Wave, Current and Sediment Transport Modeling at Tiger and Trinity Shoals, Off Marsh Island, Louisiana

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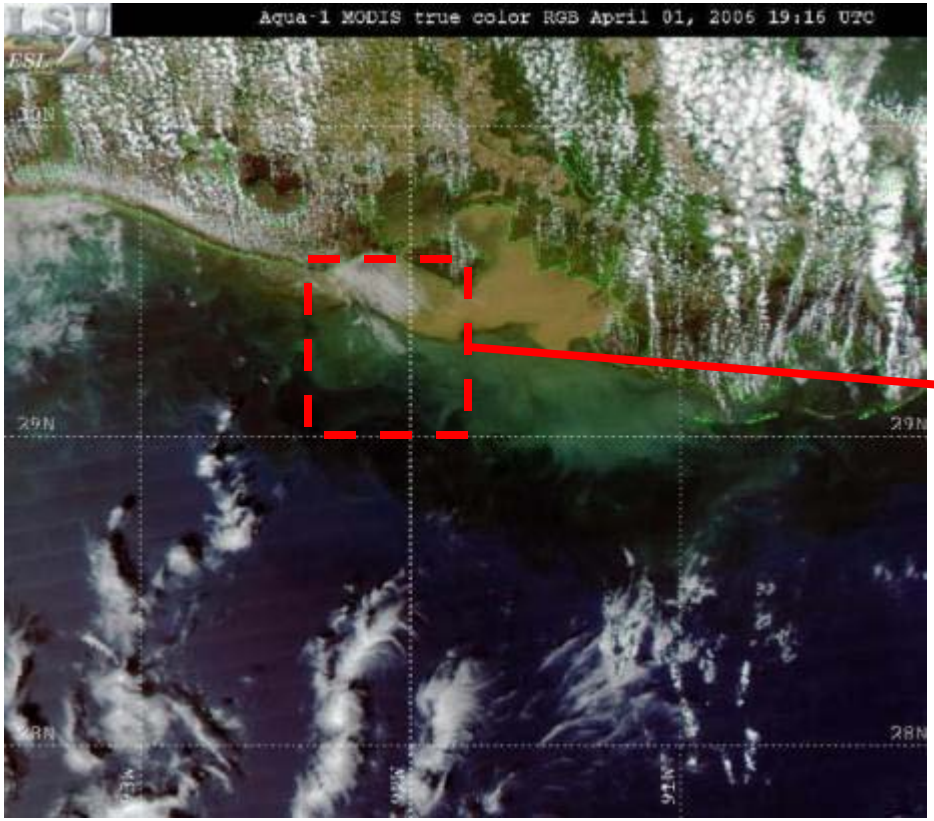
Presentation Outline

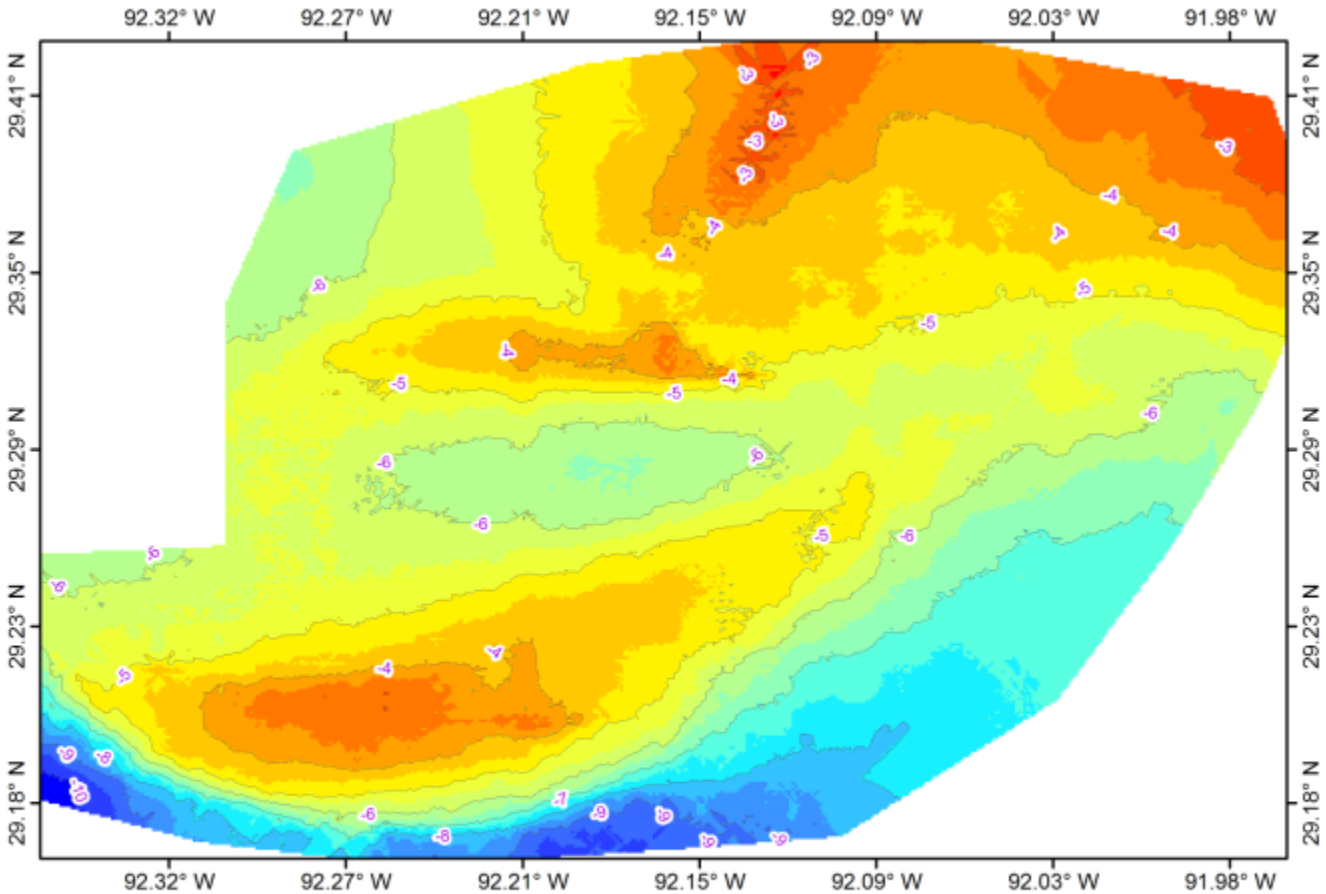
- Statement of Problem
- Physical Measurements and Modeling
  - field deployments
  - numerical modeling
- Summary and Conclusions

Study Area



Station mean water depth:
Tiger Shoal: 7 m
Trinity Shoal: 8 m
Off Trinity Shoal: 16m
CSI 03: 4.5 m

Shoal Complex Bathymetry



Trinity & Tiger Shoals Complex

< -10	-8.49 - -8	-6.49 - -6	-4.49 - -4	-2.49 - -2
-9.99 - -9.5	-7.99 - -7.5	-5.99 - -5.5	-3.99 - -3.5	
-9.49 - -9	-7.49 - -7	-5.49 - -5	-3.49 - -3	
-8.99 - -8.5	-6.99 - -6.5	-4.99 - -4.5	-2.99 - -2.5	

Bathymetry (m)

Data courtesy Roberts et al. 2010

Instrumentation & Logistics

PCADP- ADCP Array

SonTek ADV

Problem Statement

- Tiger/Trinity shoal proposed as a viable sediment resource for restoration of coastal segments along the south central Louisiana coast

- Frequent deposition of fluvial sediments on Tiger shoal, particularly during spring flood season; while less influence on Trinity shoal

- Treatment of heterogeneous bottom sediments and their interaction with shoal hydrodynamics

- Seasonal field deployments and numerical modeling to examine Bottom Boundary Layer (BBL) dynamics and physical oceanographic processes

Physical Measurements

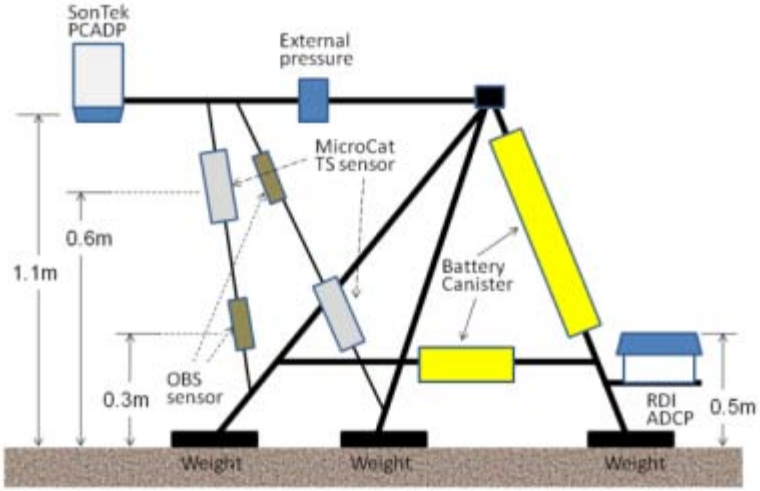
Field Deployment

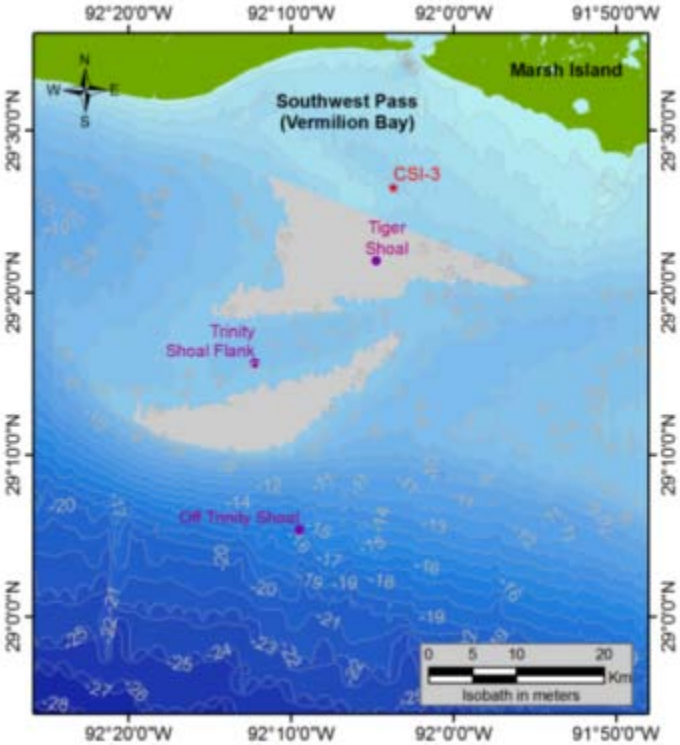
- To examine bottom boundary layer characteristics on Shoal Complex

