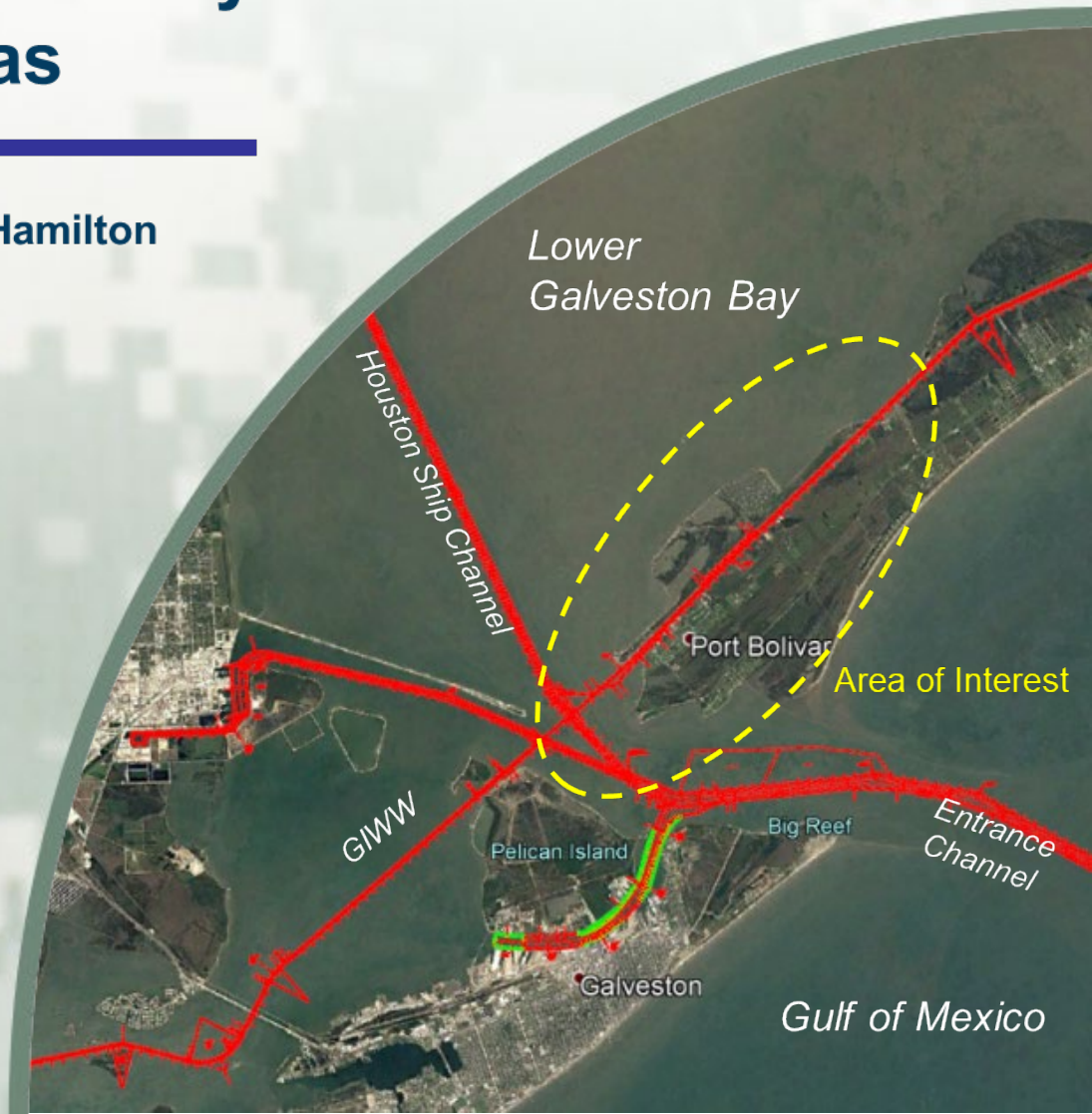
Modeling Alternatives to Reduce Channel Shoaling at Bolivar Flare of Gulf-Intracoastal Waterways in Galveston Bay, Texas

ERDC
Engineer Research & Development Center

Lihwa Lin, Zeki Demirbilek, and Paul Hamilton
US Army Corps of Engineers

CS'19, St Pete Beach, FL

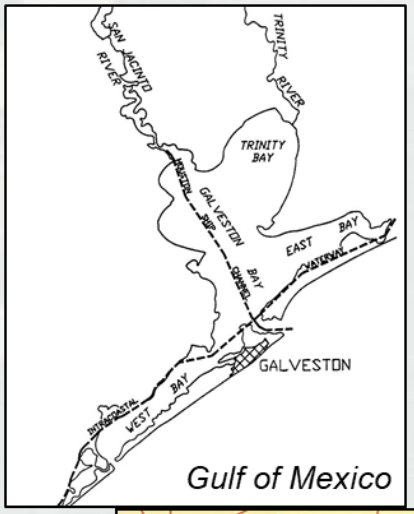
27-31 May 2019

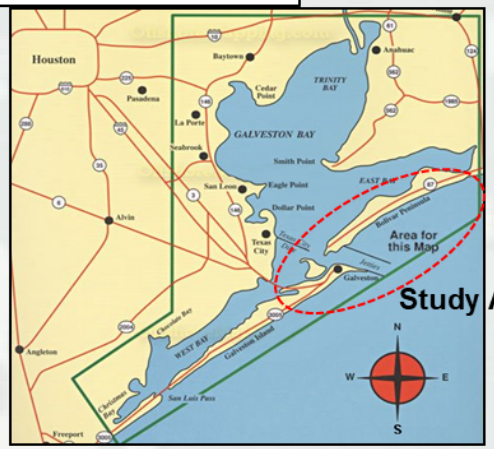


US Army Corps of Engineers®

Outline

- Background & Objectives
- Numerical Models & Settings
- Hydro, Wave, and Sediment Transport Simulations
- Modeling Alternatives
- Summary & Conclusions



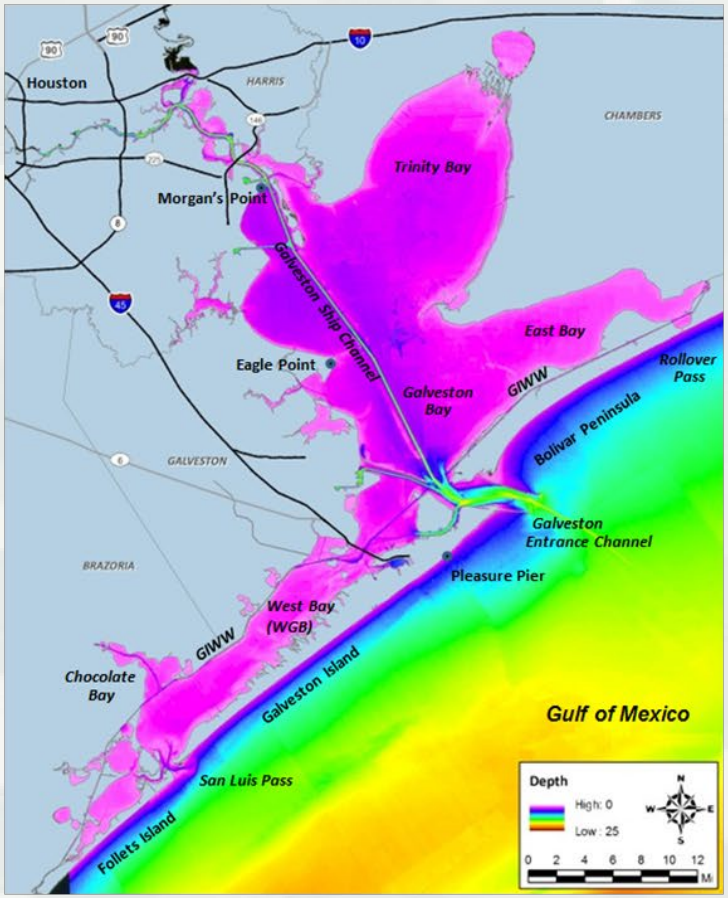


Study Area

Background

- The Gulf Intracoastal Waterways (GIWW), a light-draft inland channel mainly for barge transportation, runs along the lower side of Galveston Bay, Texas.
- Extensive shoaling in the GIWW Bolivar Flare, east of junction with Houston Ship Channel, in recent years has resulted in the need for more frequent dredging.
- USACE Galveston District considered structural alternatives to reduce high shoaling rate in the Bolivar Flare.
- RSM and CIRP assisted in the studies.

