Apparent Relationship Between Navigation Channel Dredging Volumes and Energy Production

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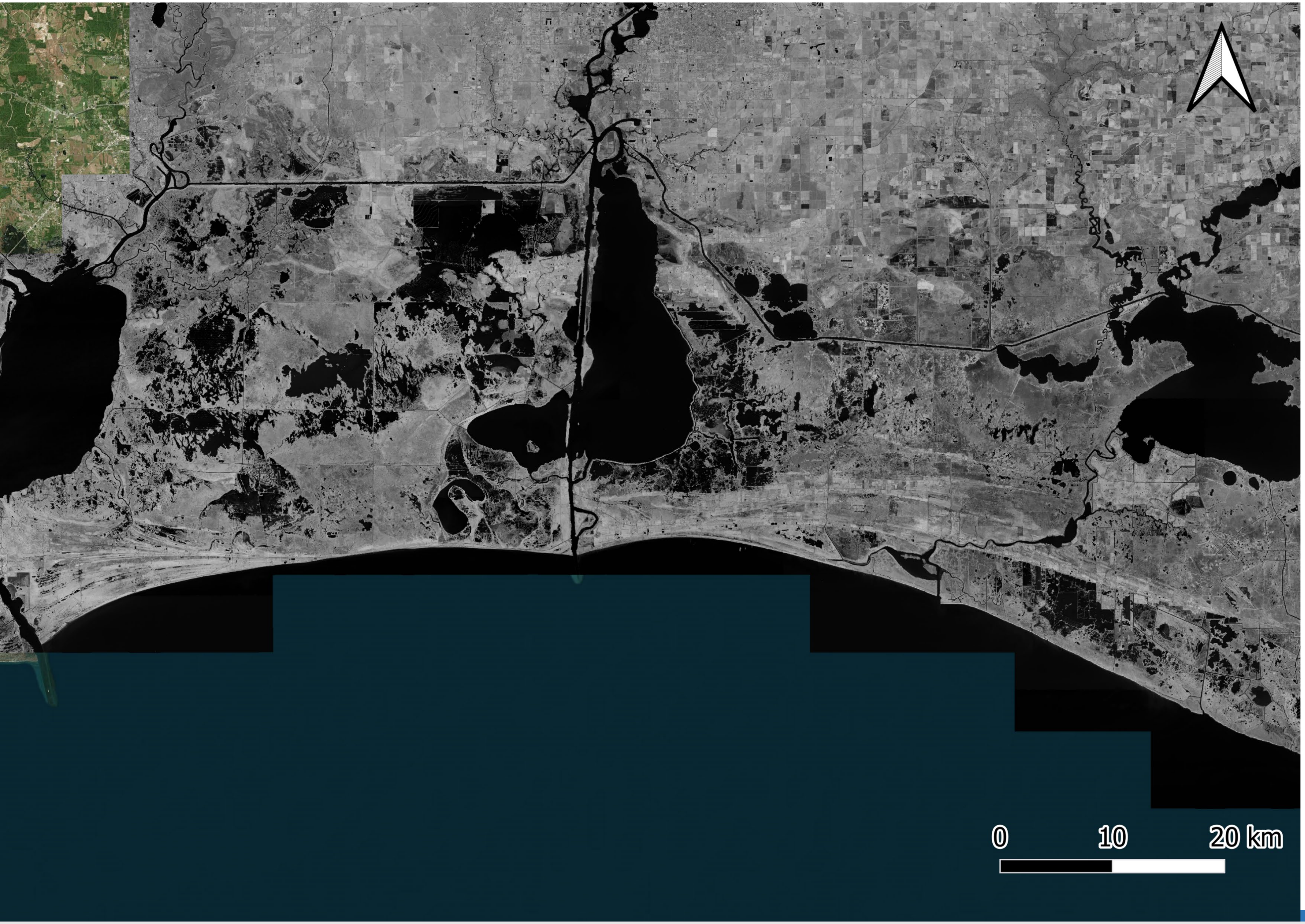
Calcasieu Ship Channel, LA



- Liquified Natural Gas facilities
- Chlorine plants
- "One of the most important" stopping points for migratory birds
- Historically also heavily used for fur trapping, farming, some oil and gas production – Pecan Island.
- Critical protection for nearby inland communities, LNG plant.
- ~170m of erosion in 10 years (2009-2019)

Calcasieu Ship Channel, LA

APPROACH: Select one case study with:

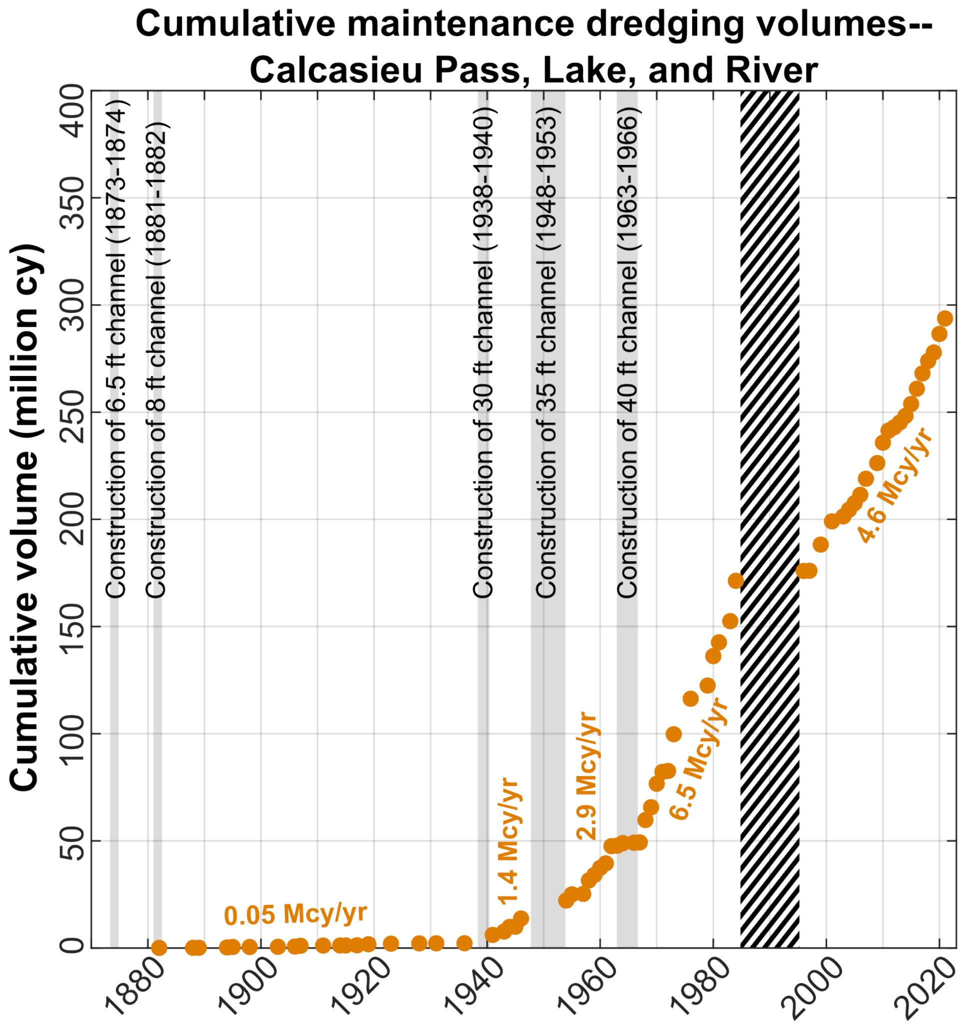
- Decades of modification
- A long record of data

TASKS:

1. Accumulate historical records of dredging and morphology
2. Numerical modeling to evaluate historical dredged sediment placement strategies
   - Compare to dredging data
3. <u>Data analysis at local to basin scale</u>
   - <u>Investigate factors excluded from the modeling</u>

Historical Dredging Rates

- Channel and dredging information was determined from the Annual Reports to the Chief of Engineers, U.S. Army, on Civil Works Activities between 1874 – 1980
- Dredging information before 1980 was combined with more recent data from 1996 to 2021 and grouped by channel configuration to understand decadal scale shoaling changes
- Are there comparisons that we can make with available data and numerical model results to explain changes in dredging rates?