  Data Collected

  (2008/12/03 – 12/17)
  (2009/03/19 – 04/23)
  CSI 03: 10 years met-ocean data

- Thick accumulation of cohesive sediments cause difficulties during deployment/retrieval





Shoal Face Granulometric Characteristics

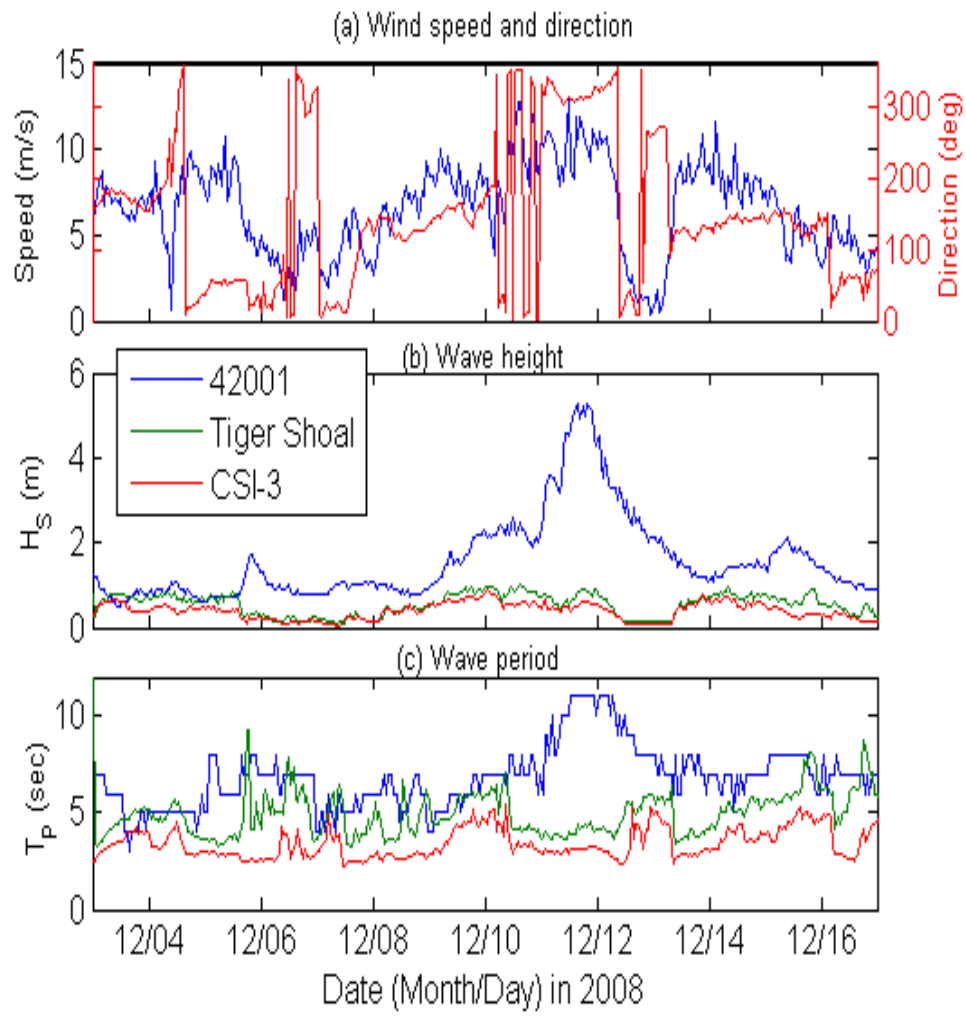
2 weeks

Deployment
Fluid mud

Retrieval
Shelly sand

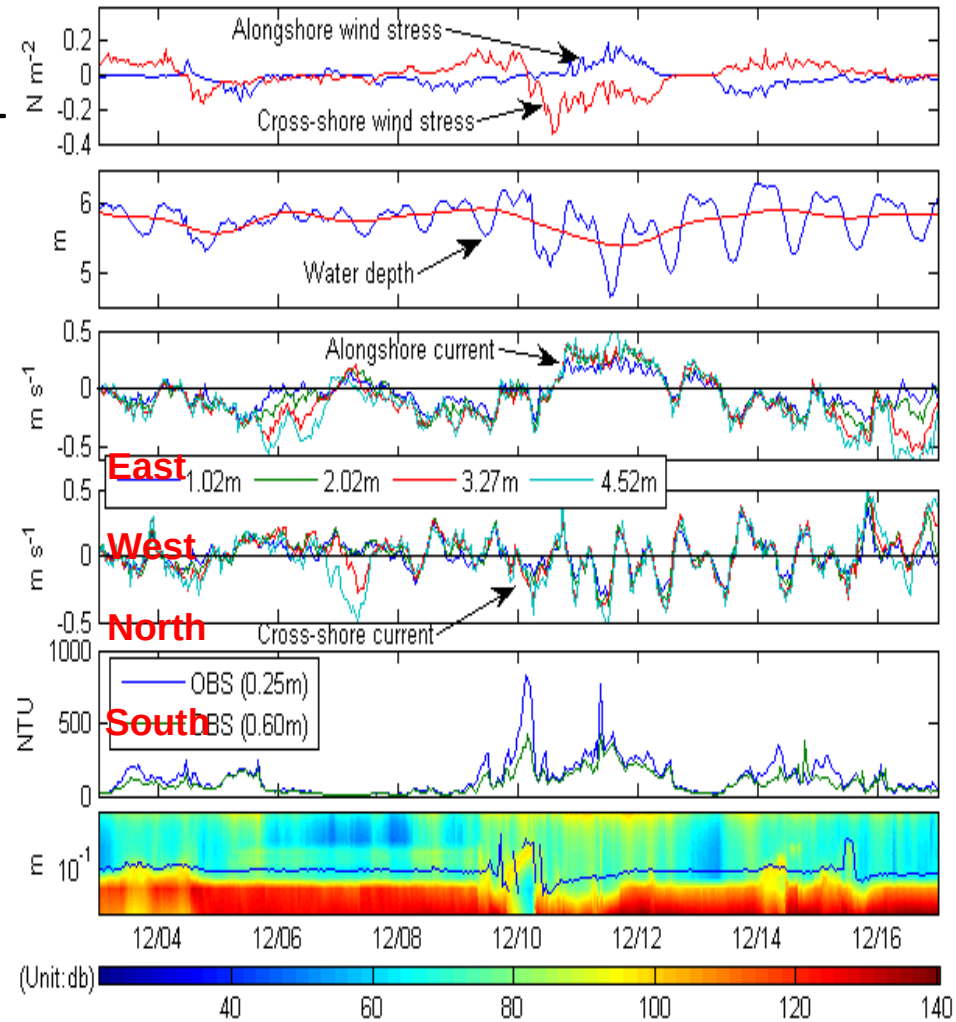
Hydrodynamic Parameters (Waves)

- A strong winter storm on December 11, 2008
- Wind speed attained 14.2 m/s
- Deep water wave height exceeded 5 m; wave height over TS < 1 m
- Wave dissipation associated with bottom friction



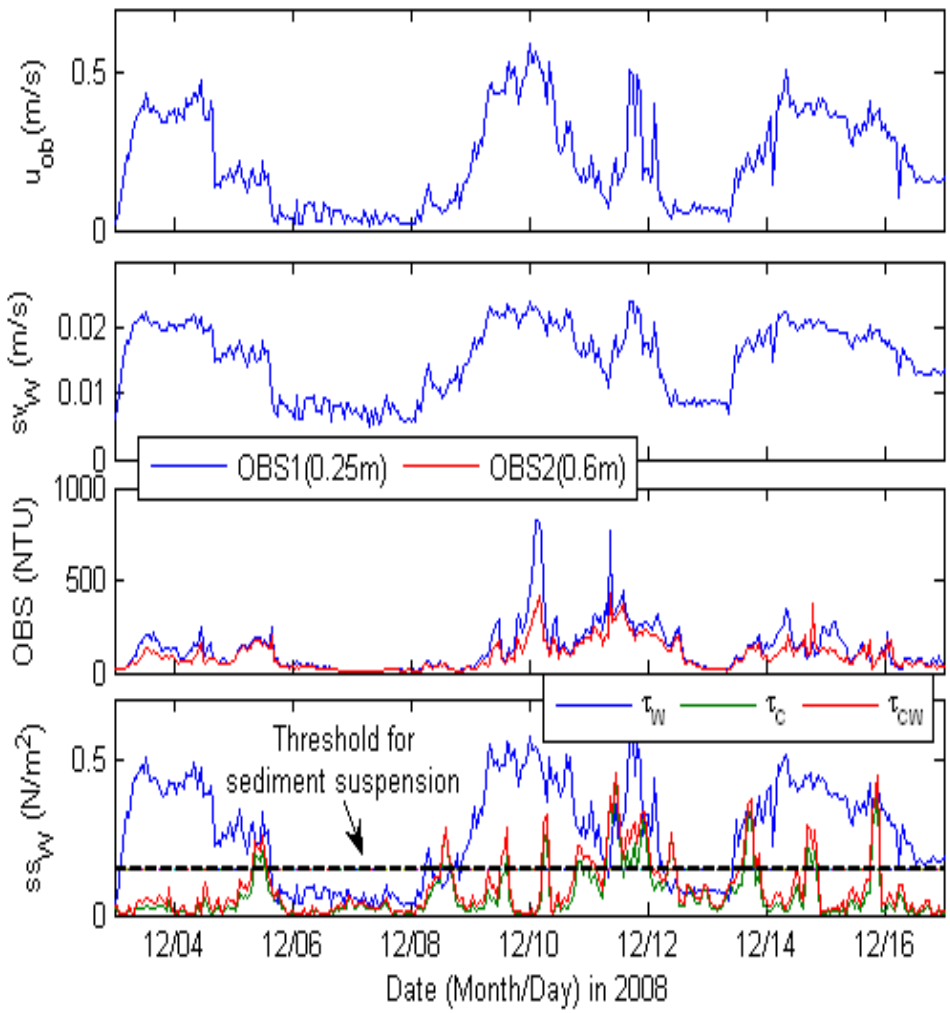
Hydrodynamic Parameters (WL, Flow)