Galveston Bay System



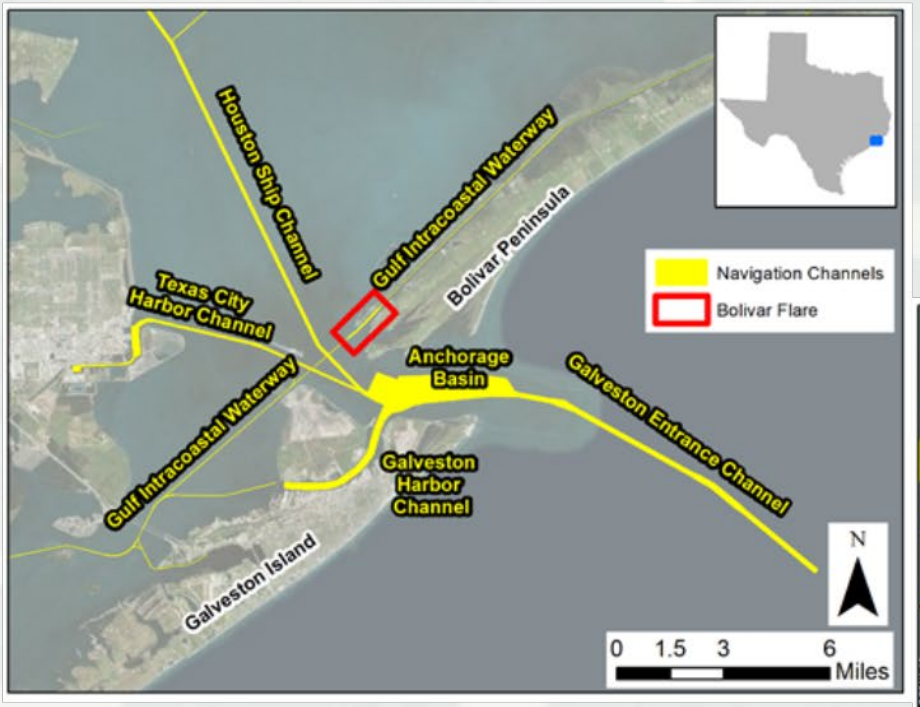
Muliti-inlet system:
1. Galveston Bay Entrance
2. San Luis Pass
3. Rollover Pass

Four subbays:
1. Galveston Bay
2. Trinity Bay
3. East Bay
4. West Bay (WGB)

Two main channels:
1. GIWW
2. Houston Ship Channel (HSC)

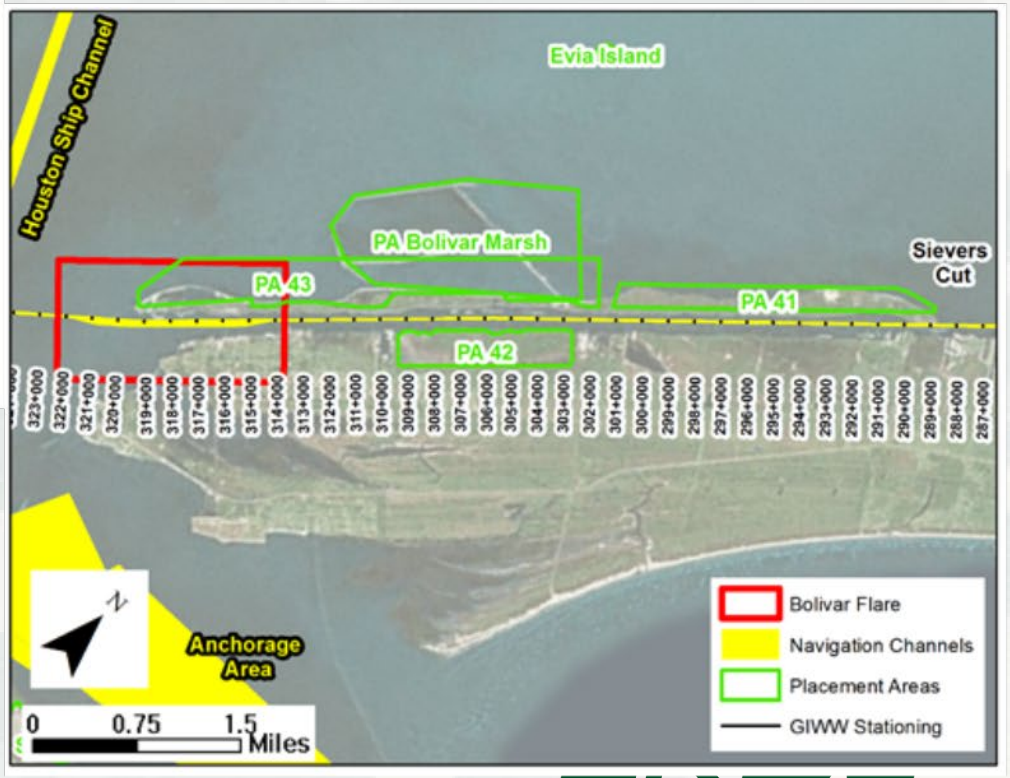
Galveston Bay on average 7-9' deep; WGB ~ 5-7' deep
GIWW, 125' wide, 12' deep; HSC, 530' wide, 45' deep

GIWW Stationing & Placement Areas (PA)



