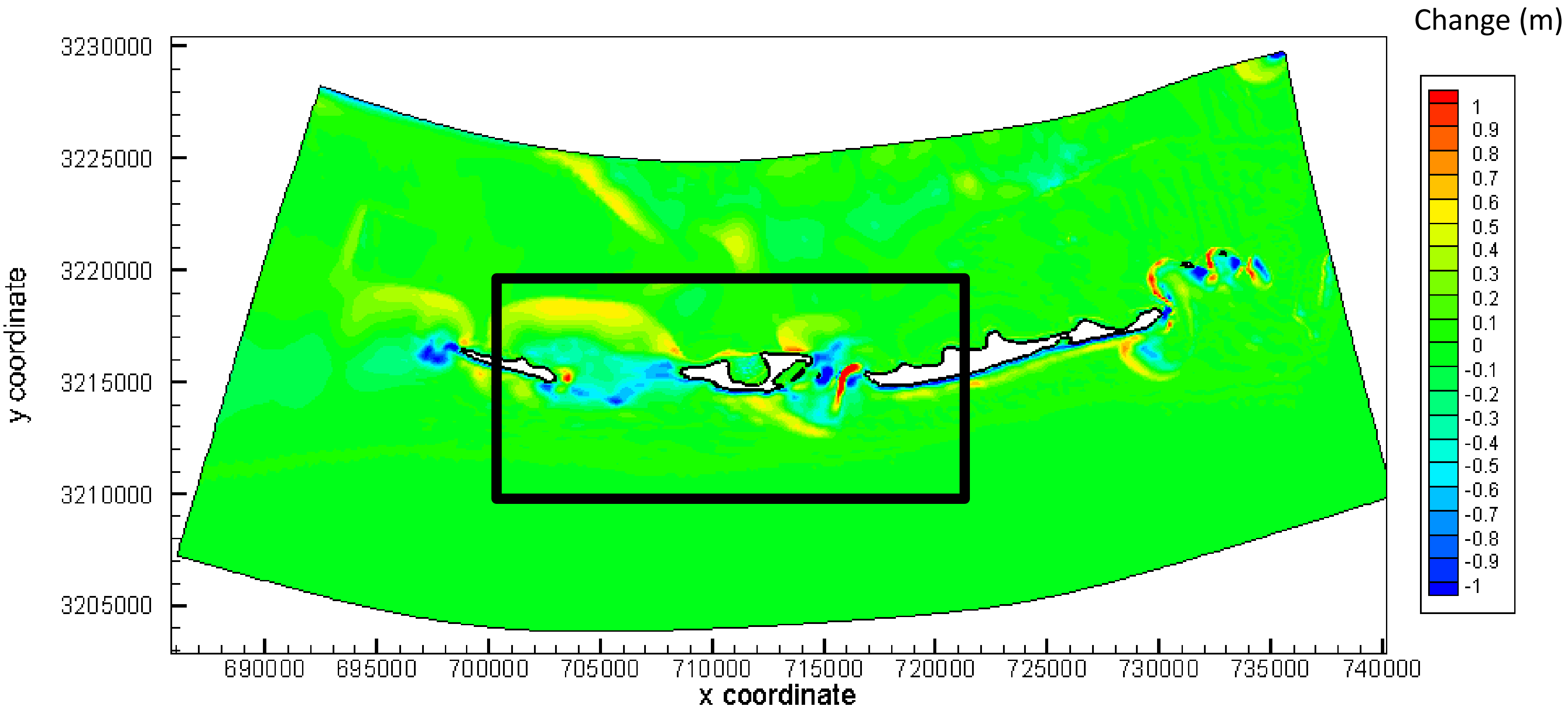
No suspended sediment at boundaries

Suspended and