- A strong storm on December 11
- ≈ 0.5 m change in adjusted water level
- Currents >≈0.5 m/s
- Higher currents expected over the shoal due to current acceleration
- Sediment flush-out
- High SSC during storms



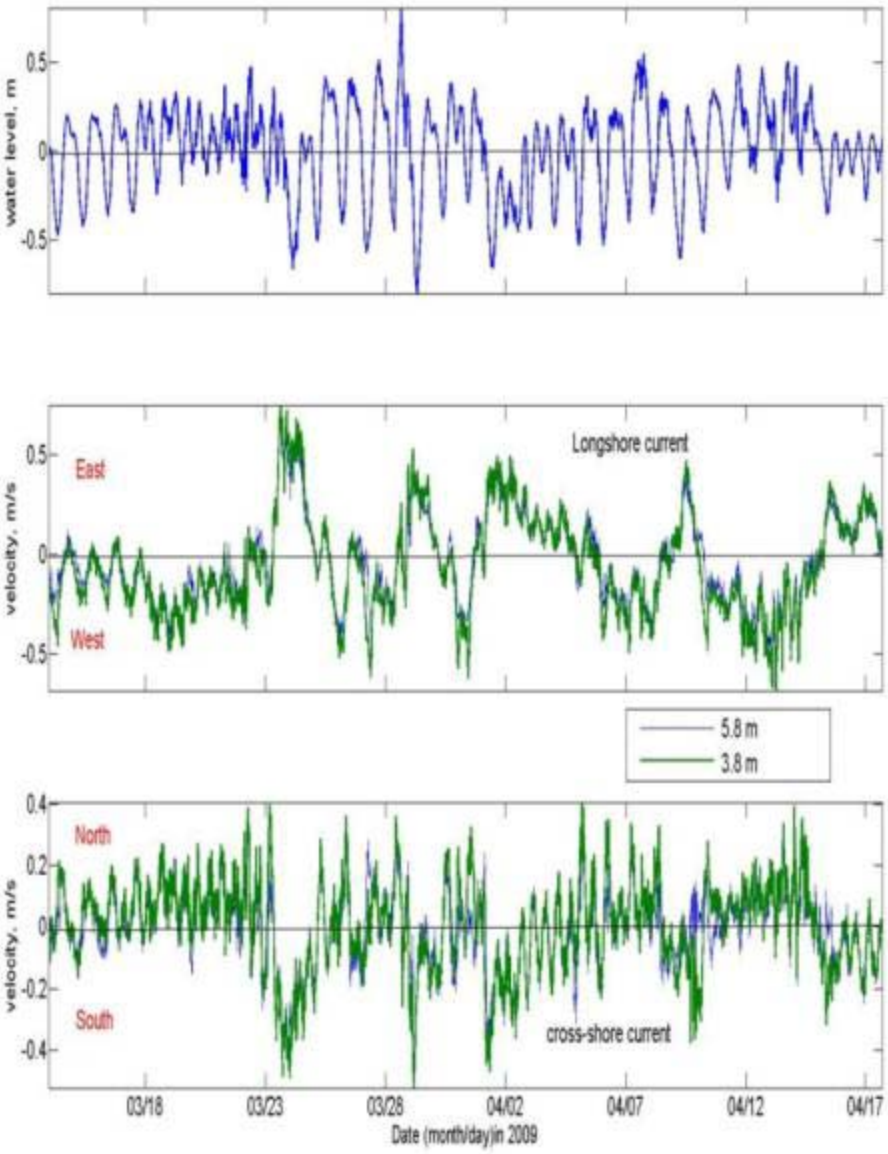
BBL Parameters

- Significant sediment re-suspension during a storm
- Sand in the shoal was exposed during the post-frontal phase
- Water depth and hydrodynamic forces are factors
- Influx of fluvial sediments complicate the dynamics
- Difficult to implement sediment transport model



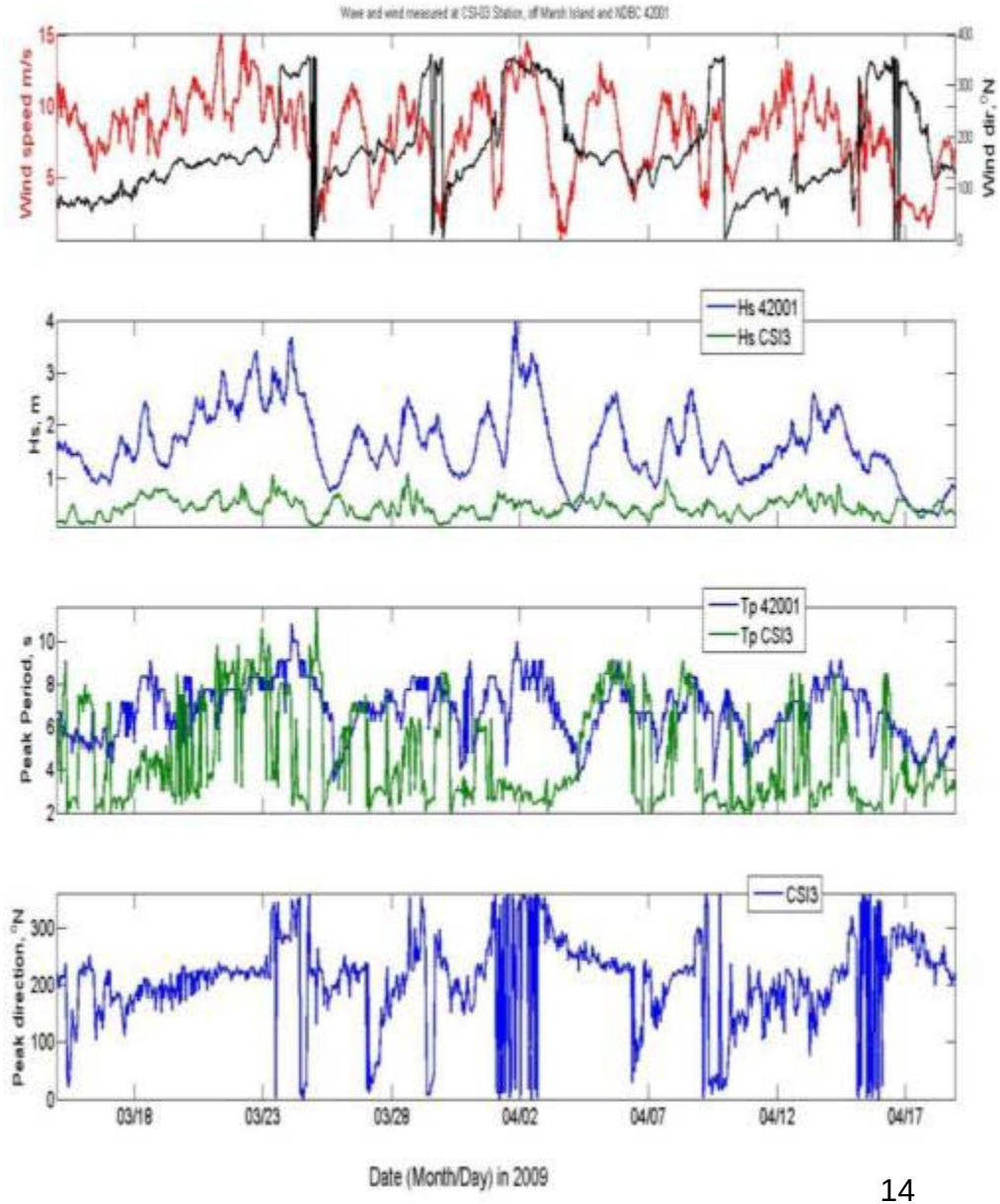
Hydrodynamic Parameters: Trinity Shoal

- Max water level fluctuation = 0.8m
- Along shore currents stronger and remain stable
- Across shore currents: highly oscillating, indicating the influence of river discharge and its mixing and interference from off-shelf phenomena; eddies from Loop Current



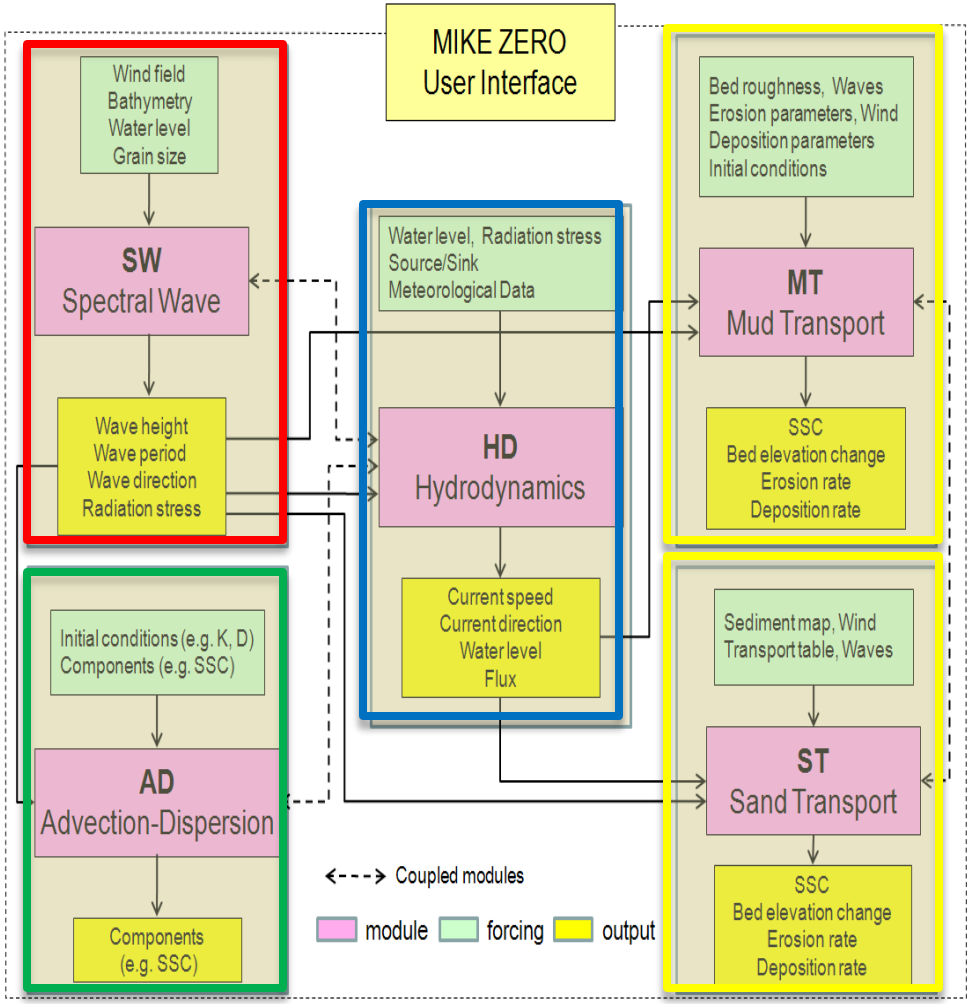
Wave Data: 2009 Deployments

- Offshore wind speed exceeds 15 m/s
- 5 distinct cold fronts crossed the coast
- Offshore Hs max =4.2 m
  At CSI3, Hs Max= 1 m
- Significant wave damping again observed during the deployment period