Sediment Budgets

Source	Volume (M CY/Y)	% Dredge Volume
Calcasieu River	0.26	6
Bankline Erosion	0.7	14
Wetland Erosion	0.5-1.8	10-38
Gulf of Mexico	1	
Total	2.5-3.8	51-79

	Unaccounted Volume
ERDC	21-49%
The Water Institute of the Gulf	52-73%

No indication in any of the project's results suggests that an engineering solution can be offered that would clearly reduce substantial shoaling that is coming from a unique source within the system. In summary, there are no easy engineering solutions to reduce shoaling. (Perkey et al. 2022)

(Perkey, Priestas, Corbino, Brown, Hartman, Tarpley and Phu V, 2022)

Wetland Erosion

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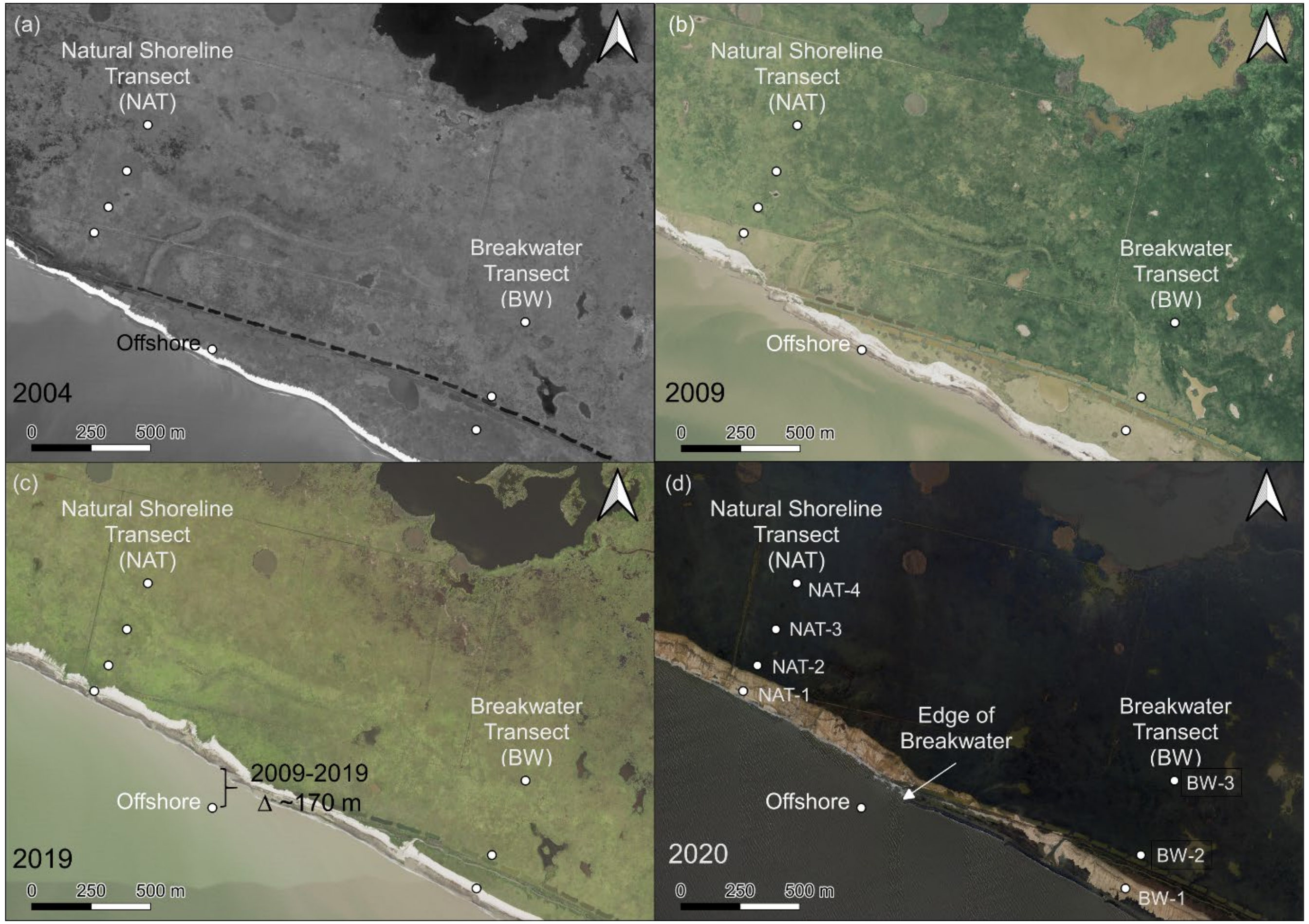
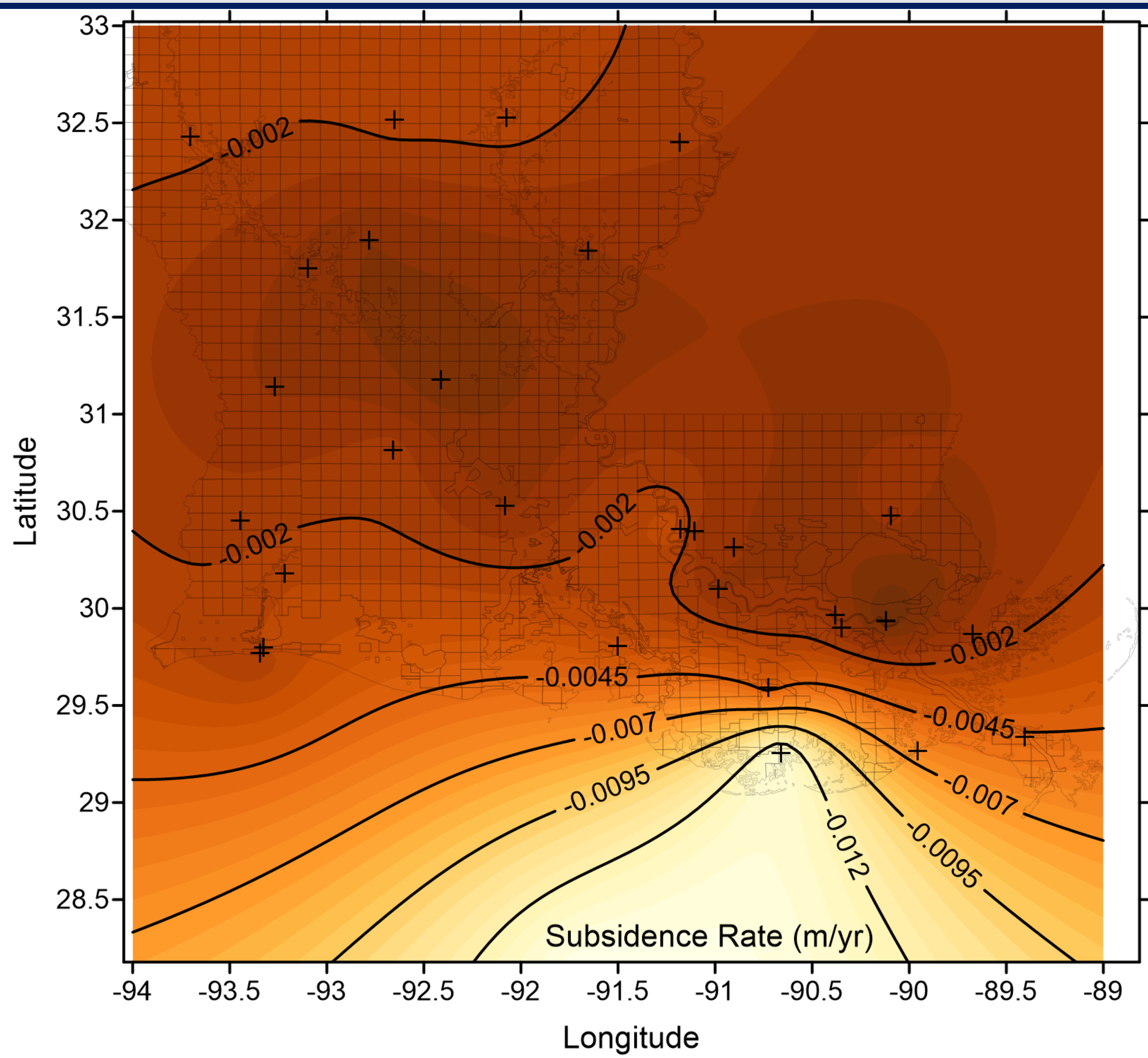
Subsidence? Hurricanes? Oil and gas canals?