bedload within the domain

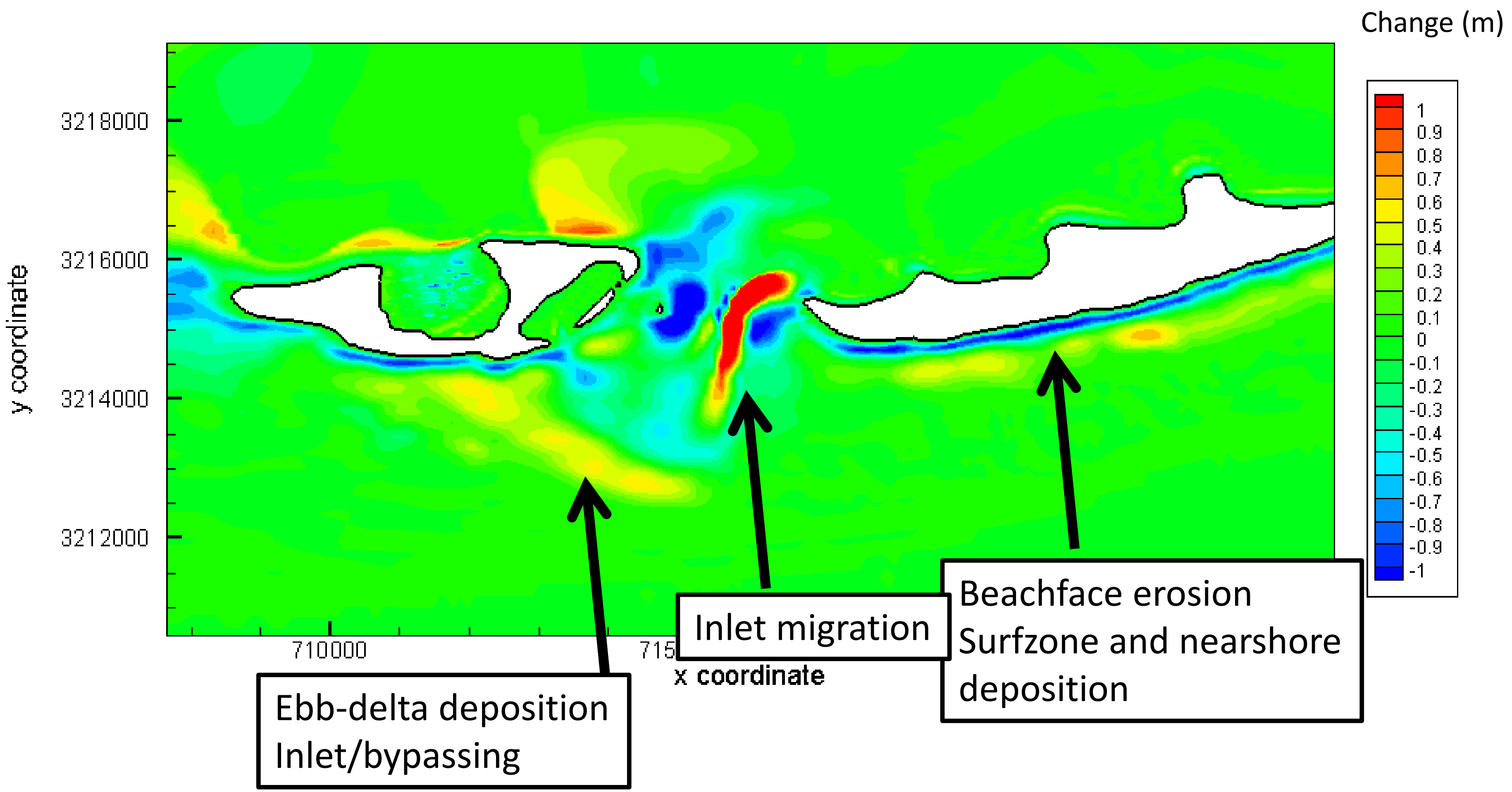
Morphology upscaling (~20-40)