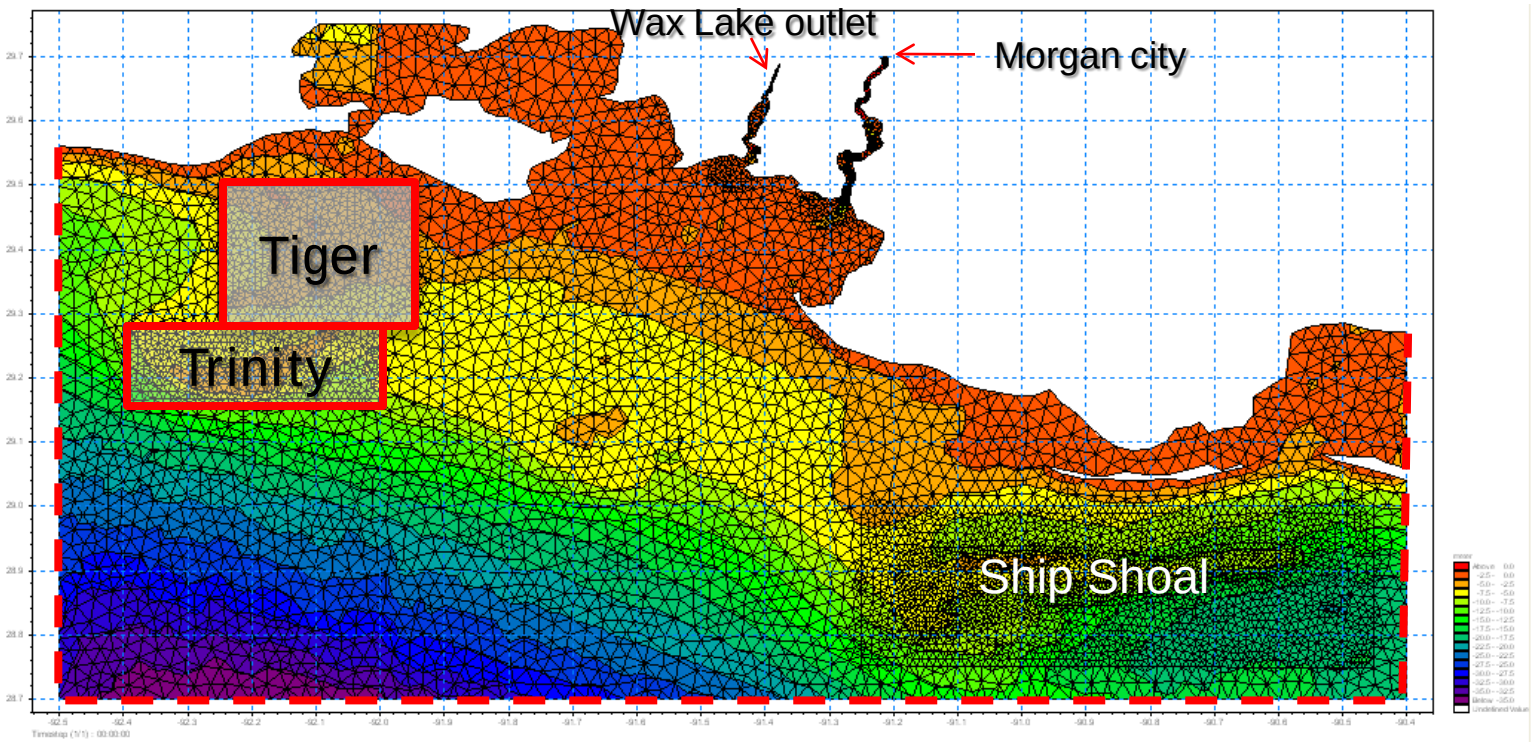
Numerical Modeling
DHI MIKE 21/3

- Waves, currents, and sediment transport, dispersion
- Unstructured triangular mesh grids
- Nested modeling
- To examine wave transformation/circulation patterns/sediment suspension
- Influence of fluvial sediment on Tiger/Trinity shoals



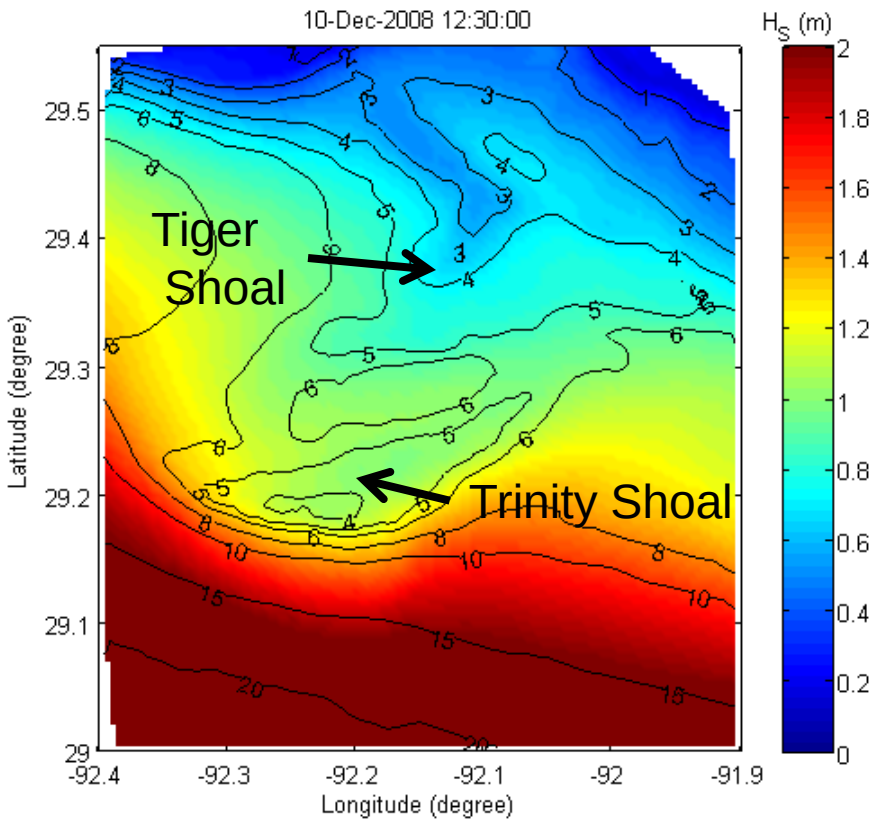
Model Domain

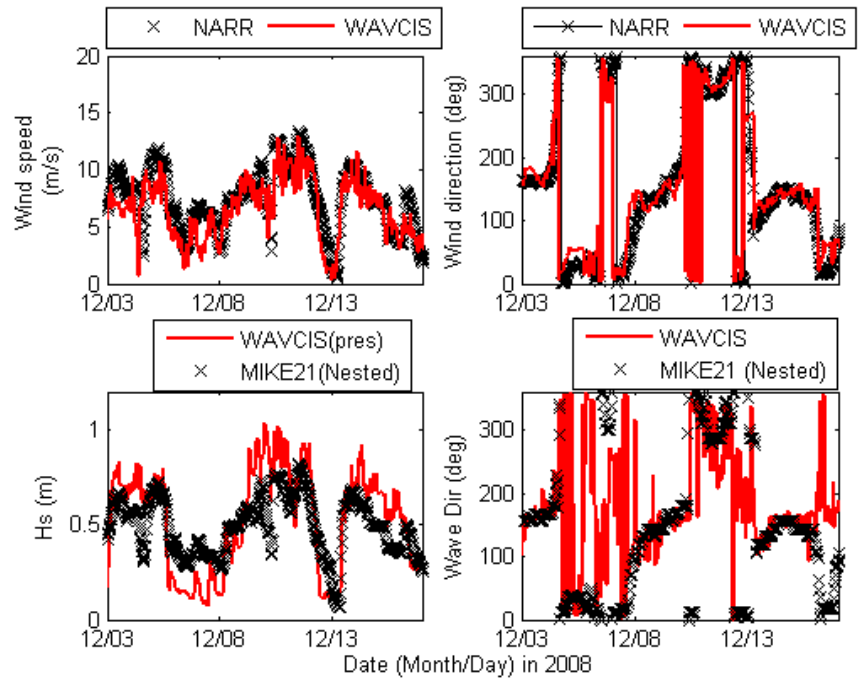
- Covers Atchafalaya shelf, Ship Shoal, Tiger/Trinity shoals
- Fine mesh over Tiger/Trinity shoals
- Incorporates Atchafalaya River sources
- Boundary conditions (water level for each boundary)



Model Results (Waves)