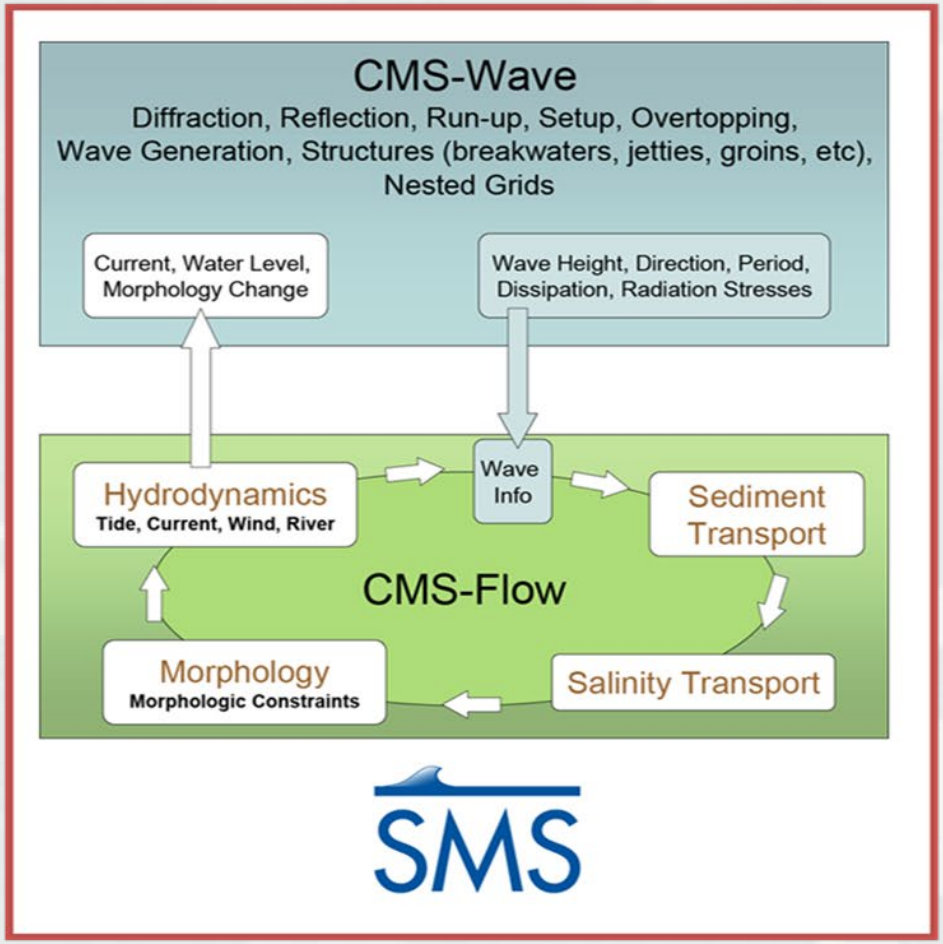
Regional context of the study area

Bolivar Flare and PAs 41, 42, and 43

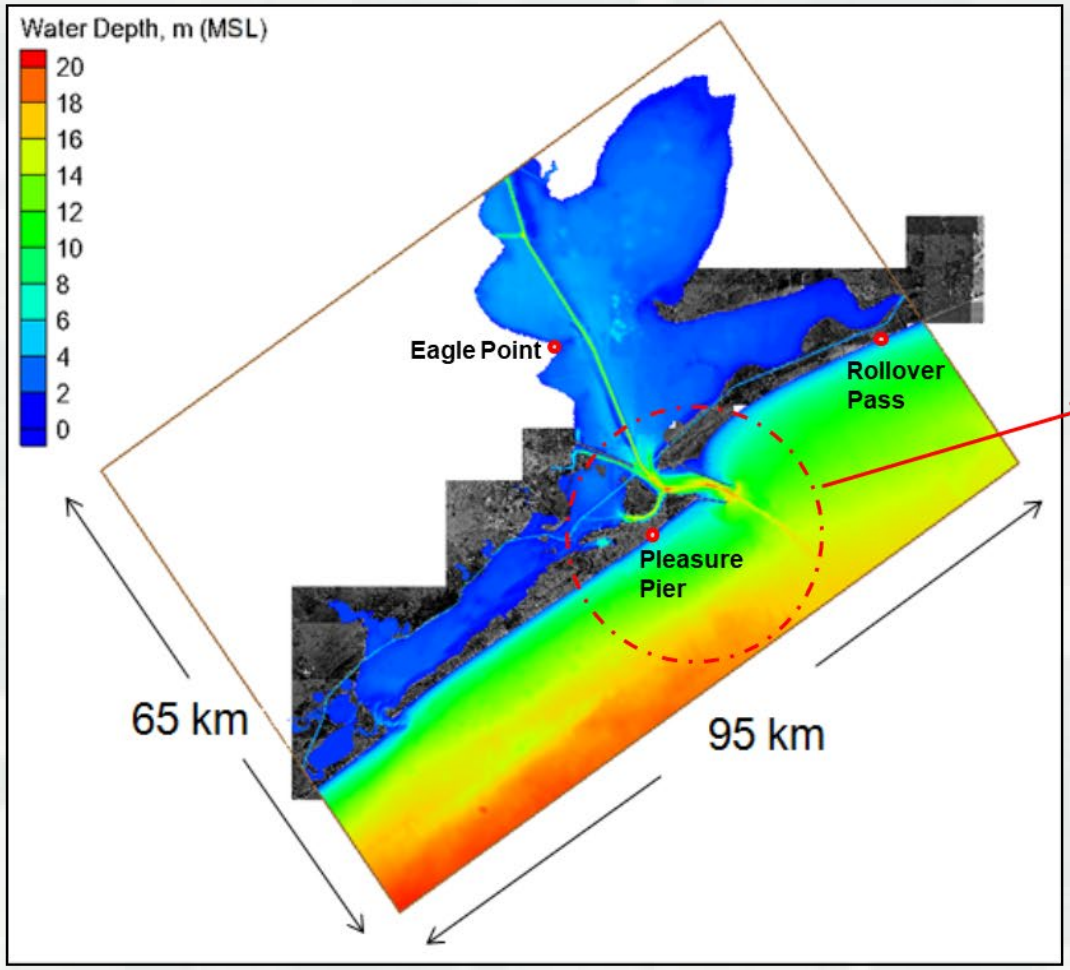


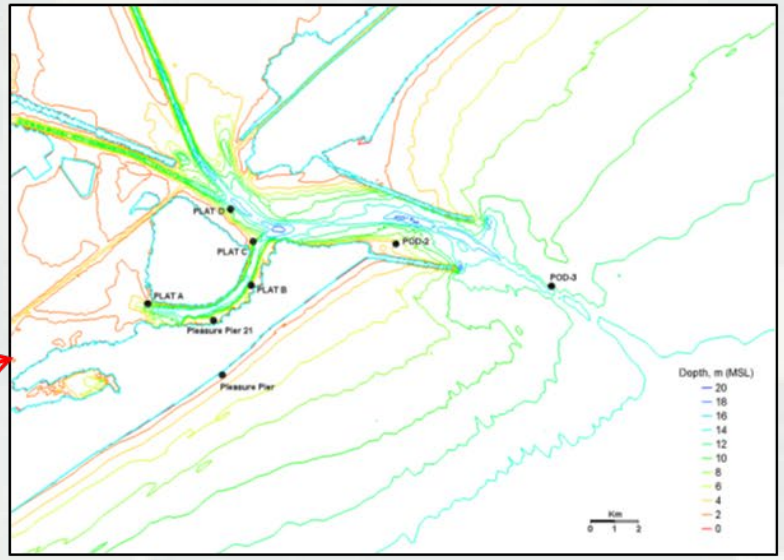
Numerical Models

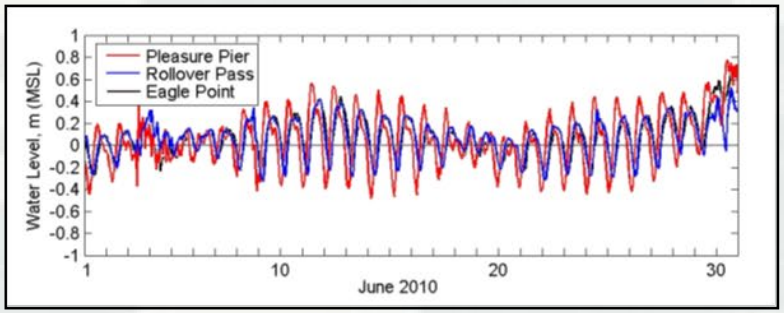
Coastal Modeling System (CMS)