(Perkey et al. 2022; Cadigan et al. 2023)

Geological Environment – Delta Plain vs. Chenier Plain

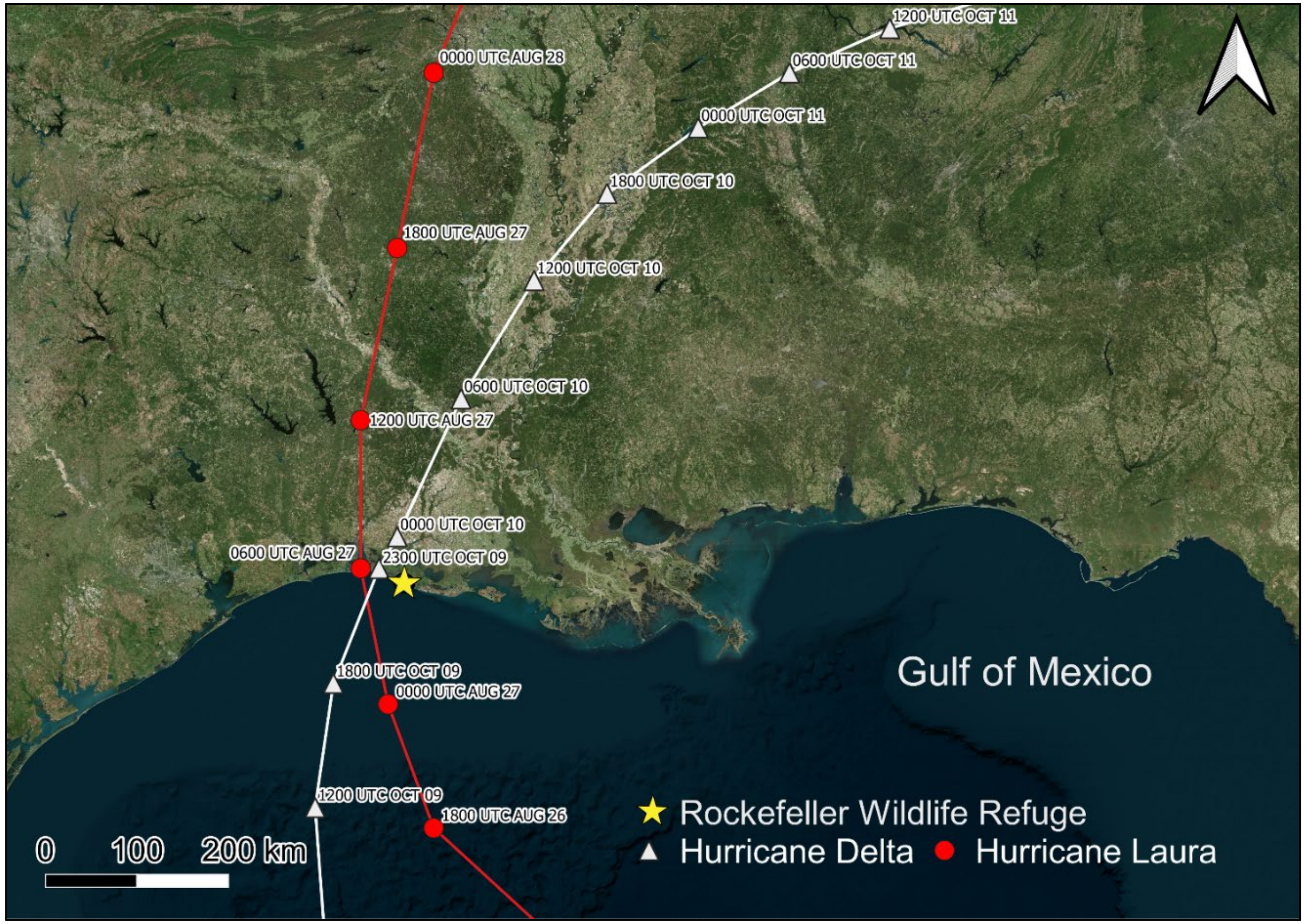
- Delta avulsions – when Mississippi River took a westerly course, sediment was transported and deposited along southwest Louisiana.
- Those pulses built up higher elevation oak ridges (oak trees grew in these higher elevation ranges) “cheniers”
- Water and plant material is built up between these ridges with occasional mineral rich sediment from offshore during storms
- Low-salinity, highly organic marshes
- Thinner Holocene sediments = less subsidence than deltaic plain.



(Map created using NOAA CORS)

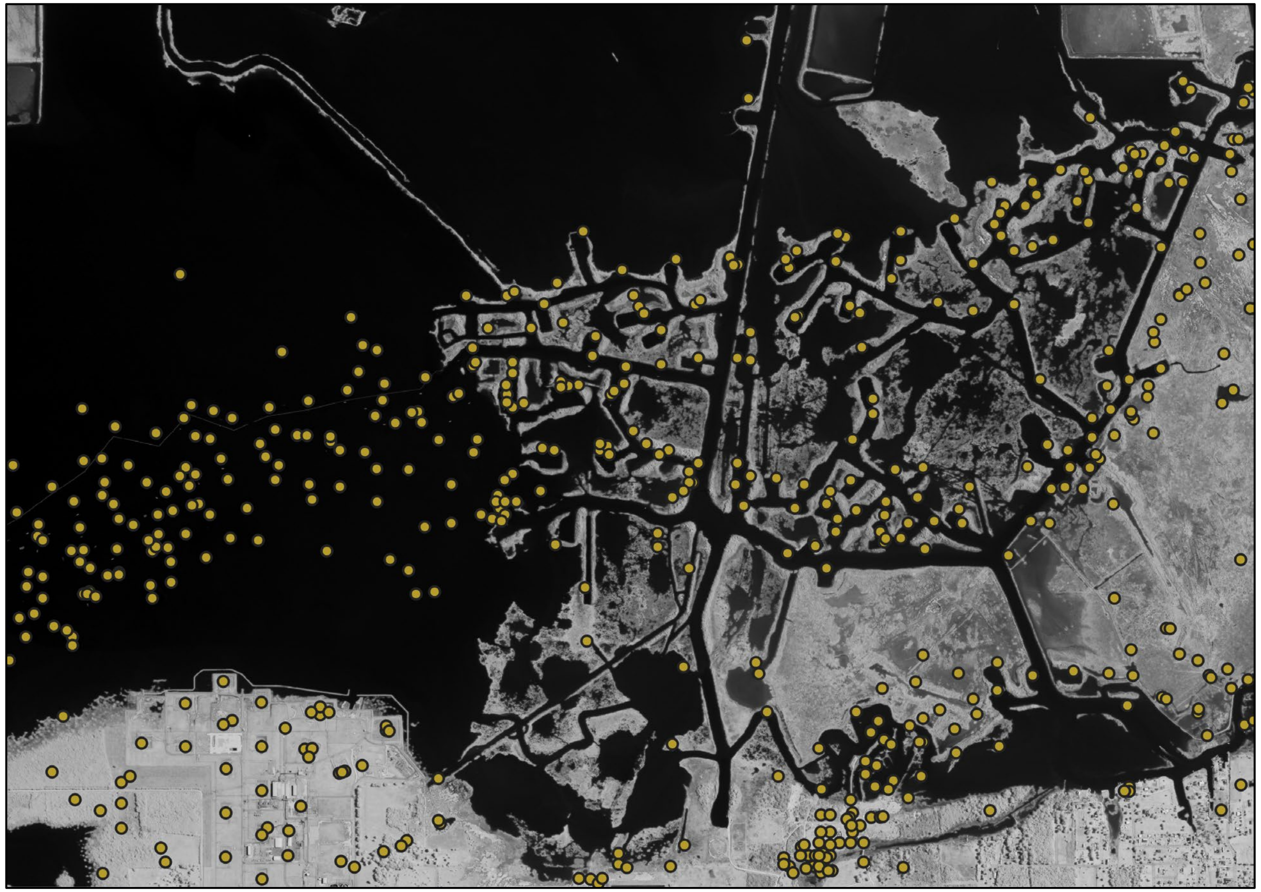
Hurricanes?