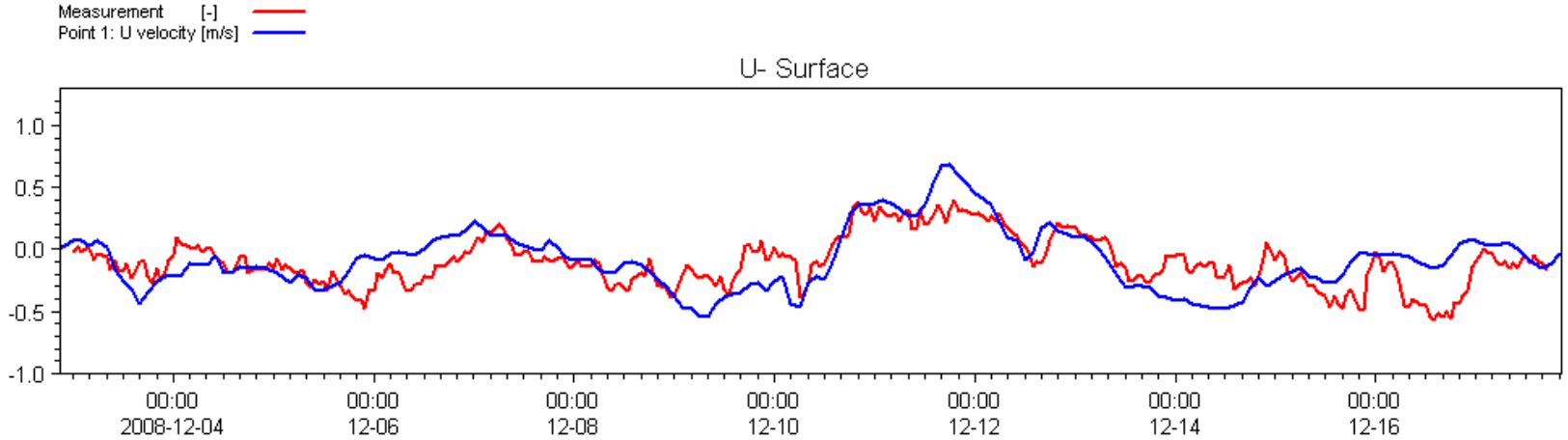
- Wind and bulk wave parameters are in good agreement with *in situ* data

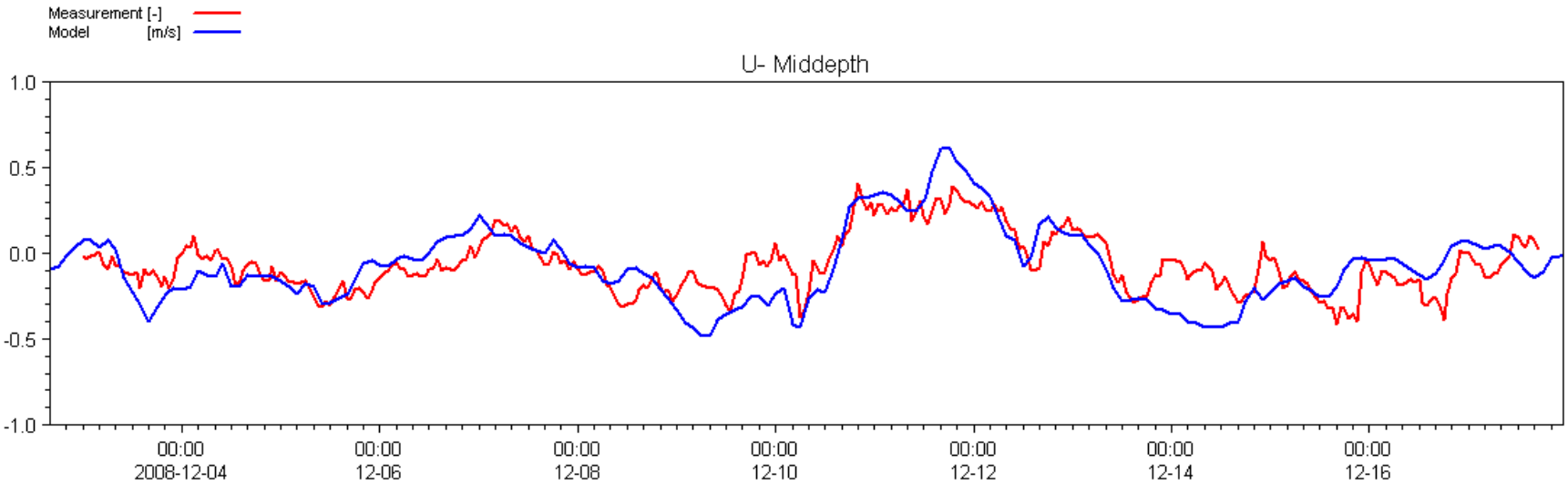




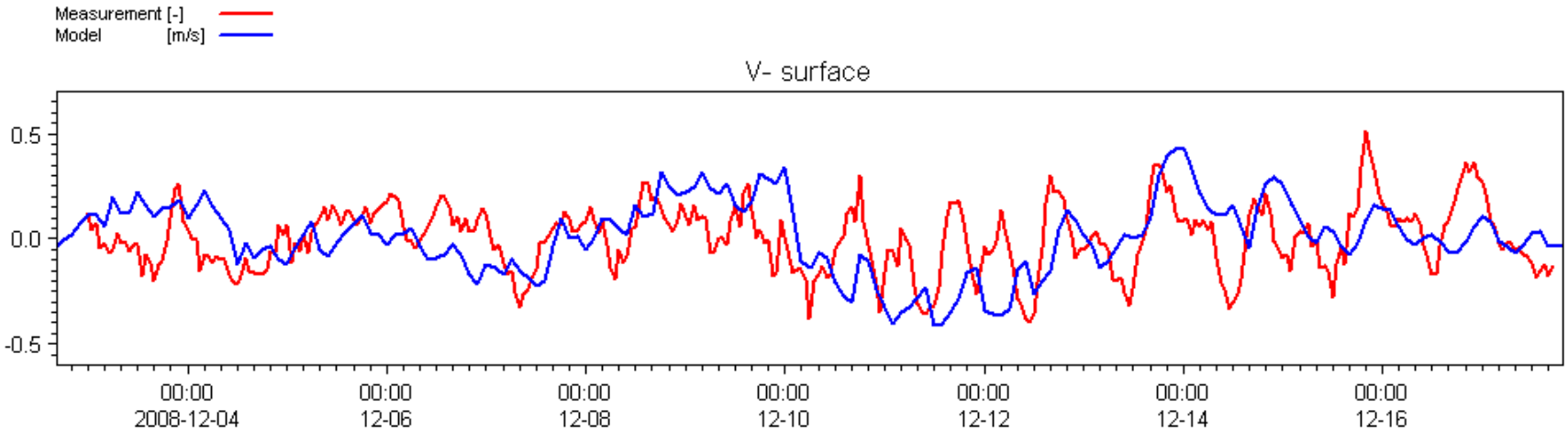
- Wave dissipation seaward of Trinity shoal
- A contrast between Tiger and Trinity shoals