CMS Grid and Water Level Input

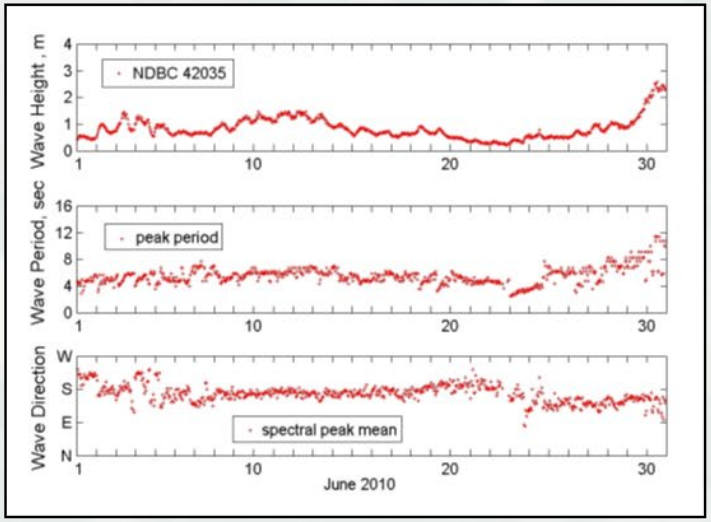


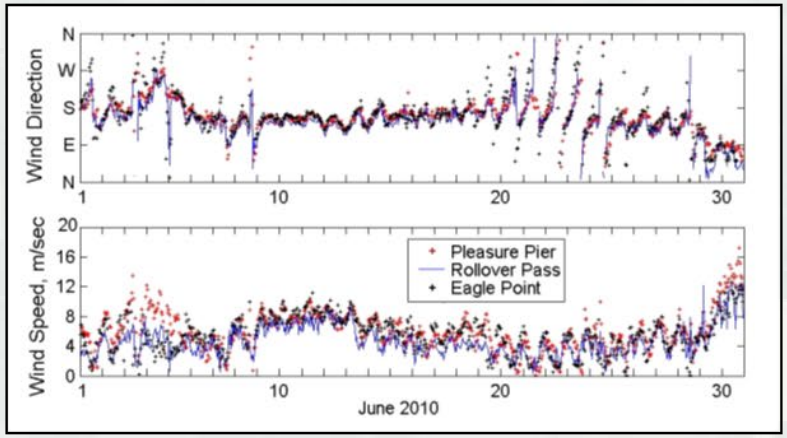


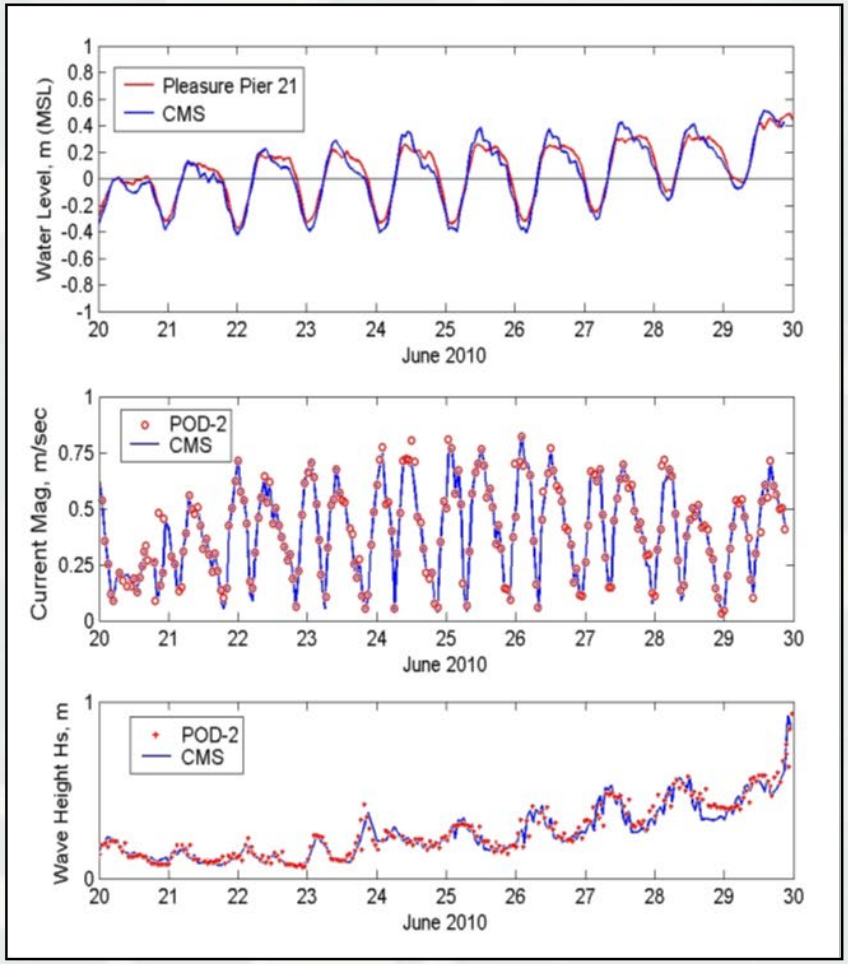


Model Calibration: June 2010

Wind Wave Input & Model Calibration

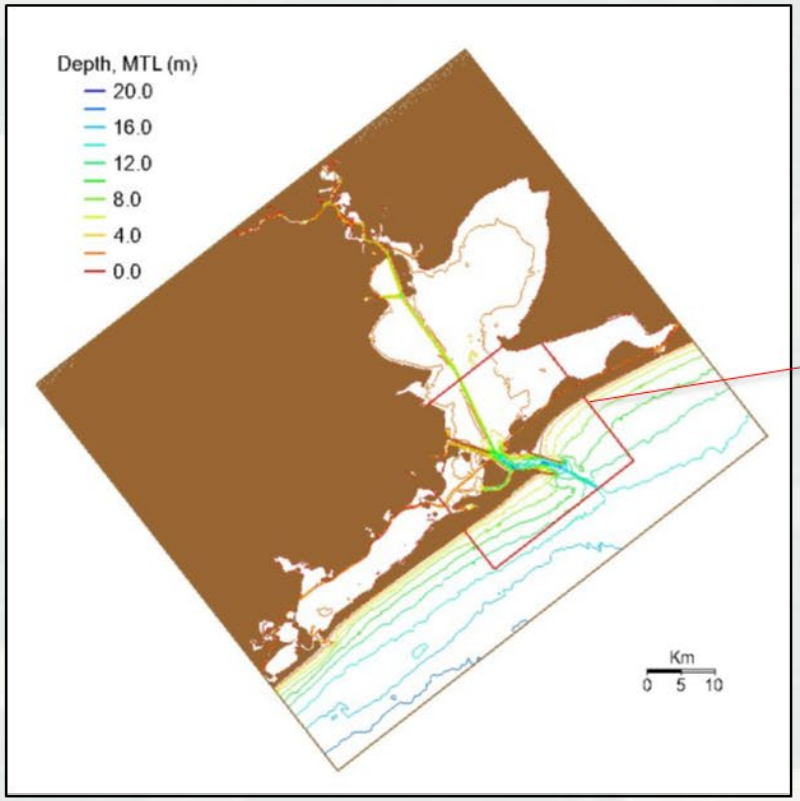