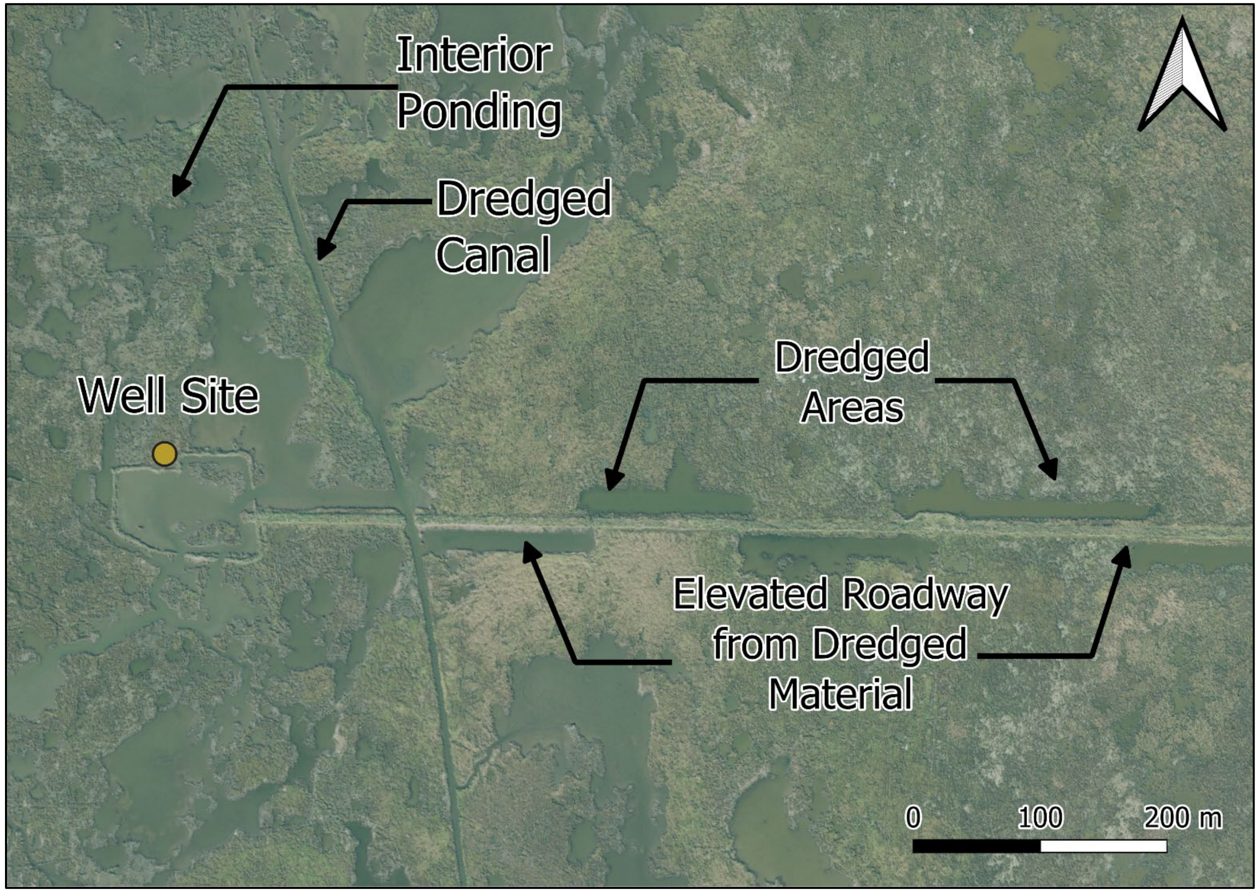
The average rate of erosion-driven shoreline retreat shows extreme rates of 19 m/yr and 25.5 m/yr during the years Hurricanes Rita (2005) and Ike (2008) struck (Yao et al., 2018).



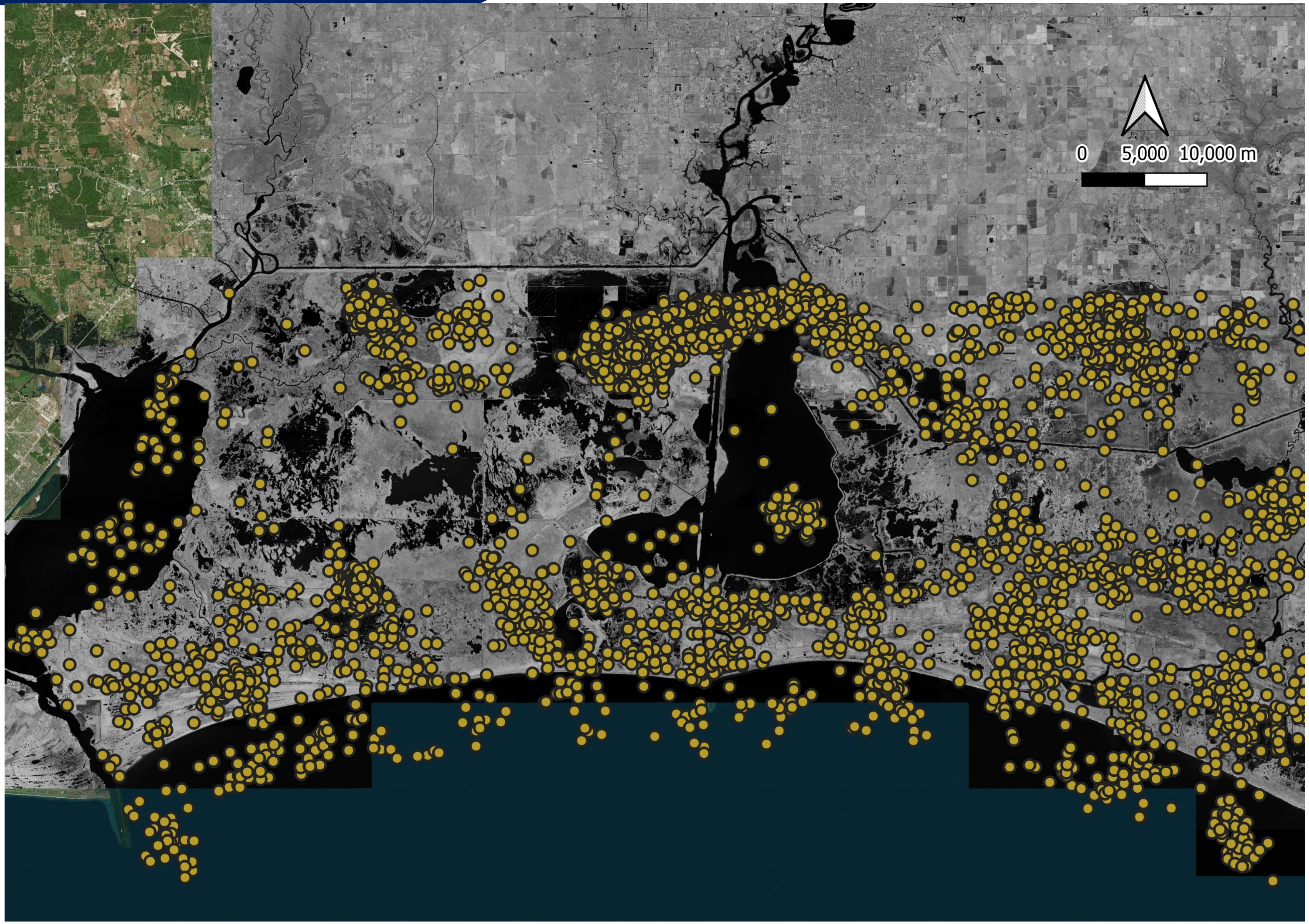
(Cadigan et al. 2023; Map created using NOAA CORS)