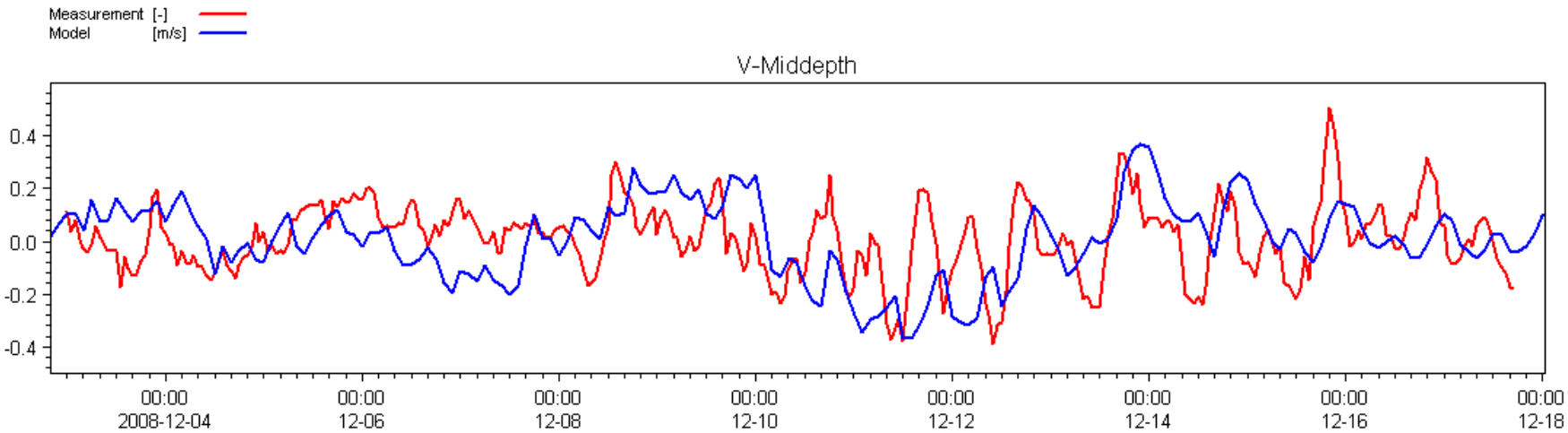
HD Model Validation



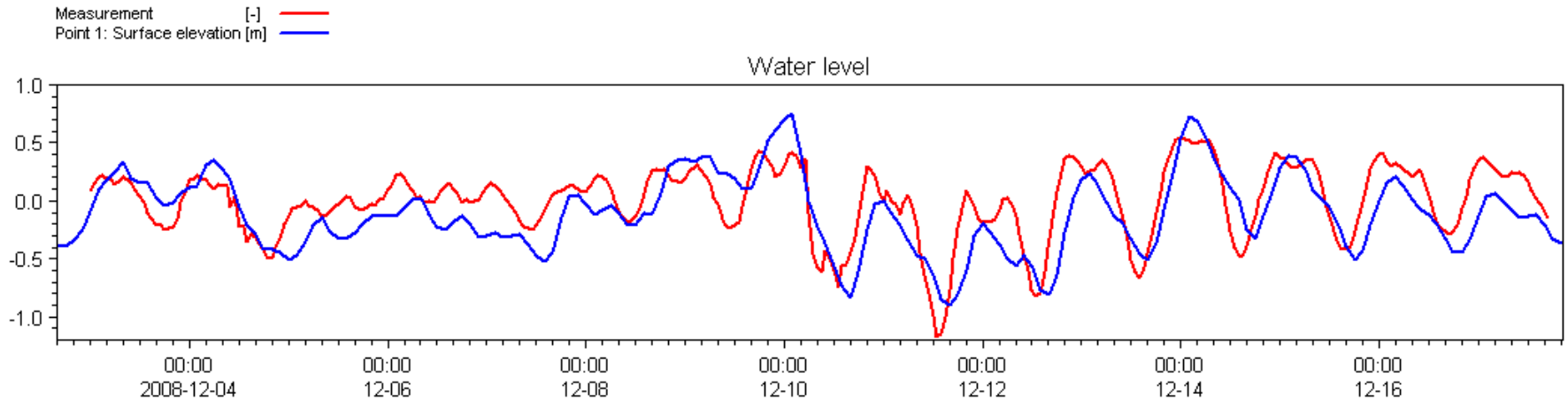


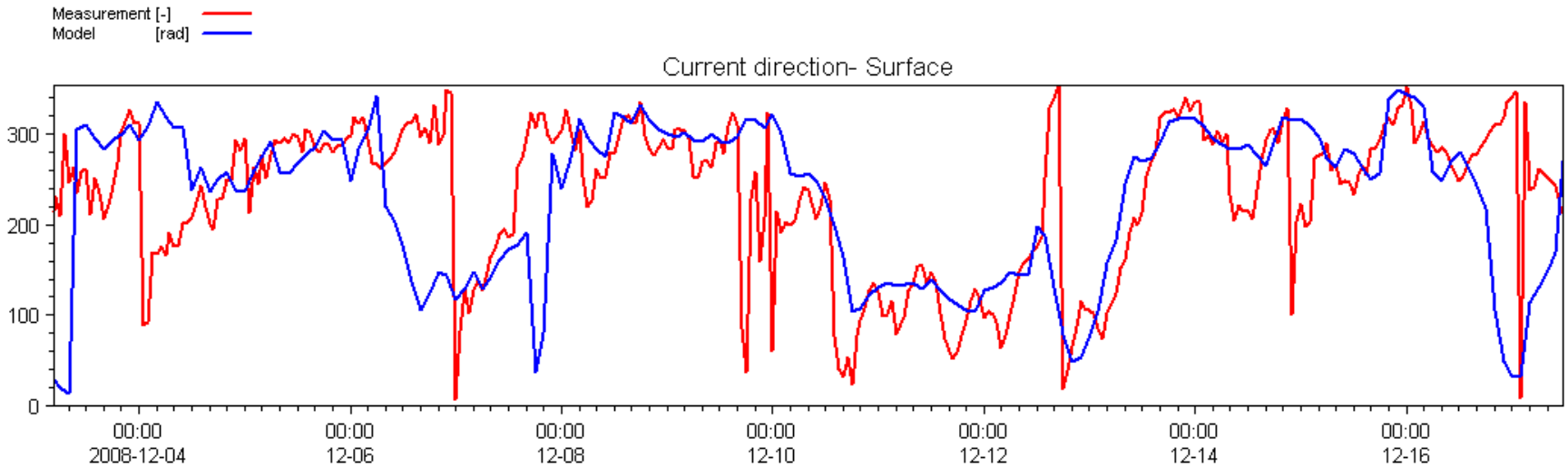
HD Model Validation (cont.)



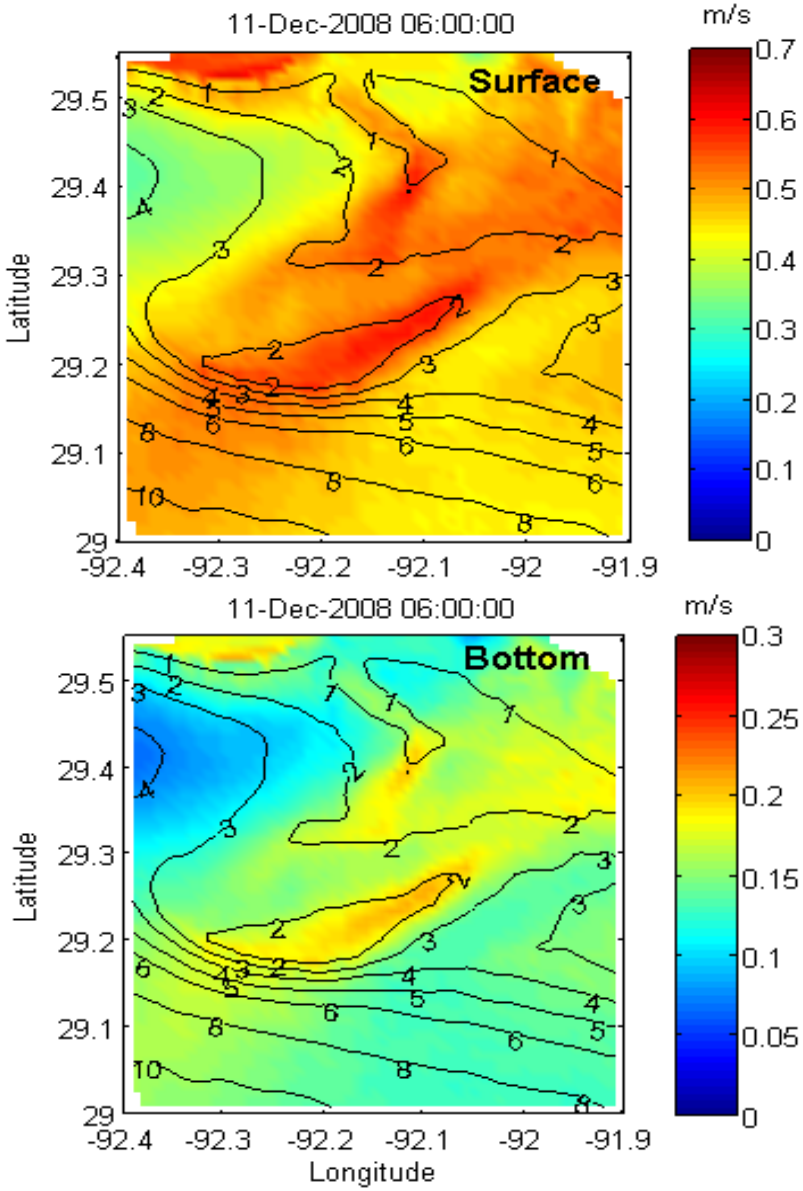


HD Model Validation (cont.)



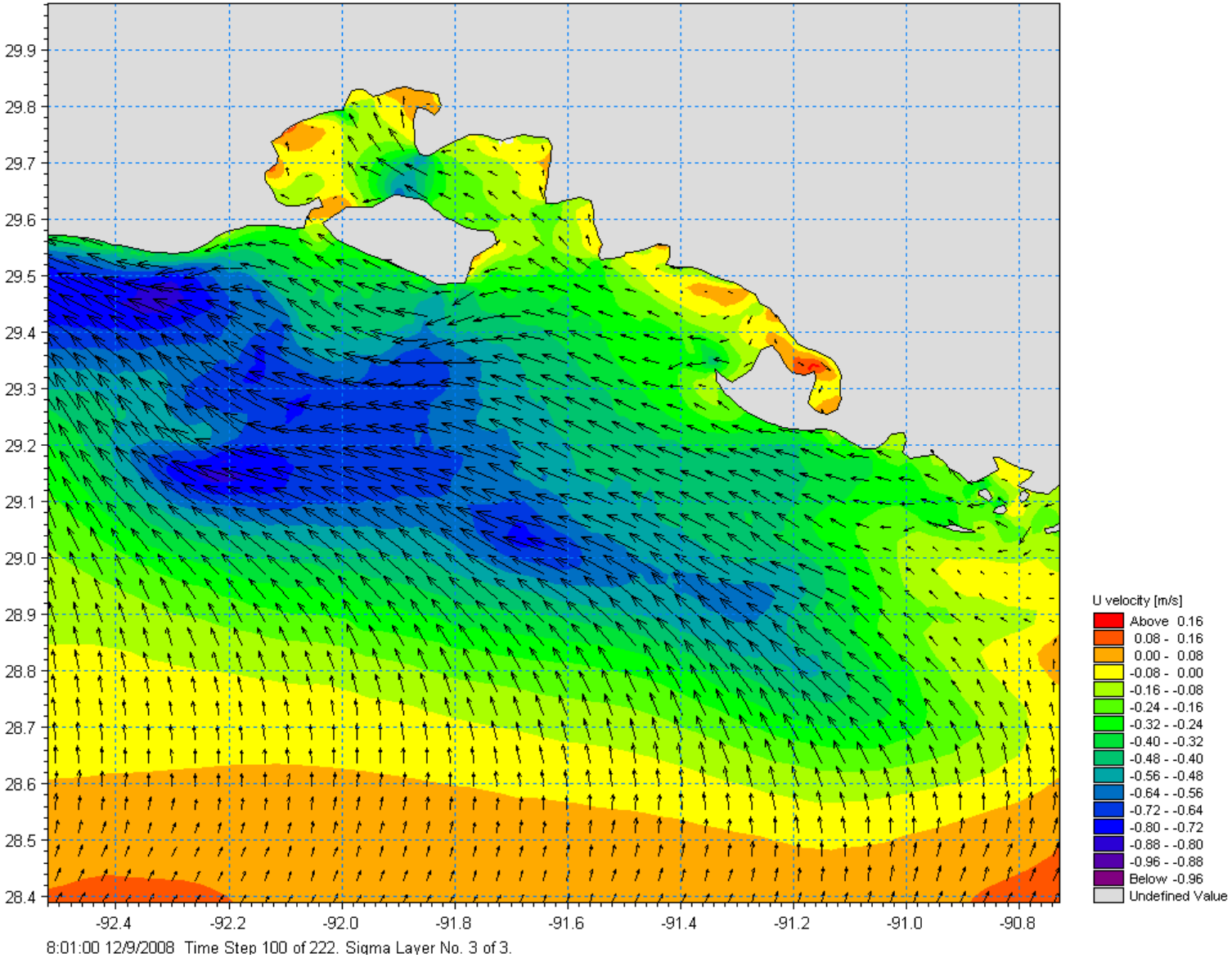


HD Model Results (Currents)