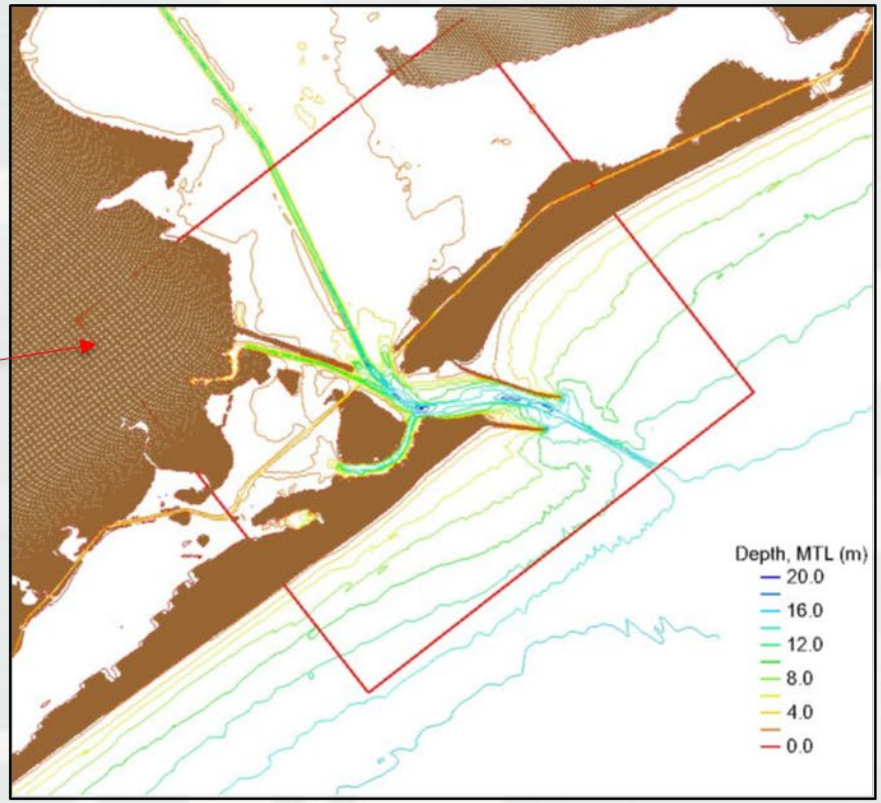


Model Calibration: June 2010

CMS Model Domains & Bathymetry

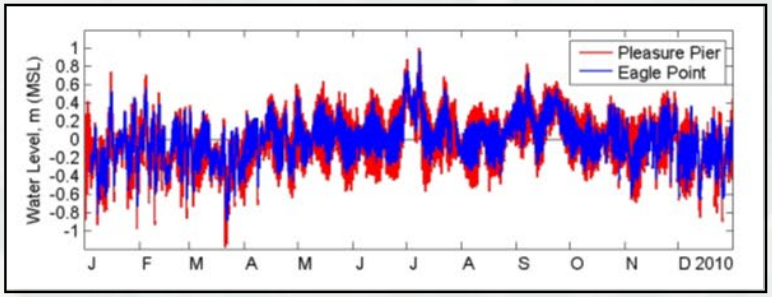


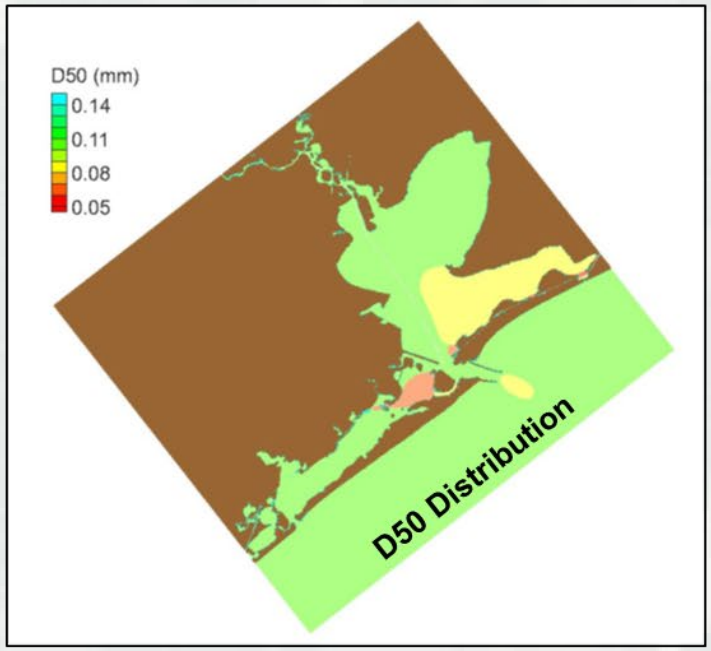
Regional Model Domain
(85 km x 95 km)

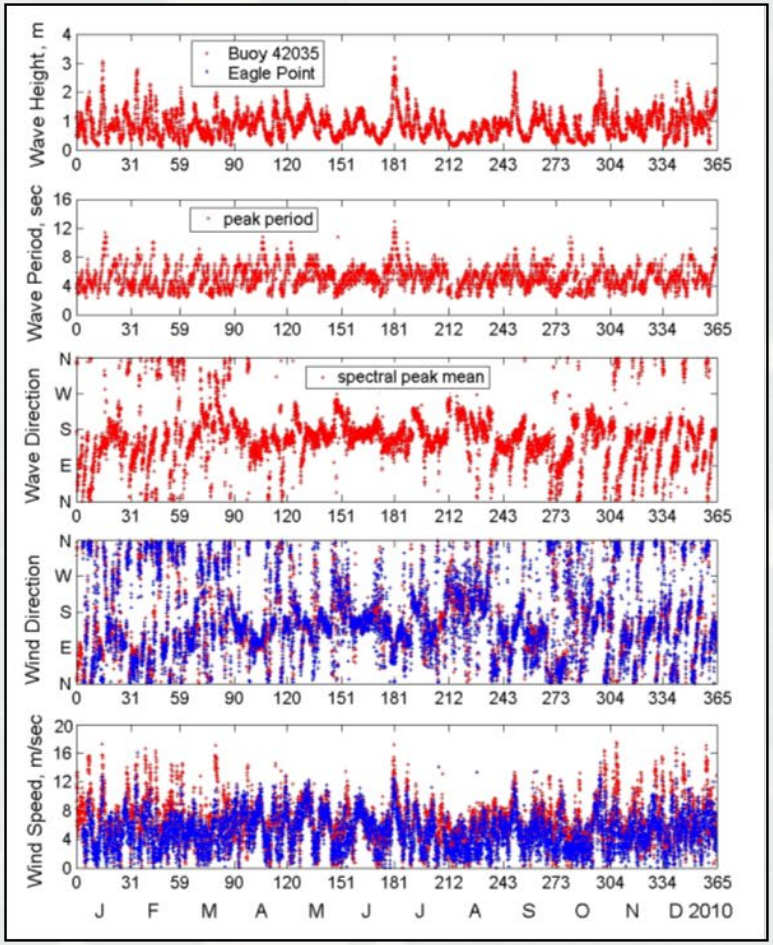


Local Model Domain
(30 km x 30 km)