Energy Infrastructure / Hydrological Connections

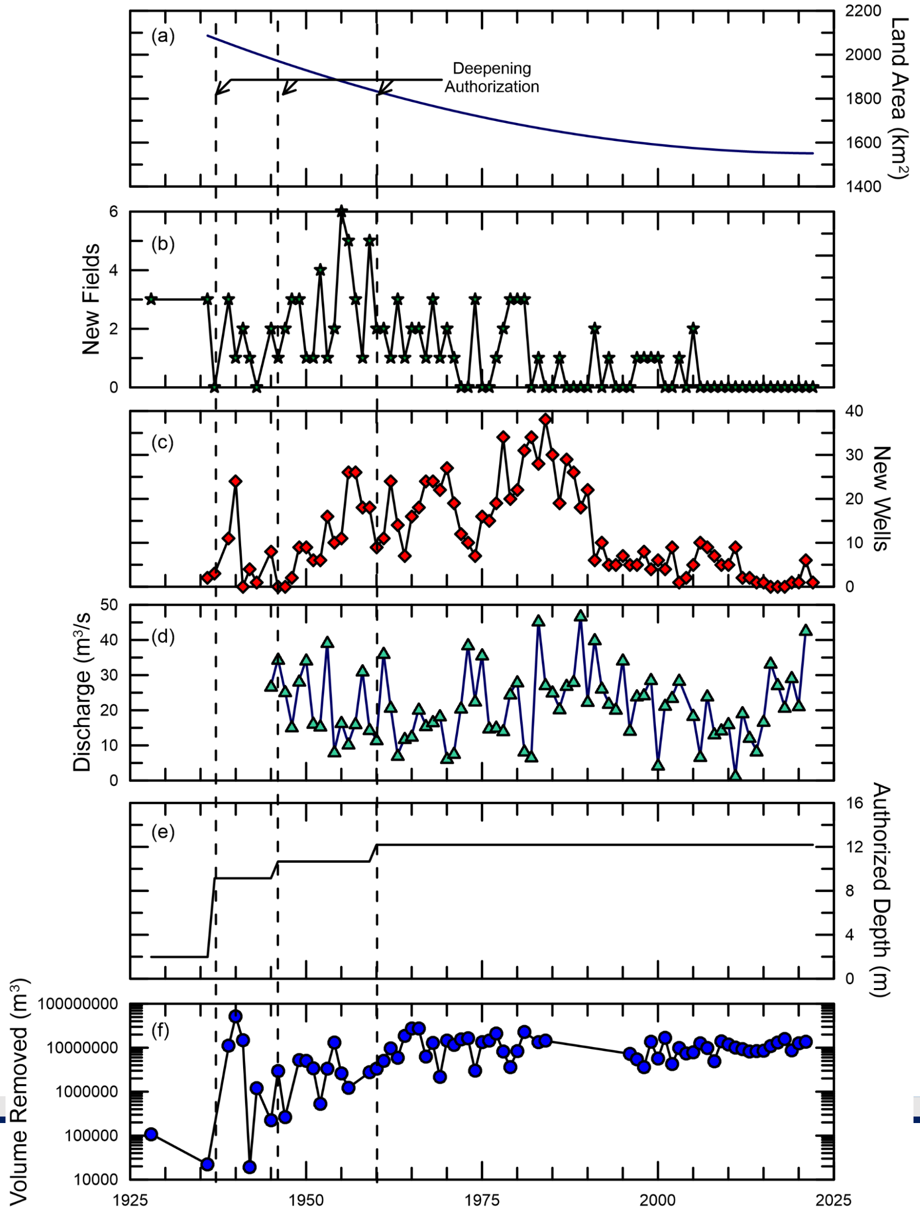




Oil and Gas Wells

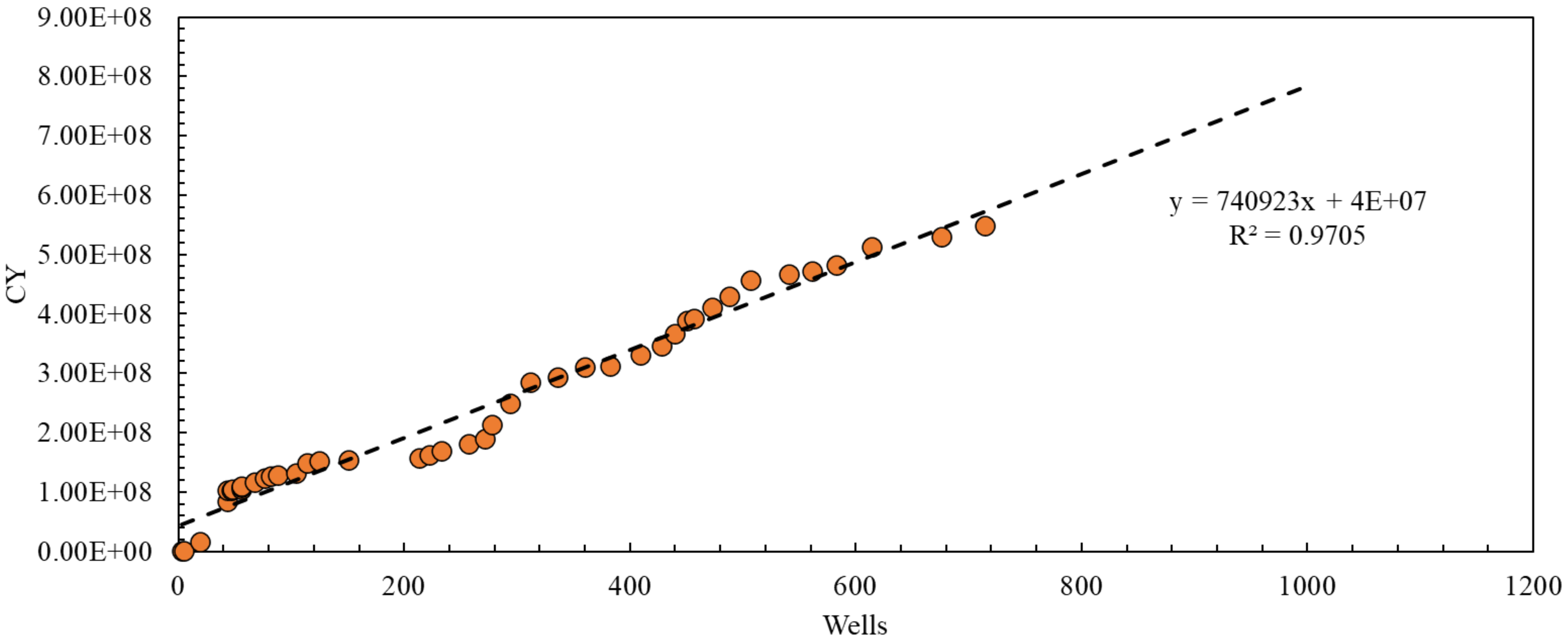


Data Sources and Limitations

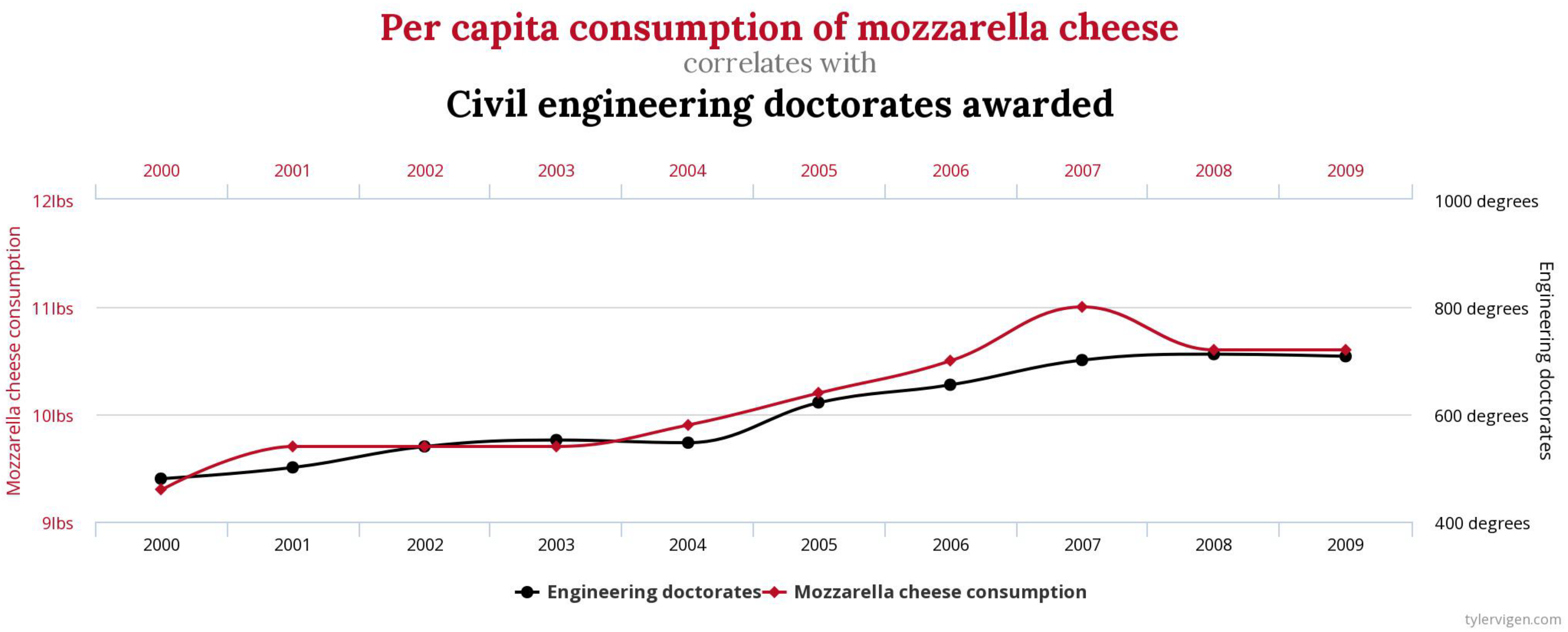


- USACE Chief's Reports
  - ❖Dredging Volumes
  - ❖Deepening Authorizations
- Louisiana DNR – SONRIS
  - ❖Oil and gas production records
  - ❖Permits for new wells
- USGS
  - ❖Brady Couvillion -- Land Loss and Model
  - ❖River Discharge