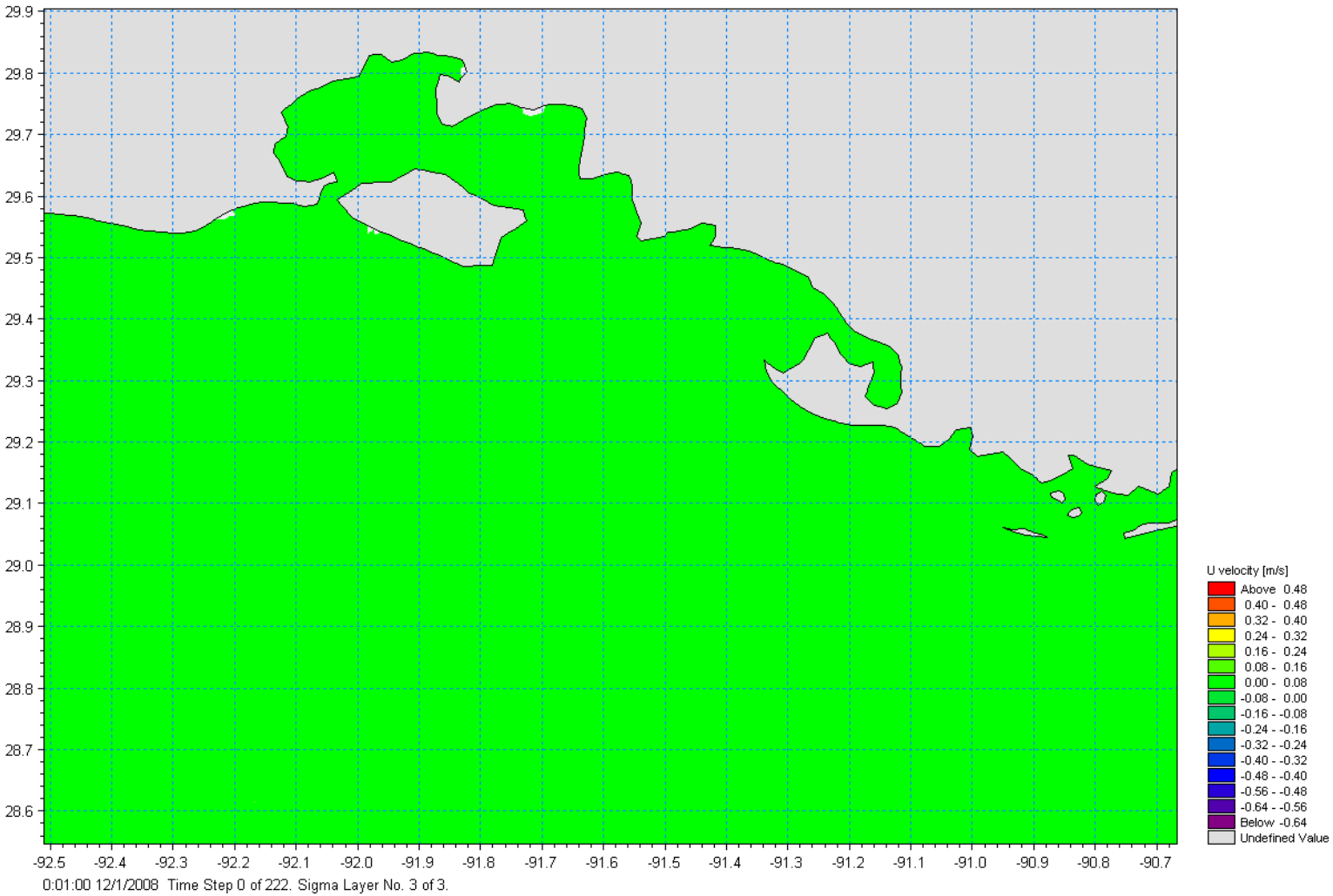


- Good agreement with *in situ* data from the shoals
- High current over both shoals, expecting sediment flush-out during winter storms
- Flow acceleration is attributed to the rapid change in bathymetry ; reported from Ship Shoal also

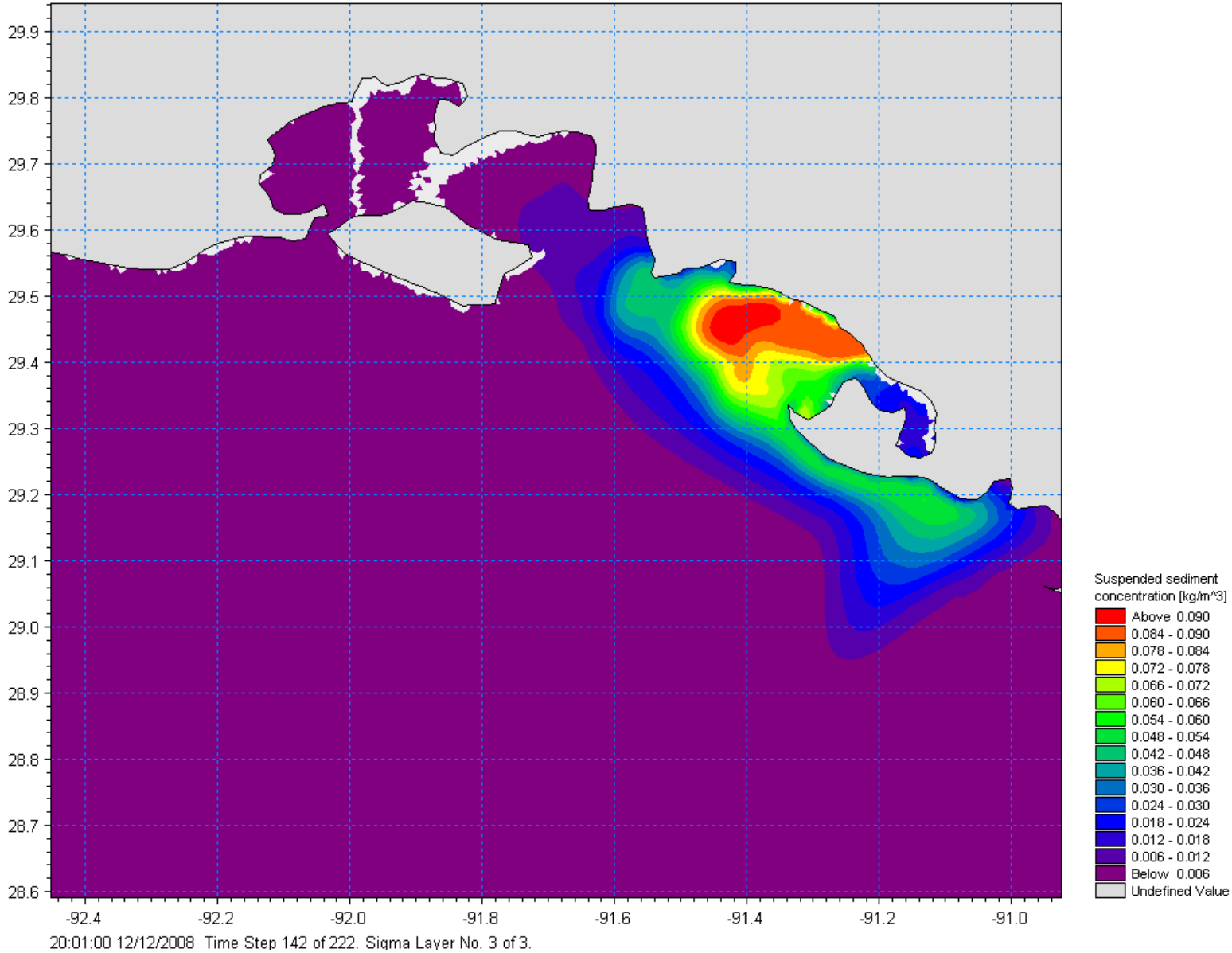
HD Model Results (Surface Currents)



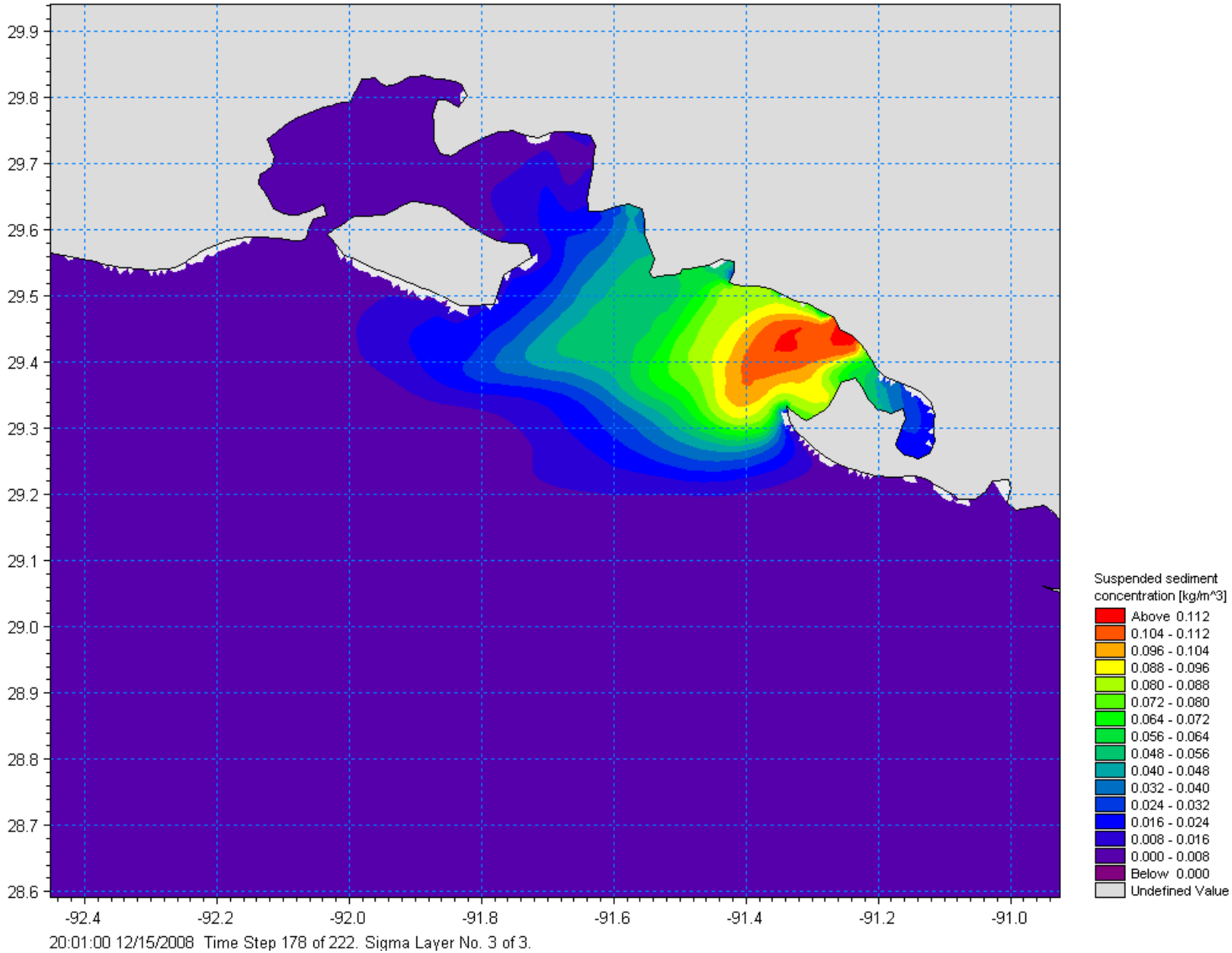
HD Model Results (Surface Currents)