Mixed Sediment Transport Modeling

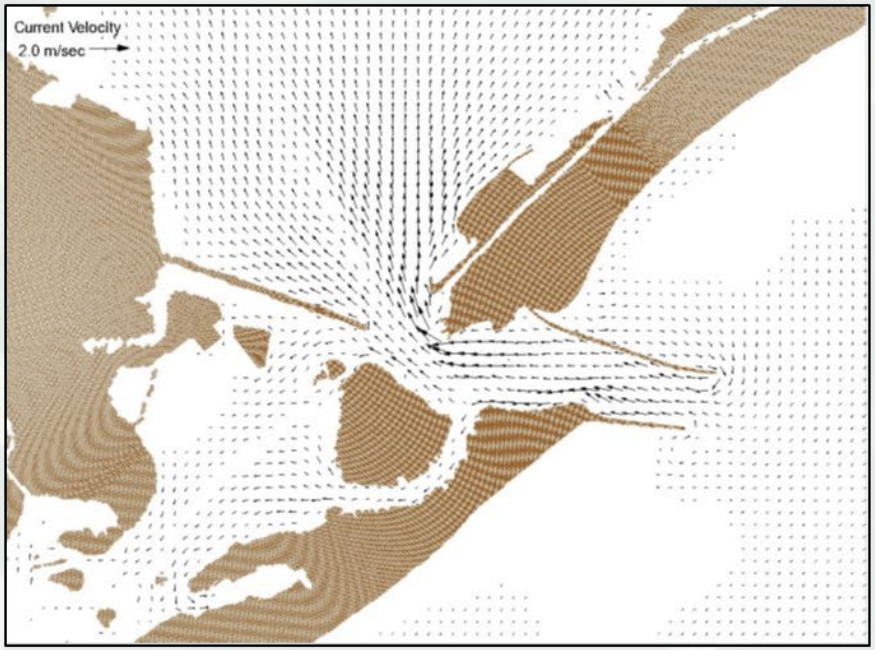




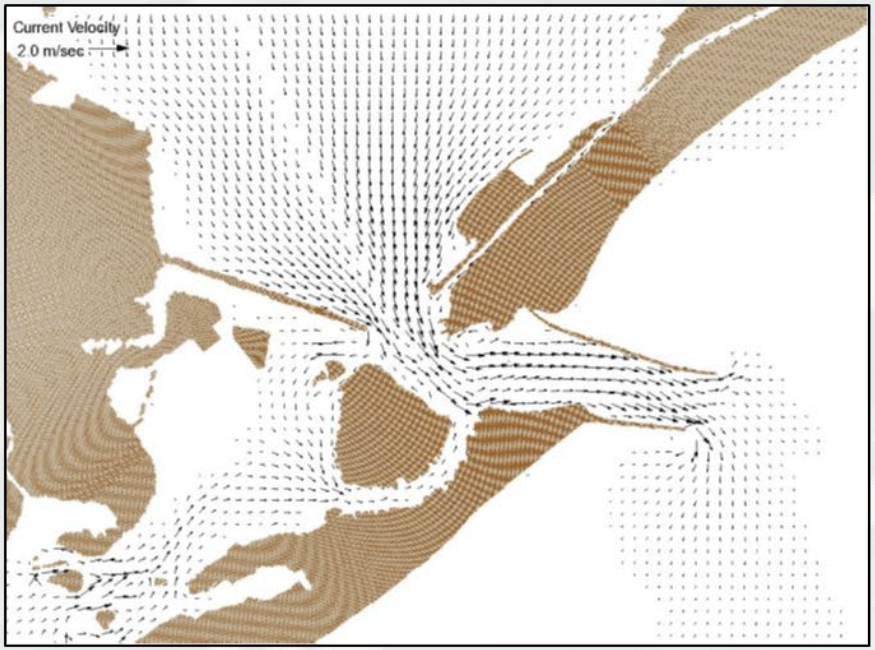


Sediment Transport Modeling: 1-yr Simulation: 2010

Typical Flood and Ebb Current Fields

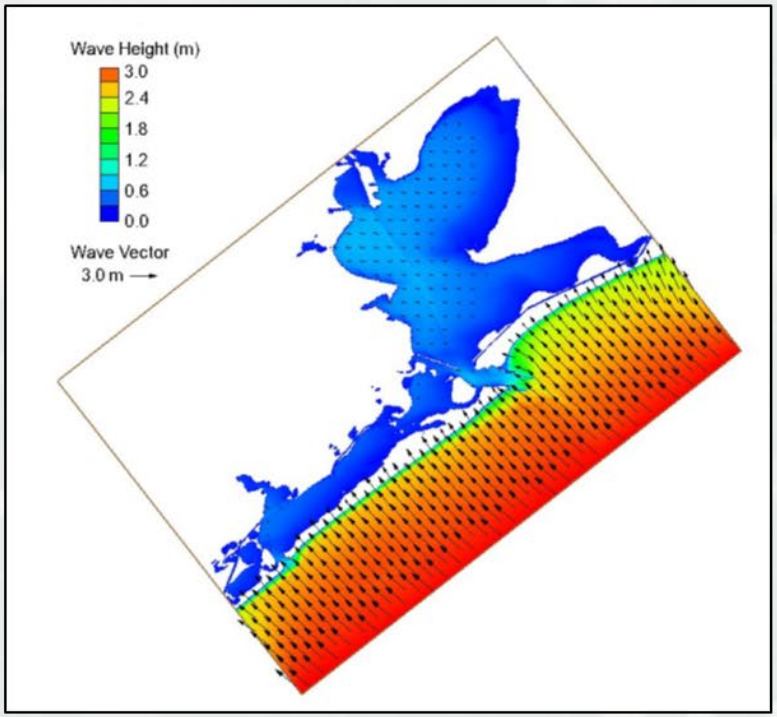


11 Jan. 2010 @ 00:00 GMT

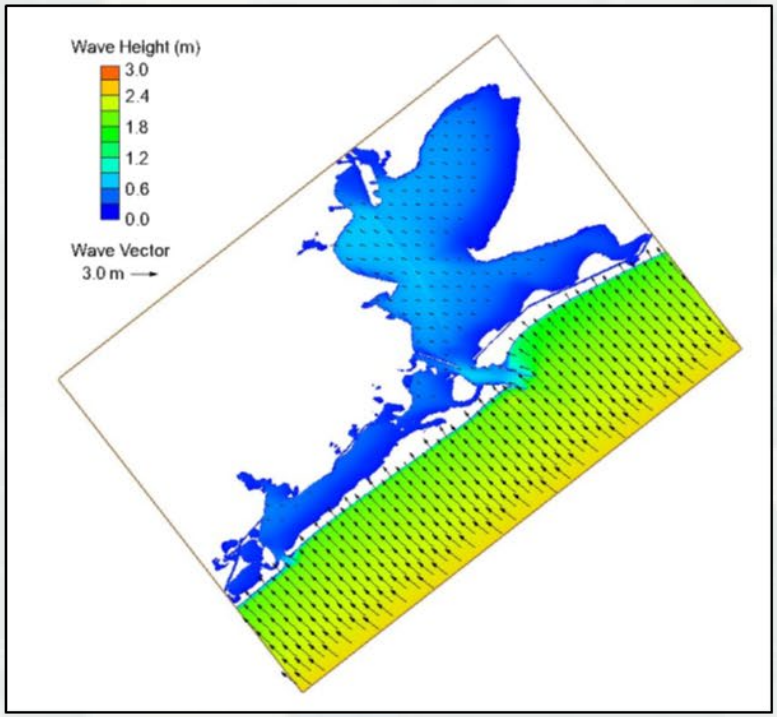


18 Jan. 2010 @ 00:00 GMT

Example Model Storm Wind Wave Fields

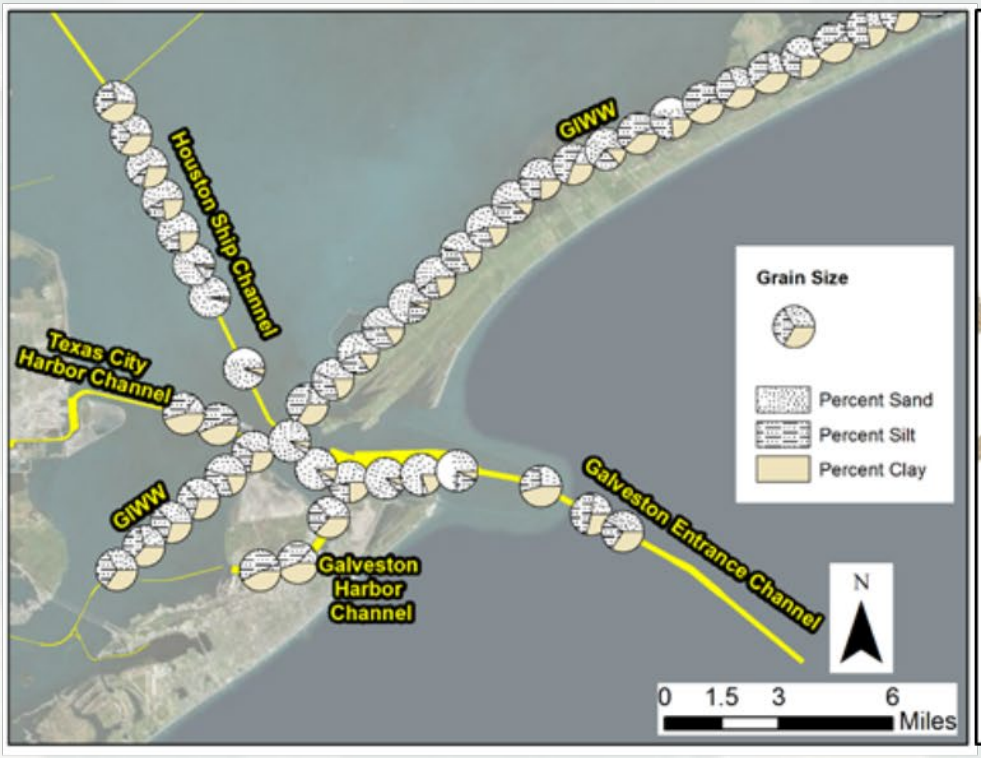


16 Jan. 2010 @ 00:00 GMT

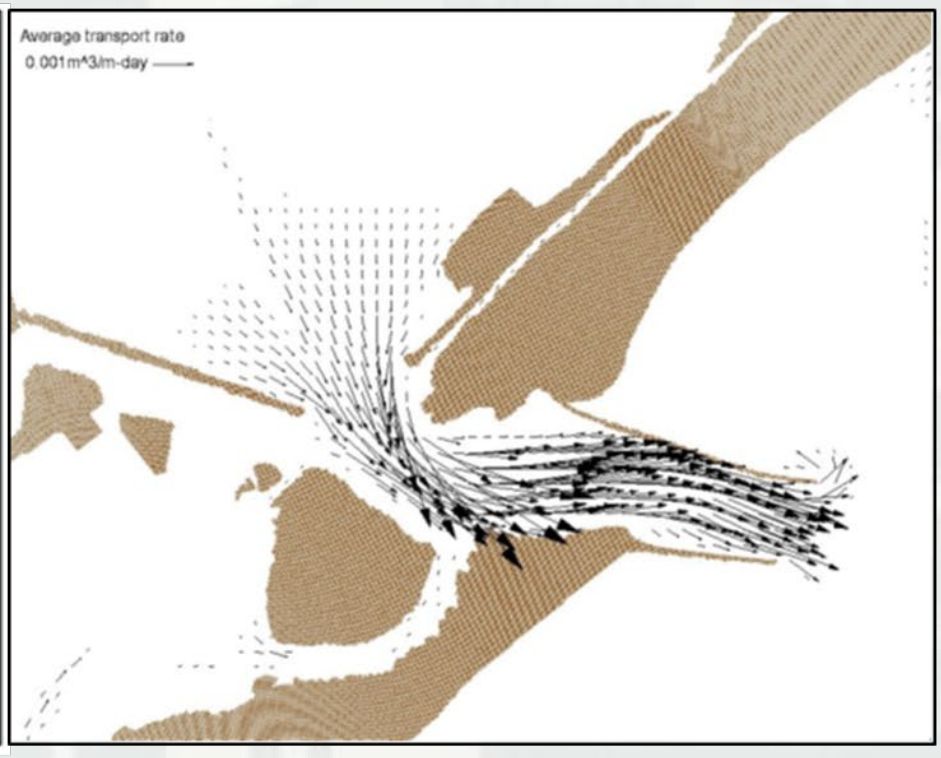


30 June 2010 @ 00:00 GMT

Model Sediment Transport Rate

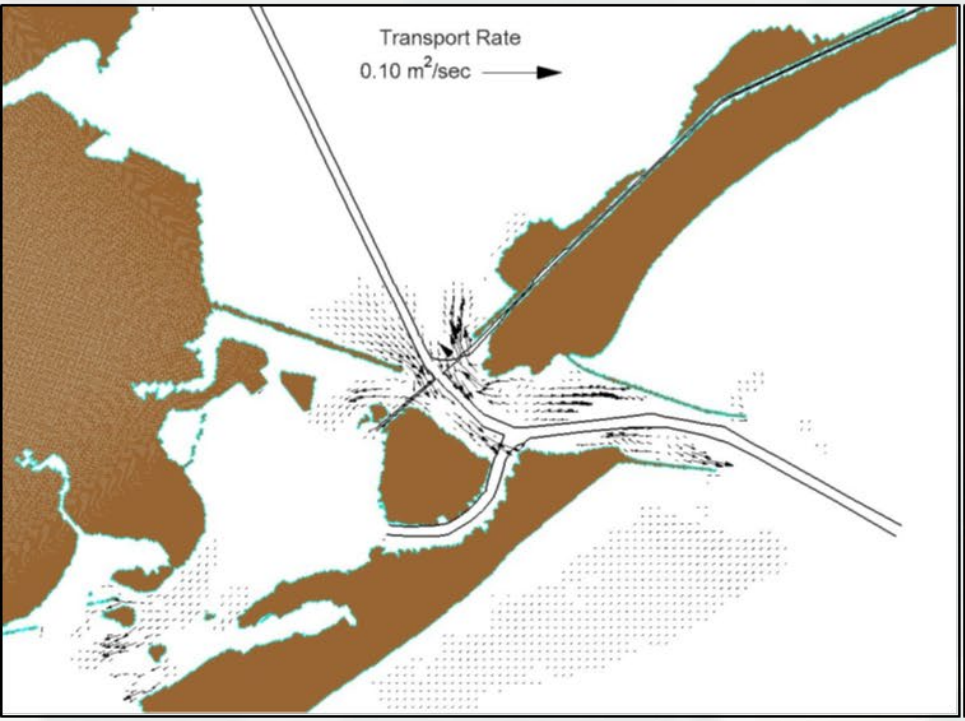


Grain size data along navigation channels

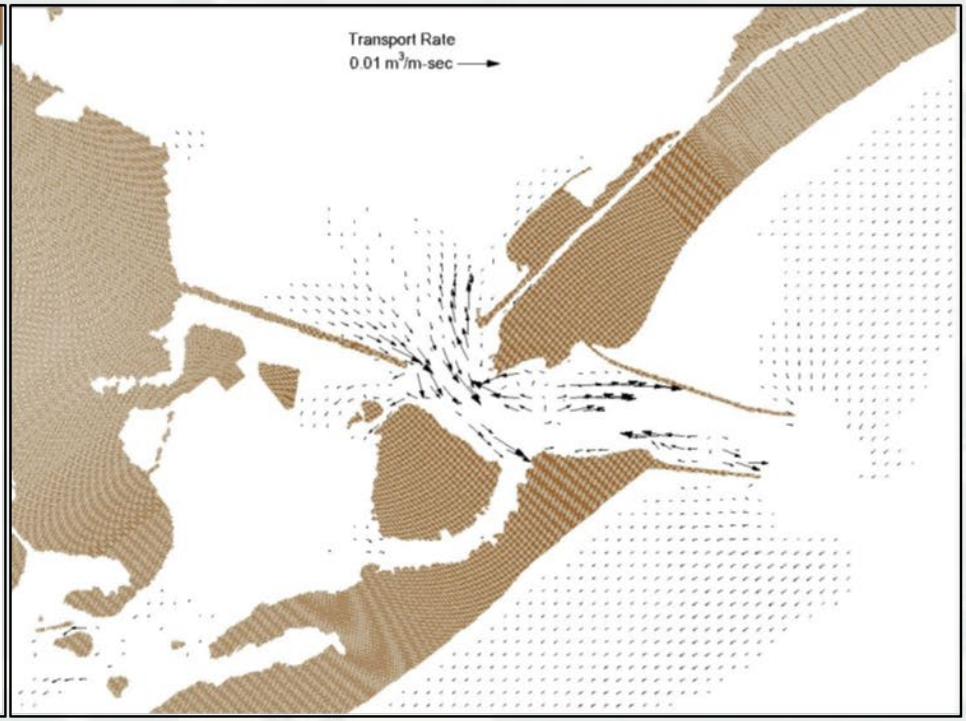


Hourly averaged transport rate
11:00 GMT @ 16 May 2010

Averaged Sediment Transport Rate in 2010



Averaged transport rate of Jan 2010



1-yr (2010) averaged transport rate

Model Structural Alternatives

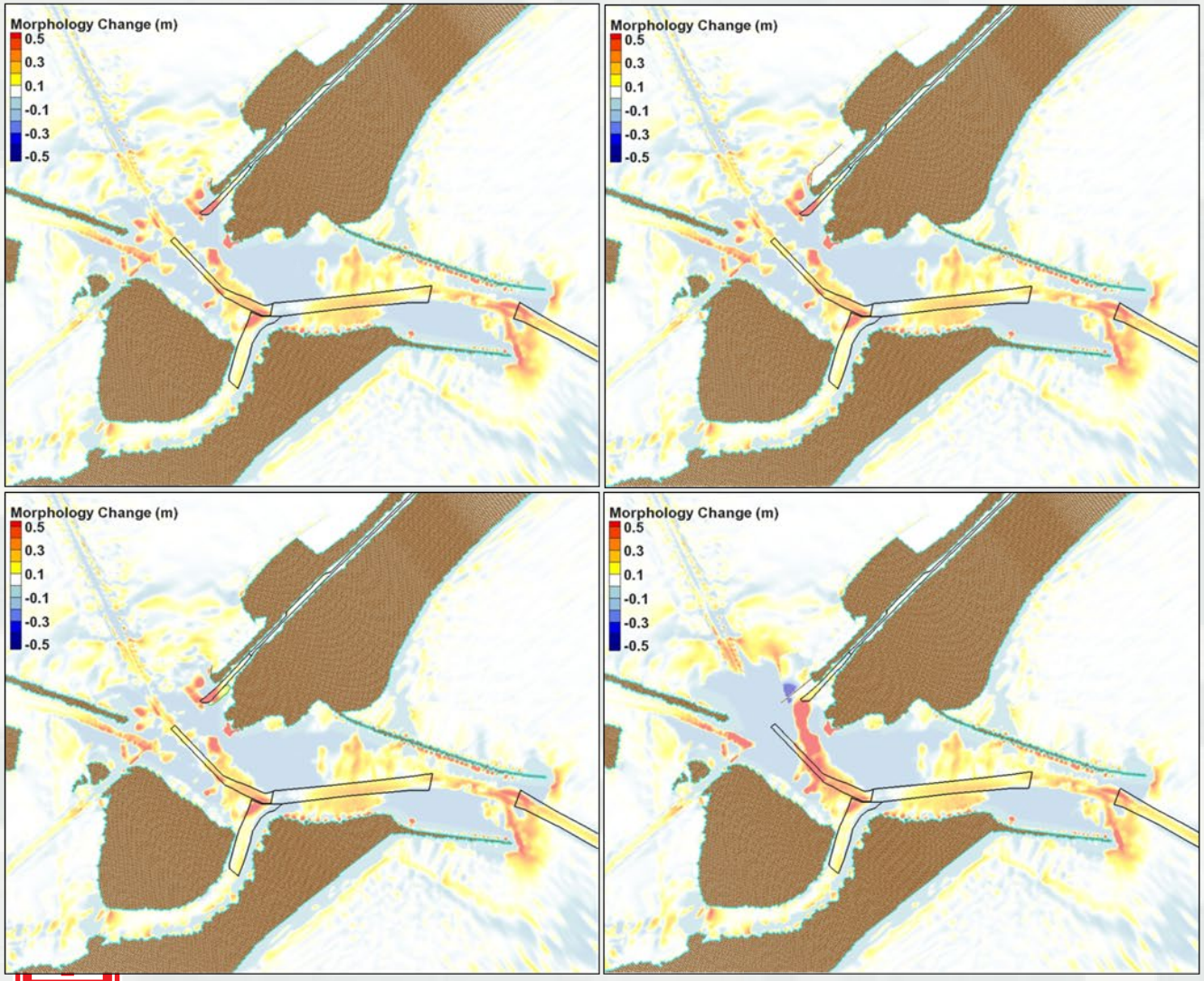
Shoaling reduction alternatives

Description of model alternatives

Alternative	Configuration	Features