Exploratory Data Analysis: Volume dredged vs. Wells



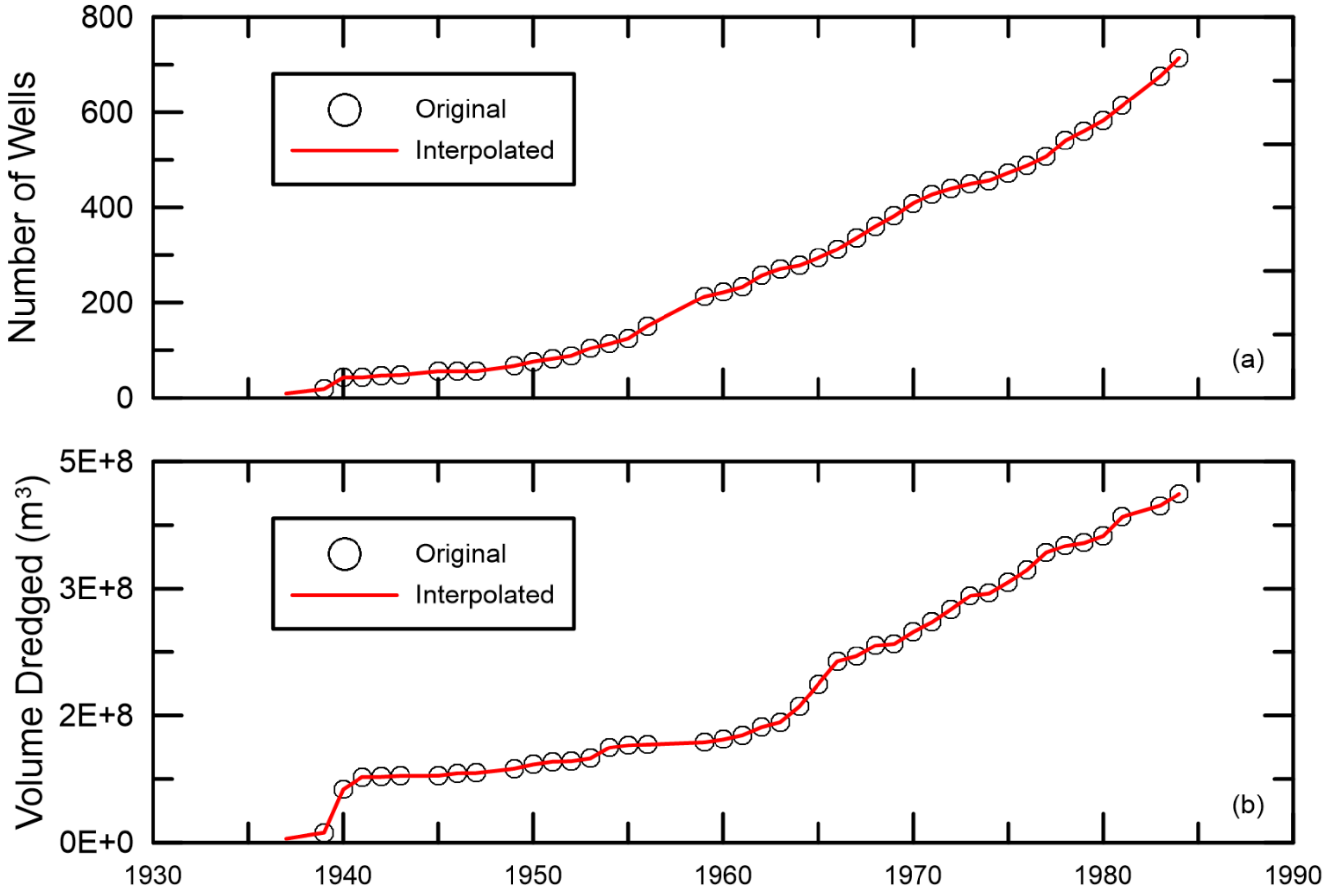
Data Analysis – Spurious Correlation of Time Series



- Spearman's Correlations
  - non-uniform distributions, less sensitive to outliers
- Granger Causality
  - Does one time series variable "cause" another?

Processing for Analysis

- Data re-interpolated linearly to 1-year intervals.
  - Granger analysis – lags are yearly
- Percent change calculated
- Variables like hurricanes: 0 for no hurricane, 1 for hurricane



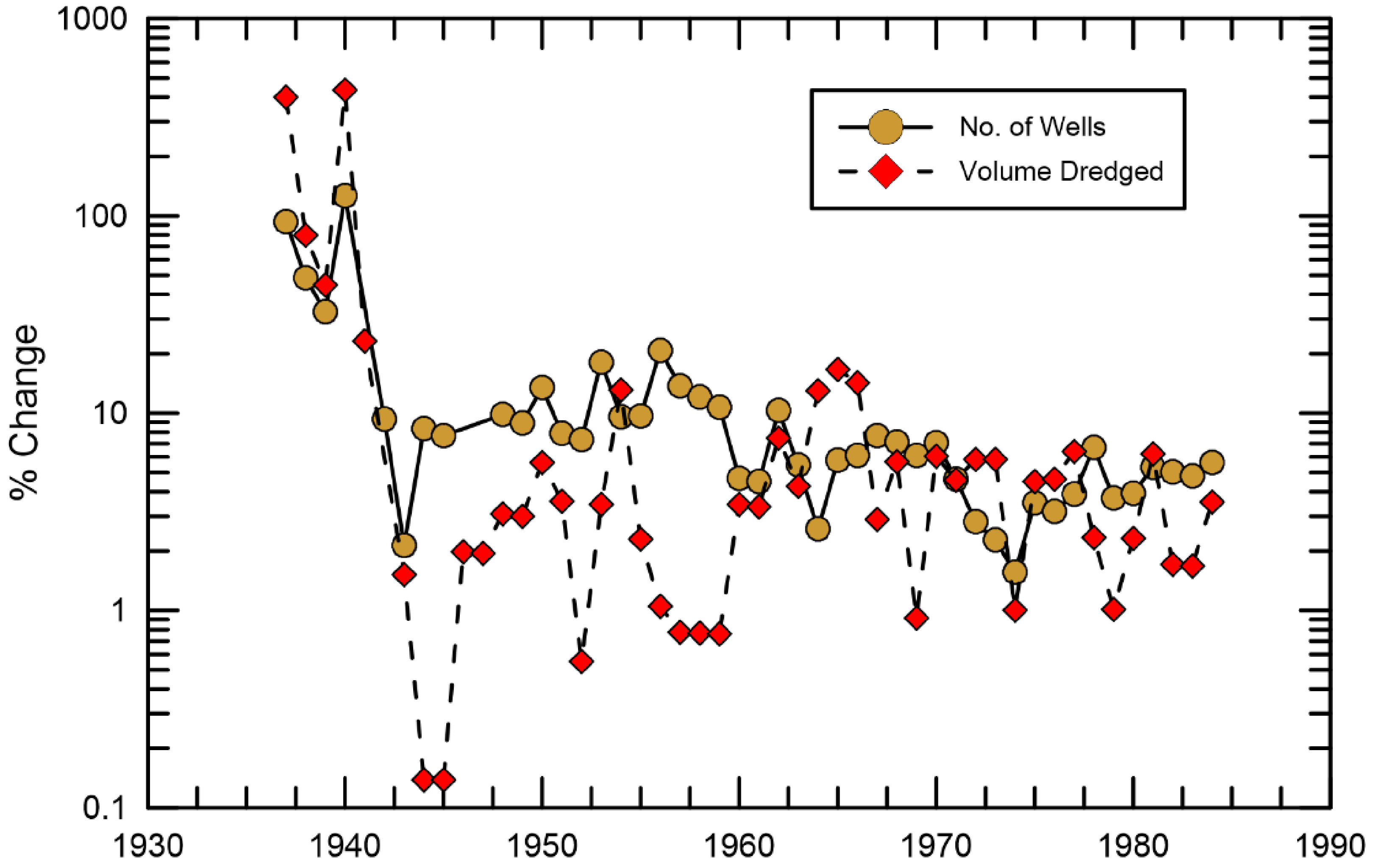
Spearman’s Correlations

Table 1: Spearman’s correlation (ρ) for percent change across all variables. Abbreviations: (H) hurricane occurrence, (D) authorized channel depth, (V) volume removed, (CV) cumulative volume removed, (O) oil, ,produced, (G) gas produced, (CG) cumulative gas produced, (CO) cumulative oil produced, (Q) discharge, (LA) land area, (NW) new wells, (NF) new fields, (CF) cumulative fields, (CW) cumulative wells