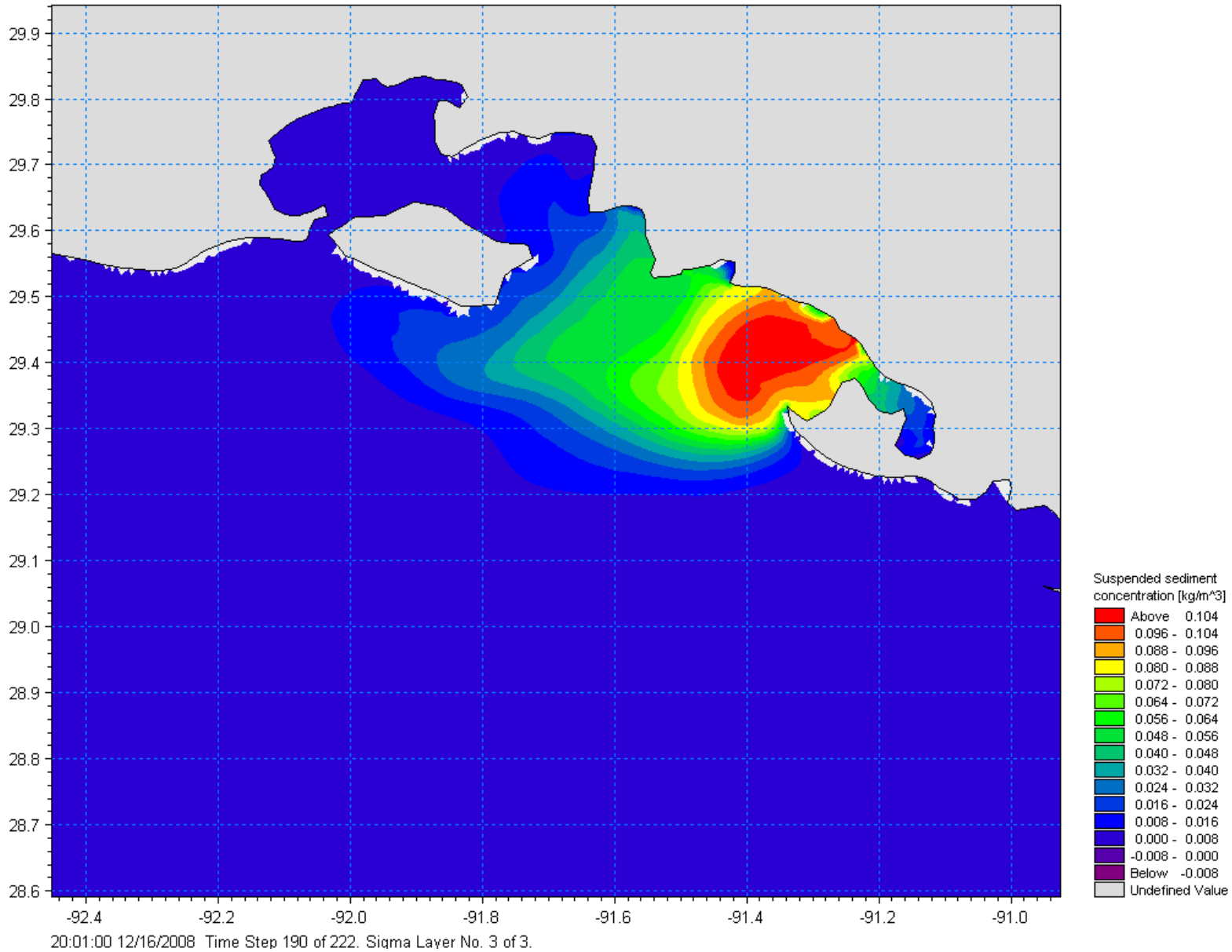
River Plume Dispersion (Post Frontal)



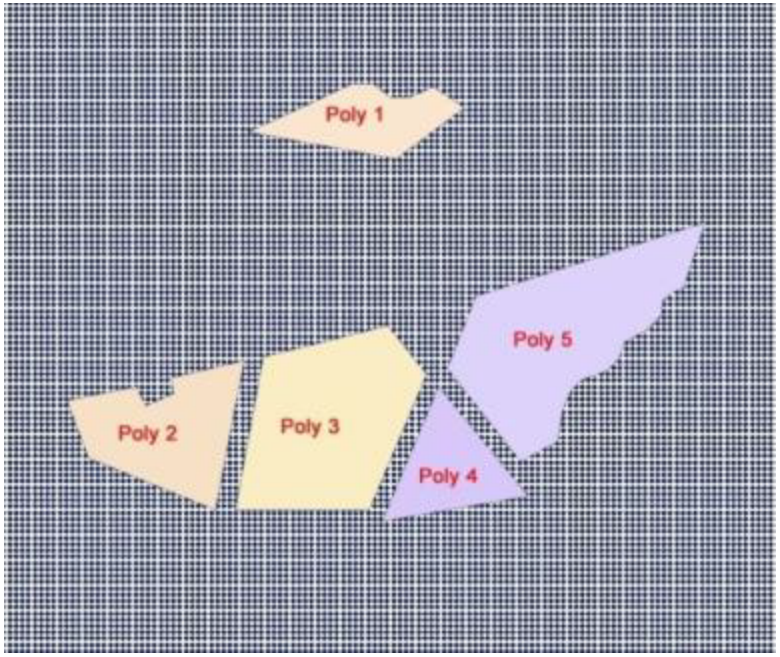
River Plume Dispersion (Pre-Frontal)

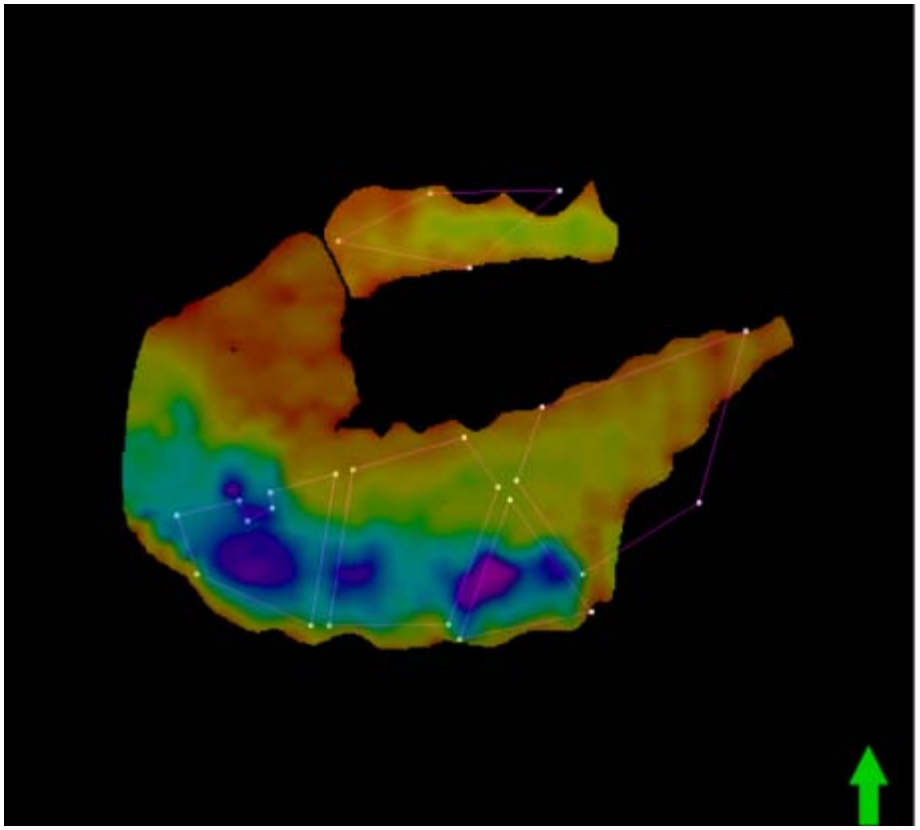


River Plume Dispersion (Pre-Frontal)



Dredging Scenarios





Data source: Clint Edrington, LSU

Dredging Scenarios (cont.)

Polygons	1	2	3	4	5
Scenarios	Depth to be dredged in meters				
Deeper_1	2	2	2	2	2
Deeper_2	0	2	2	2	2
Deeper_3	0	3	3	3	2
Deeper_4	0	3	2	3	0
Deeper_5	2	4	3	4	2
Status quo	0	0	0	0	0

Conclusions

- In winter/spring season, Tiger and Trinity Shoal experienced dramatic changes in bed characteristics
- Wave energy dissipation off Trinity Shoal was significant, and waves got refracted around the shoal
- Sediment re-suspension on Tiger/Trinity Shoal was profound in winter
- Likely strong contrast with spring with a high river discharge regime

Ongoing Research

- Model implementation with updated bathymetry from the shoals (Roberts et al. 2010)
- Run the models for post-mining bathymetries to quantify the impact of dredging along the coast
- Present the results at national/international conferences
- Timely submission of Report to BOEMRE and submit manuscripts in peer-reviewed journals

Acknowledgments

Late Dr. Gregory W. Stone

Field Support Group of Coastal Studies Institute at LSU did all the field deployments

Dr. Harry Roberts, Syed Khalil, Dewitt Braud and Clint Edrington provided data support

Colleagues at WAVCIS Lab

Reference

Roberts, H.H., D. Braud and C. Edrington. 2010. Results of a geophysical and sedimentological evaluation: Tiger-Trinity Shoals as sources of sand for coastal restoration, Vol.1 and 2. Baton Rouge, Louisiana: Coastal Studies Institute, School of the Coast and Environment, Louisiana State University. Cooperative Agreement Study submitted to the Bureau of Ocean Energy Management (No. M07AC12517). 45 pp.