PRELIMINARY RESULTS/FEEDBACK

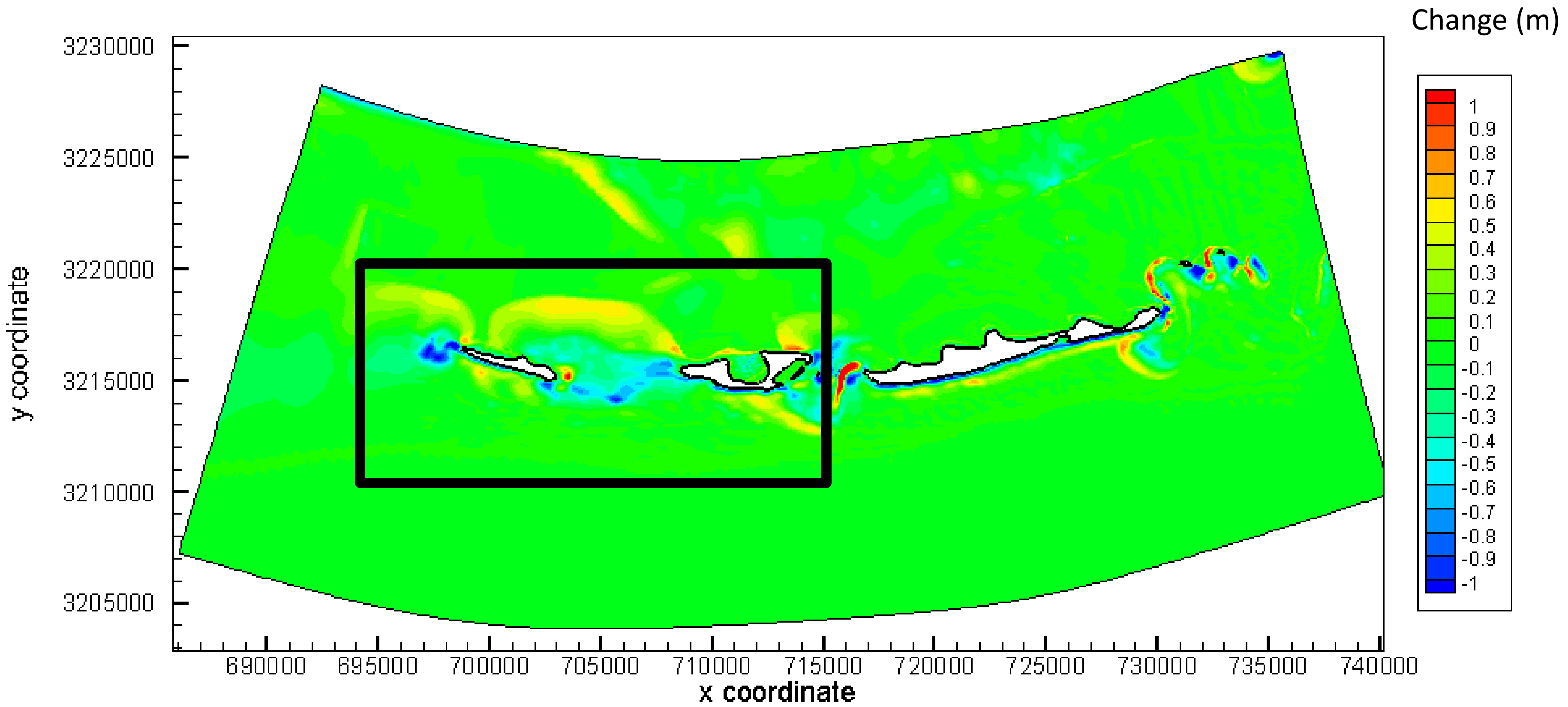
Scenario 0 – no nourishment



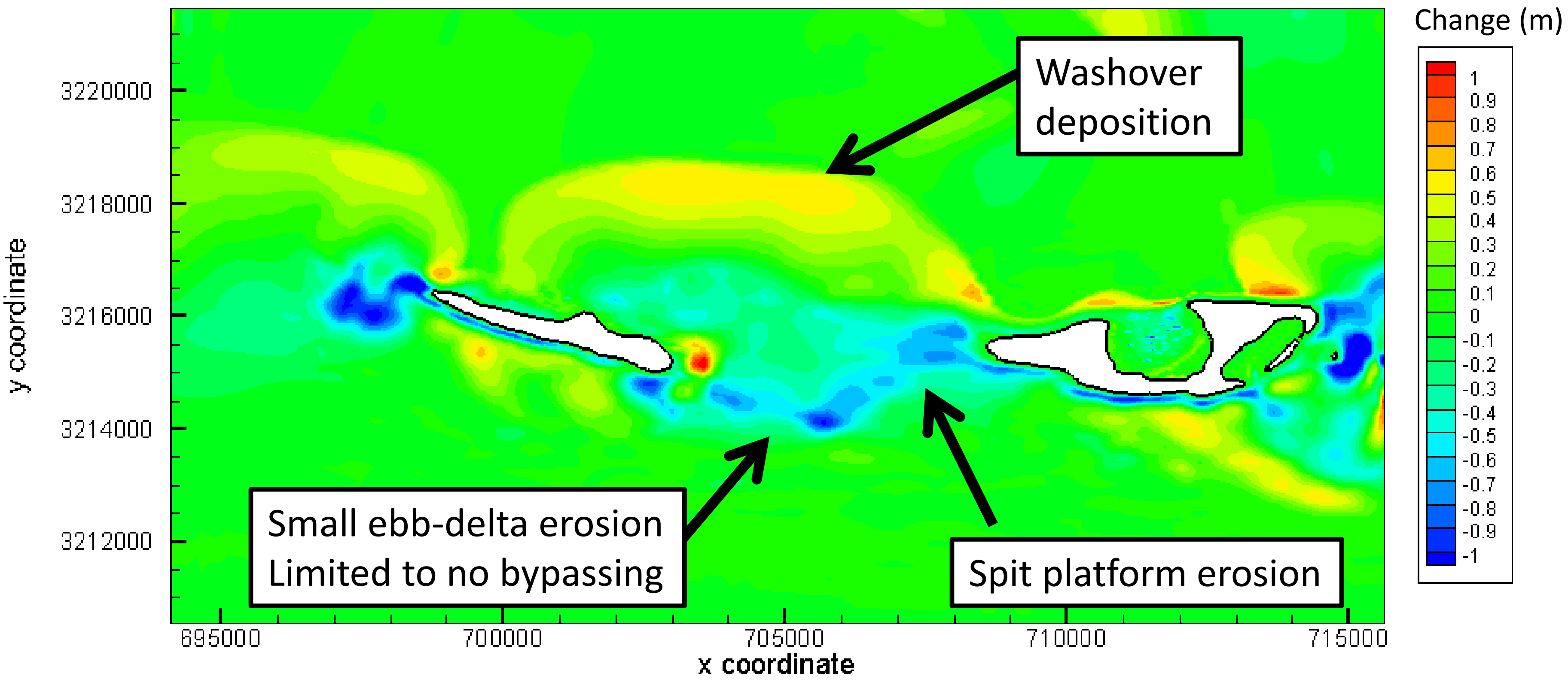
Scenario 0 – no nourishment



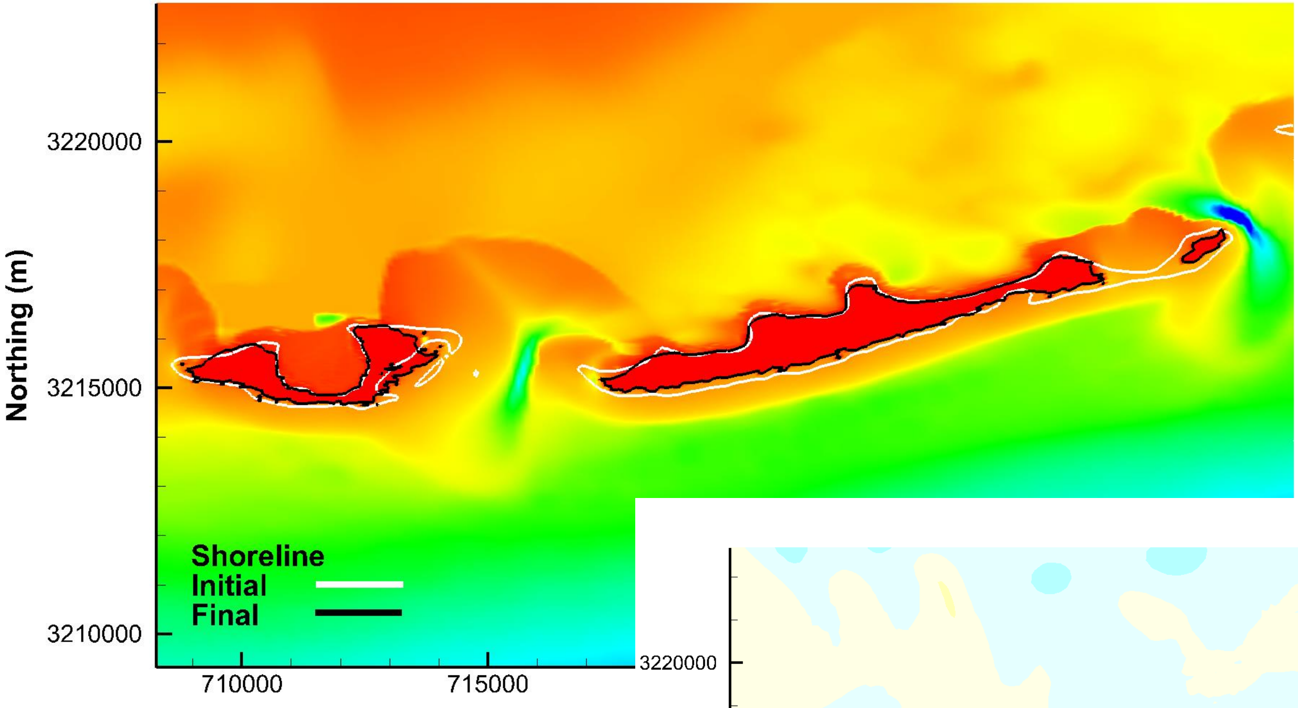
Scenario 0 – no nourishment