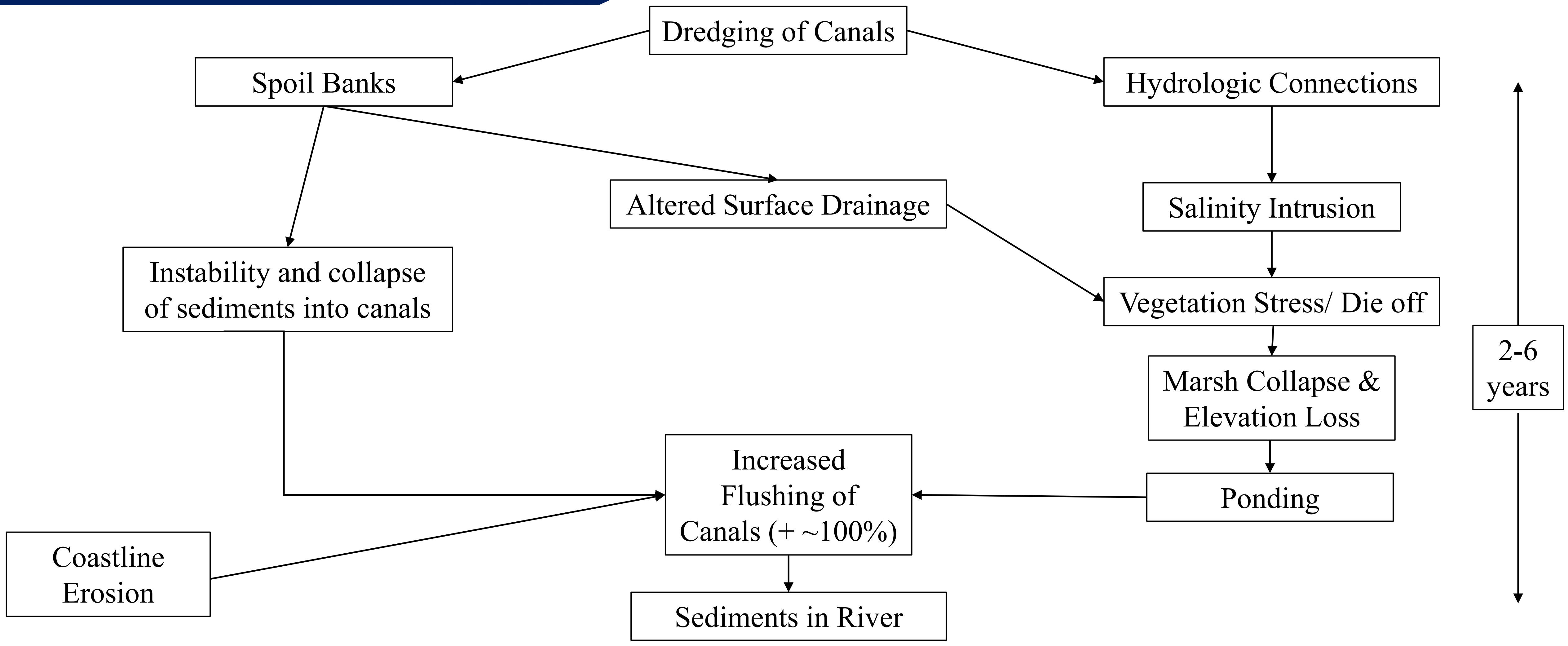
	H	D	V	CV	O	G	CG	CO	Q	LA	NW	NF	CF	CW
H	1													
D		1												
V	-0.4	0.24	1											
CV	**-0.41**	0.19	0.28	1										
O	-0.48		-0.07	0.1	1									
G	-0.42		-0.27	-0.02	0.34	1								
CG	-0.32		-0.21	**0.62**	0.25	0.35	1							
CO	-0.48		-0.01	**0.57**	0.48	0.34	**0.98**	1						
Q	-0.16	0	0.09	-0.03	-0.04	-0.2	-0.04	0	1					
LA	0.53	-0.25	-0.12	**-0.78**	-0.1	-0.31	**-0.99**	**-0.73**	0.02	1				
NW	-0.06	-0.14	-0.01	0.13	0.08	0.05	0.08	0.04	-0.16	-0.11	1			
NF		-0.17	-0.24	0.18	-0.19	0.1	0.52	0.1	-0.24	-0.27	-0.14	1		
CF	-0.22	0.06	-0.07	**0.57**	-0.09	0.08	0.54	0.37	-0.06	**-0.77**	0.08	0.73	1	
CW	-0.32	0.03	0.06	**0.65**	0.08	0.35	**0.85**	0.63	-0.06	**-0.74**	0.43	0.16	0.57	1

Granger Causality

Lags (years)	F-Test (CW, CF)	p-value (CW,CF)
1	2.78, 0.847	0.104, 0.362
2	**3.23, 0.585**	**0.048, 0.561**
3	**4.48, 0.325**	**0.008, 0.807**
4	**3.76, 0.670**	**0.010, 0.616**
5	**2.64, 0.584**	**0.038, 0.712**
6	**2.03, 0.358**	**0.086, 0.901**
7	1.65, 0.502	0.155, 0.827
8	1.34, 0.519	0.263, 0.833
9	13.24, 0.877	0.000, 0.556
10	15.98, 0.603	0.000, 0.796