Alt 0	Existing condition	Present bay and channel geometry
Alt 1	Extend PA43 structure northeastwards	Extend PA43 structure* by 1,500 m (5,000 ft) along PA43 nearshore boundary
Alt 2	Add an open-water sediment trap	Build a sediment trap, 800-m (2,600 ft) long, 120-m (400 ft) wide, 4-m (13 ft) deep, south of the Bolivar Flare
Alt 3	Extend PA43 structure southwestwards	Extend PA43 structure* by 1,200 m (4,000 ft) southwestwards along north side of Bolivar Flare channel

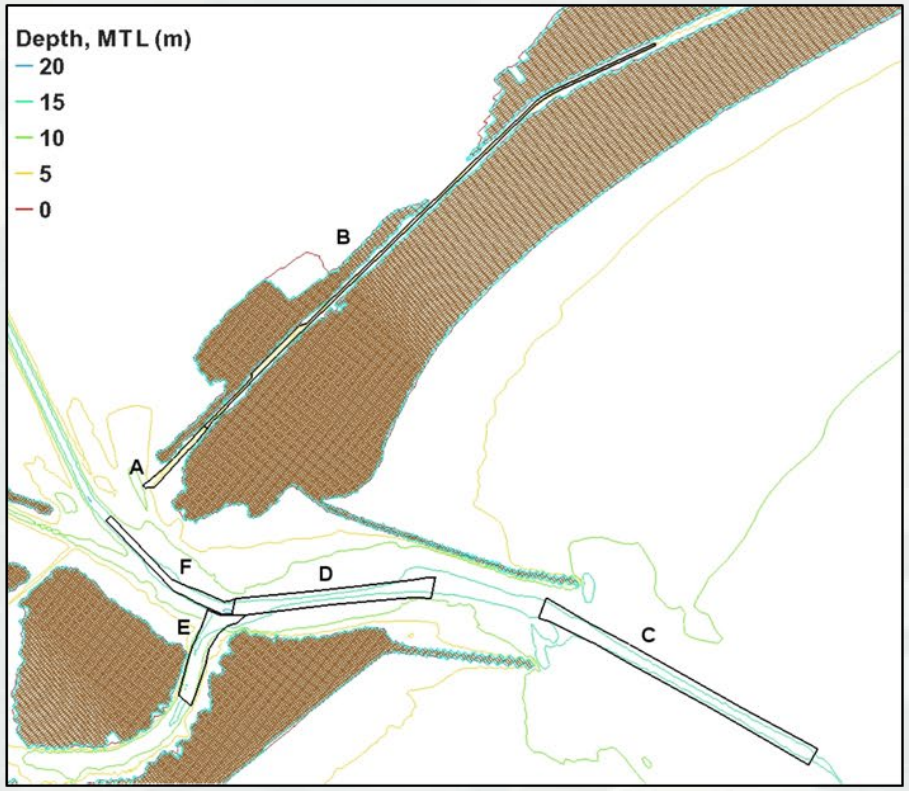
* The crest elevation of structure extension is 1.5 m (5 ft) above MTL.

1-Yr (2010) Model Morphology Change (m)



Color code:
Red – accretion
Blue - erosion

Model Volume Change
6 Channel Sections, (A) to (F)



A: Bolivar Flare

B: Bolivar Flare to Rollover

C: Outer Channel

D: Inner Bar Channel

E: Bolivar Rd to Exxon Dock
(Galveston Harbor E Channel)

F: HSC

Model 1-Yr Sediment Accumulation (CY)

Channel Area	Area Description	Alt 0	Alt 1	Alt 2	Alt 3
(A)	Bolivar Flare	141,780	135,840	127,258	22,140
(B)	GIWW East of Bolivar Flare	15,560	15,690	15,424	540
(C)	GEC Outer Channel	800,840	800,120	800,700	645,500
(D)	GEC Inner Bar Channel	286,930	286,390	286,760	214,260
(E)	GHC Eastern Channel	152,050	151,480	151,890	90,255
(F)	HSC South of GIWW	210,500	211,090	210,130	291,400

Summary & Conclusions

- US Army Engineer RSM, CIRP and Galveston District are teamed up to investigate beneficial solutions to reduce the excessive channel shoaling in the GIWW Bolivar Flare at the lower Galveston Bay, Texas.
- A Coastal Modeling System (CMS) is used to simulate mixed sediment transport in Galveston Bay multi-bay-and-inlet system. The CMS performance is validated by current and wave field data collected in June 2010.
- High shoaling rate at Bolivar Flare is mainly caused by across-channel sediment transport under combined longshore and tidal currents.
- Based on model results, Alts 1 and 2 are ineffective at reducing shoaling at the Bolivar Flare. Alt 3 would substantially reduce channel shoaling but can impact regional hydrodynamics with low BCR score.

Thank you!

Questions?

Lihwa Lin, Email: Lihwa.Lin@usace.army.mil