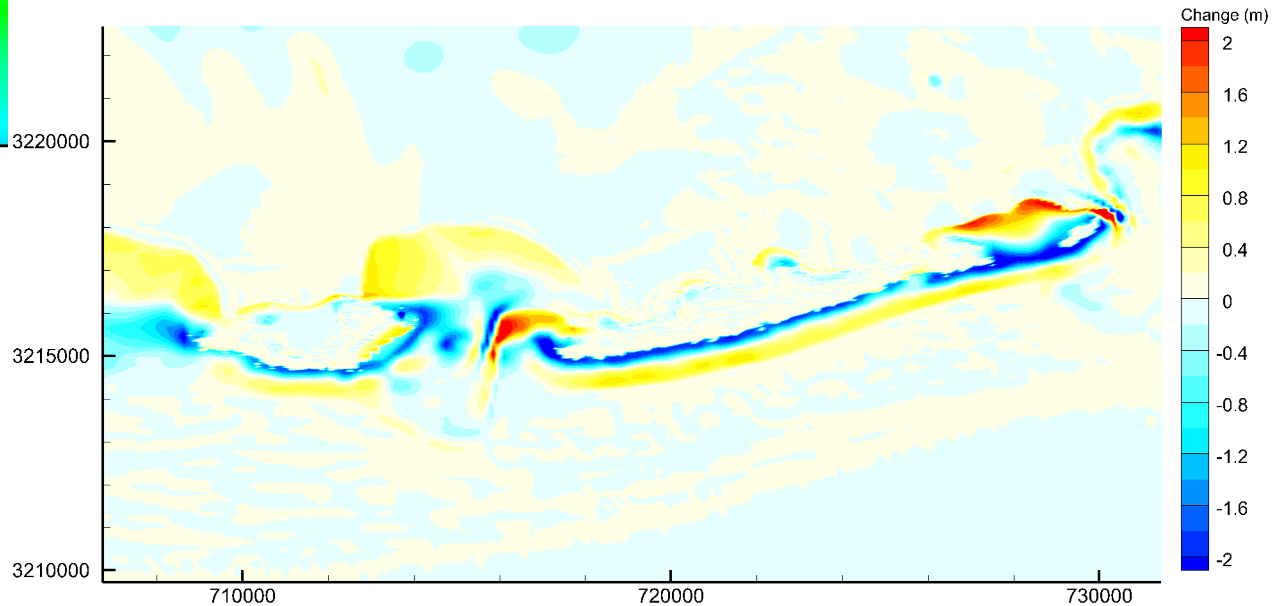


Scenario 0 – no nourishment

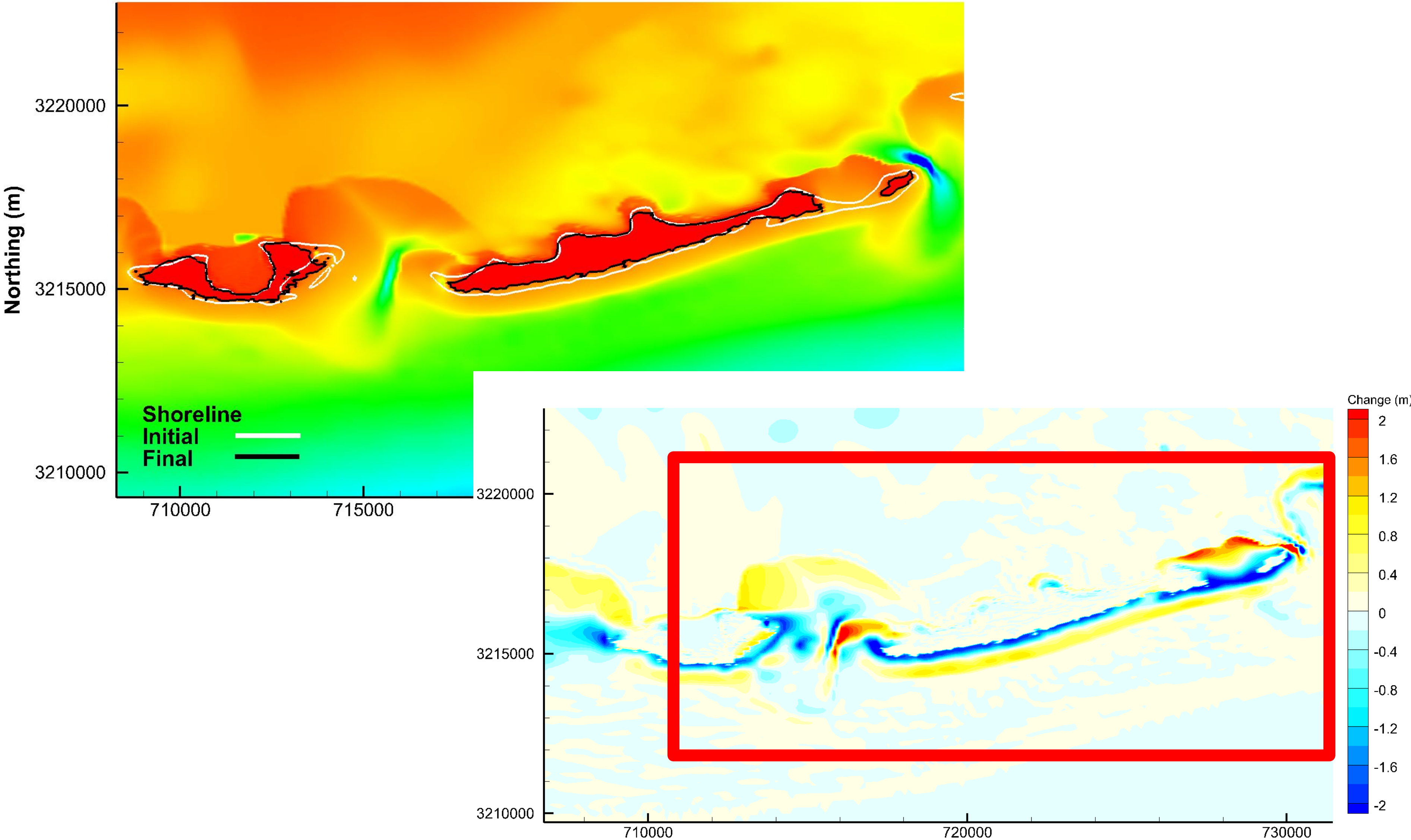


Early longer-term Results

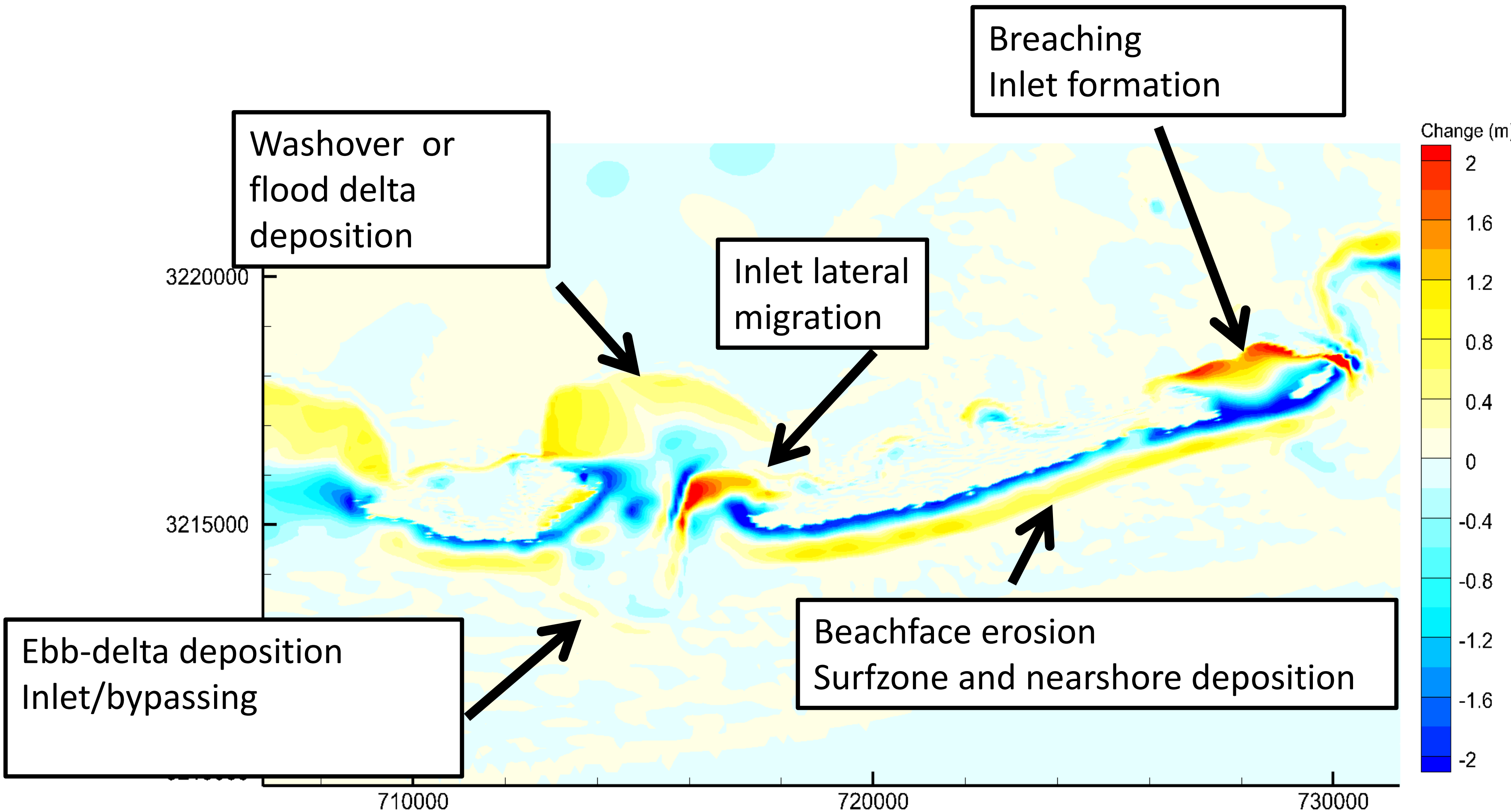




Early longer-term Results



Early longer-term Results



What Next?

Setup the final simulation matrix with team feedback

Simulations will include a selection of nearshore and offshore sand quality characteristics

Establish an array of results that provides barrier and adjacent environments morphologic change over time

Provide results to the ecomonic team for barrier morphology over time for timeframe of 20-50 years

Acknowledgements

Funding from Bureau of Ocean Energy Management through LSU CMI program

Collaboration with Louisiana State University and Mississippi State University resource economist team

Partial support from Louisiana Optical Network Initiative (LONI) for use of computational resources

Additional financial and logistical support from UNO-PIES

Complex spit patterns in the Southern Chandeleurs near Curlew, 2014