Theoretical Framework



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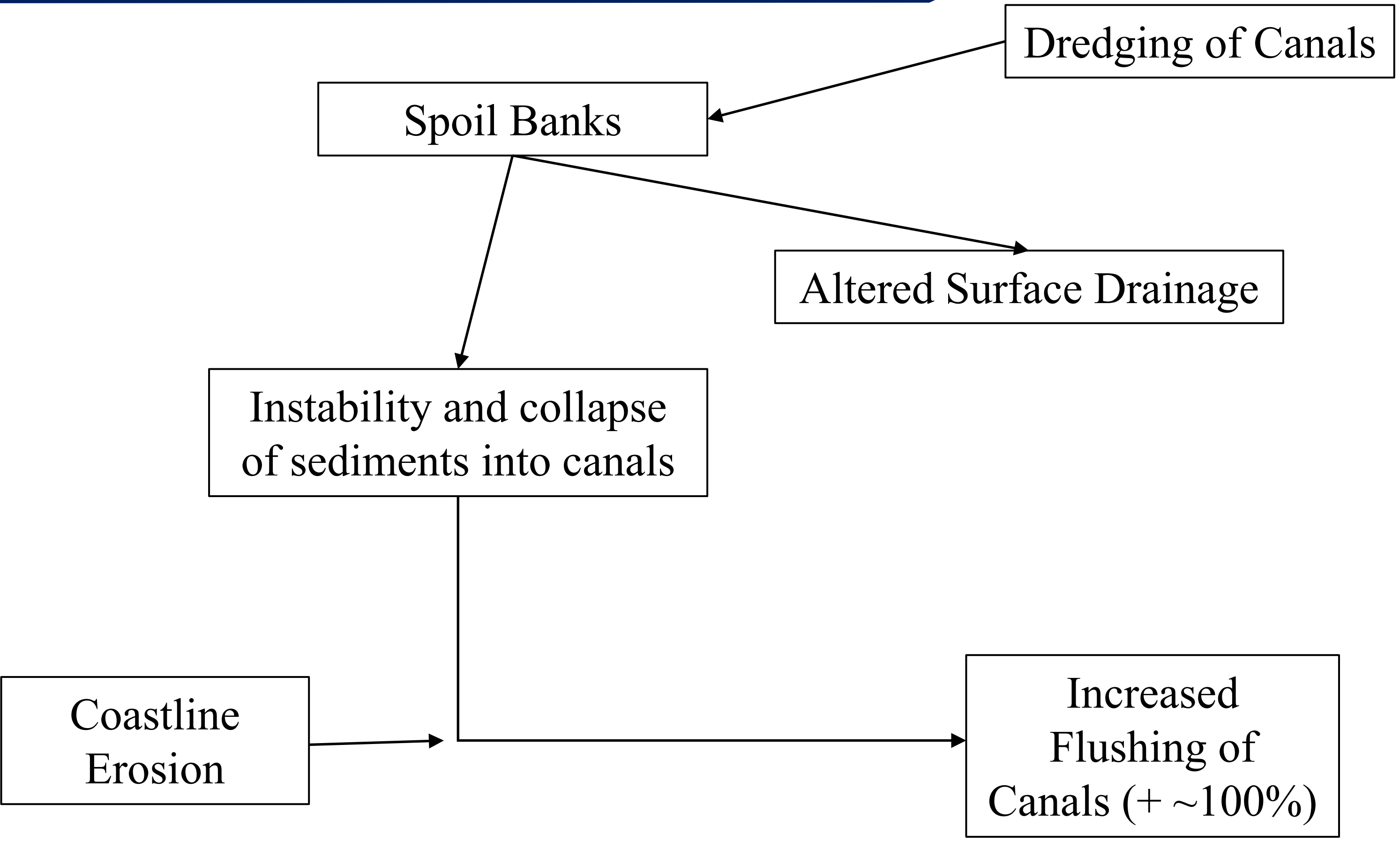
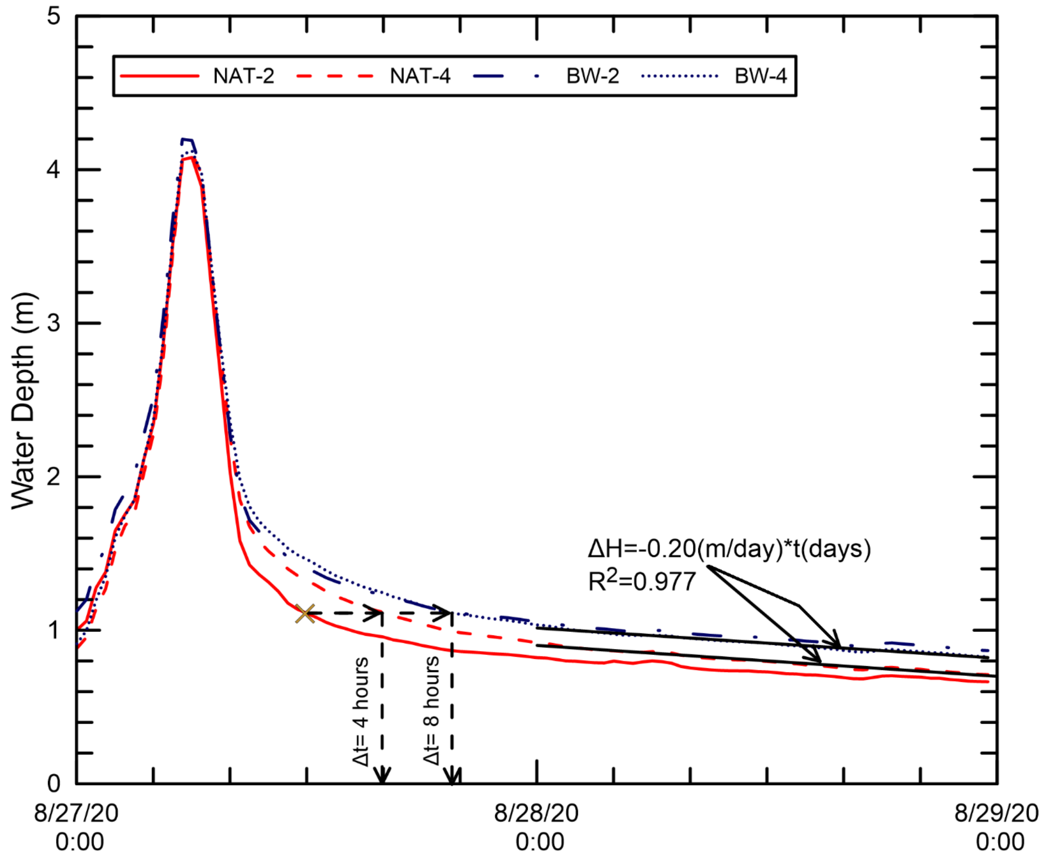
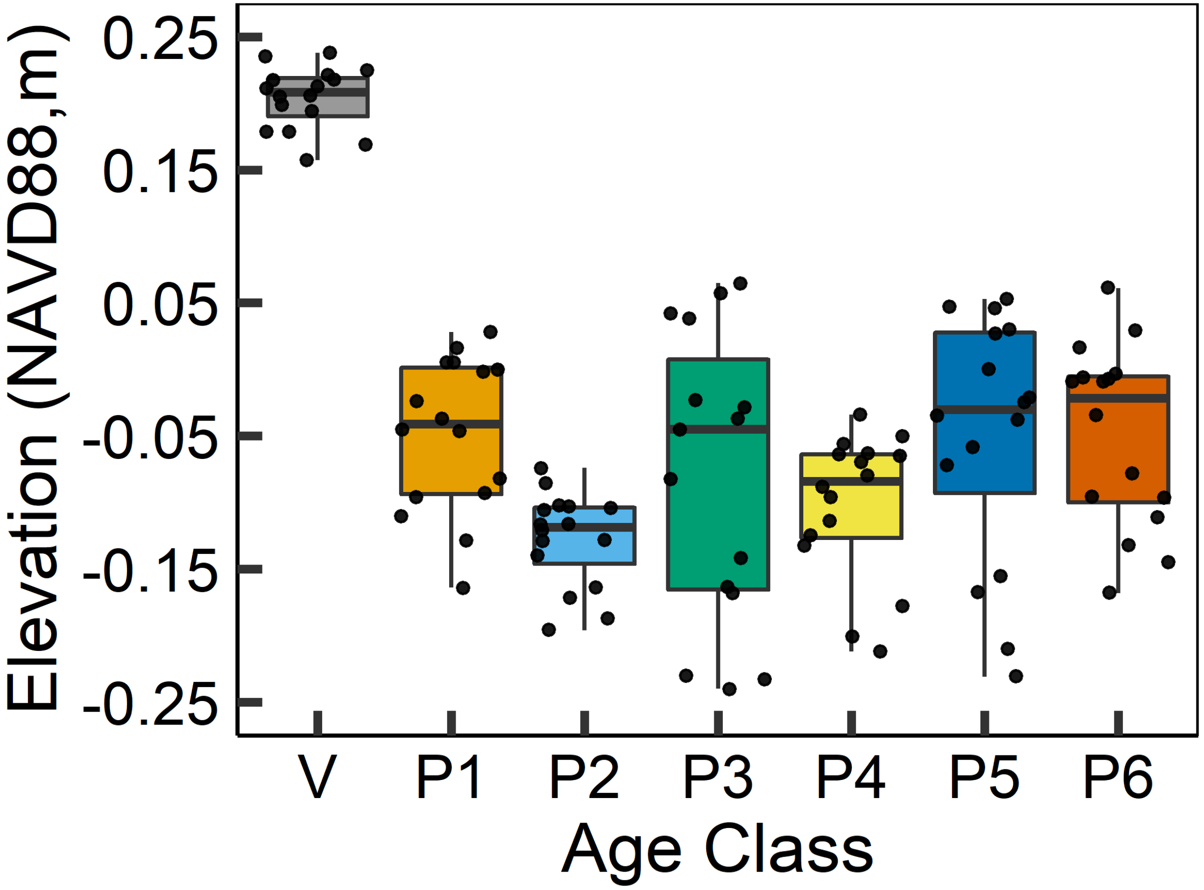


(Doiron and Whitehurst, 1974).



(Cadigan et al. 2023)

Marsh Collapse



Dredging of Canals → Hydrologic Connections → Salinity Intrusion → Vegetation Stress/ Die off → Marsh Collapse & Elevation Loss → Ponding

Vegetation Stress/ Die off → Palaeoecological study of diatoms show rapid decrease in fresh vegetation between 1940 and 1968 (Smith, 2012; Visser et al., 2000).

Conclusions / Discussion

- Strong correlation and causation relationship between wells and volume dredged:
  - Granger Causality testing indicated that a change in the number of wells in the region Granger causes a corresponding change in the volume of sediment dredged from the channel at time lags of 2-6 years.
- Proximity to coastline affects tidal prisms and currents which flush canals of sediment (Doiron and Whitehurst, 1974; Bain et al. 2022).
  - Erosion rates ~17m/yr (56 ft/yr)
- Light (1976) suggests that dredged canals in another coastal Louisiana basin increased peak discharge rates by approximately 100%.
- Hydrologic network facilitated salinity intrusion leads to marsh vegetation die-off, and ultimately collapse into ponding.
- Plug the canals?
- Numerical modeling may help better understand flushing process

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Thank you!

Questions?

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