ENVIRONMENTAL INVESTIGATION OF THE LONG-TERM USE OF TRINITY AND TIGER SHOALS AS SAND RESOURCES FOR LARGE-SCALE BEACH AND COASTAL RESTORATION IN LOUISIANA

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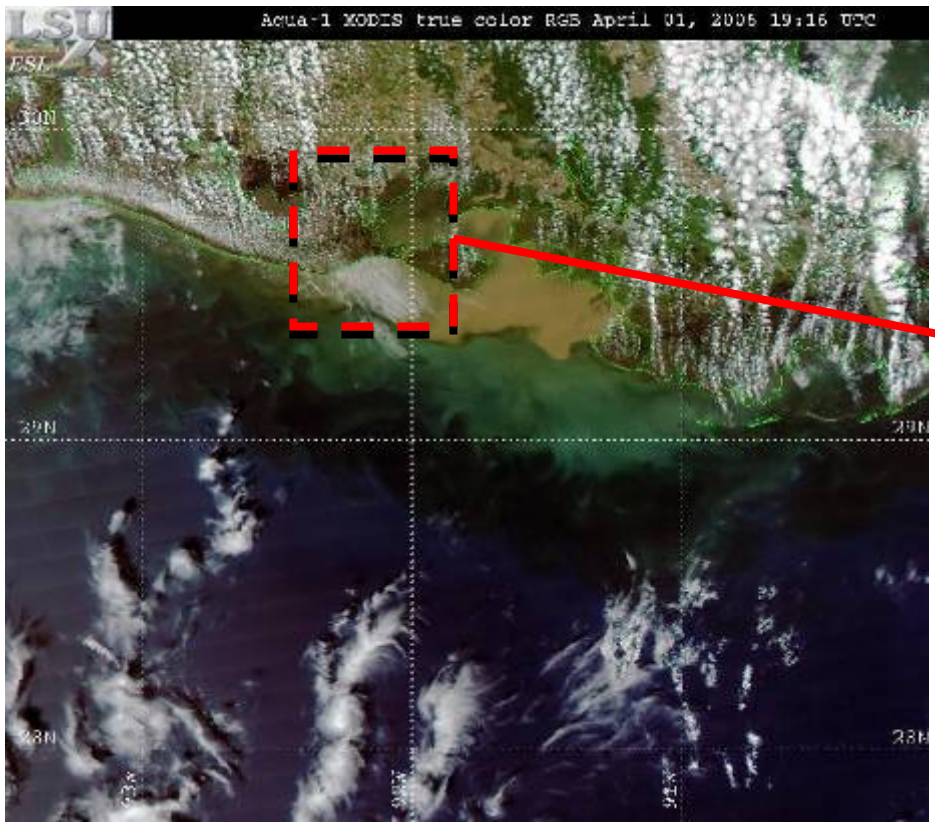
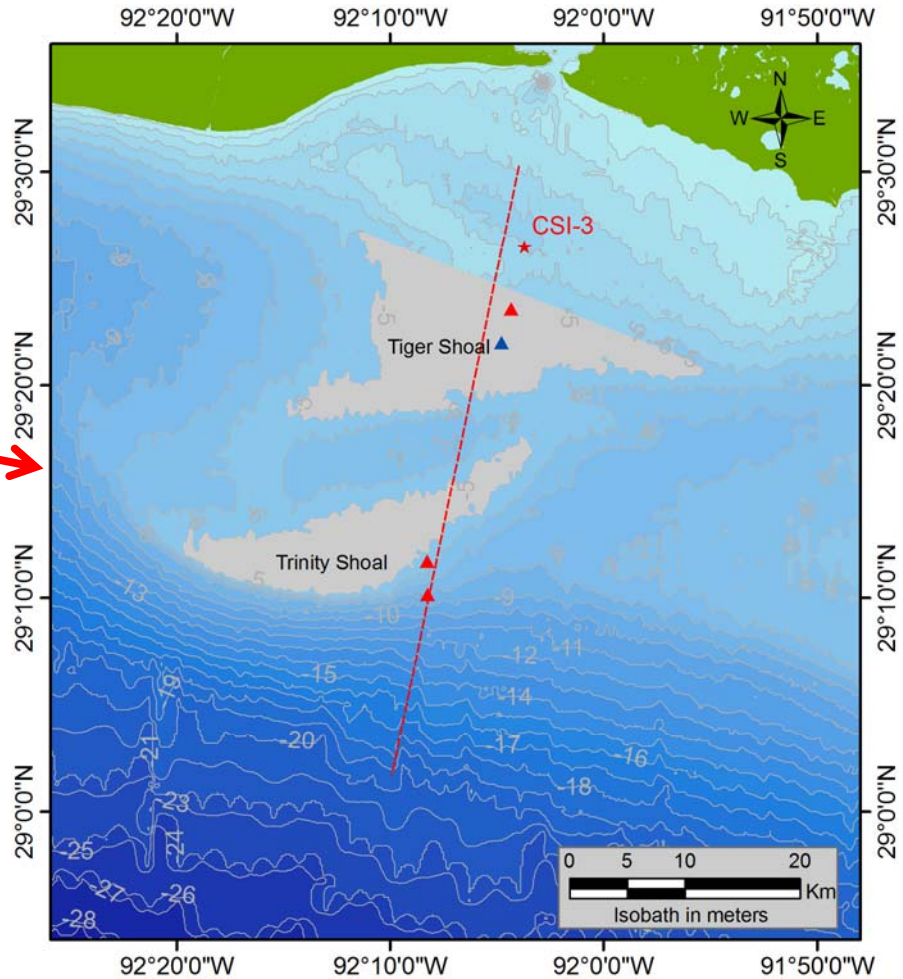
Louisiana State University

Presentation Outine

- Statement of Problem
- Physical Measurements and Modeling
  - field deployment
  - numerical modeling
- Benthic Biological Study
  - field sampling
  - statistical analyses
- Preliminary Summary and Conclusions
- Ongoing Research

Study Area


Aqua-1 MODIS true color RGB April 01, 2006 19:16 UTC


92°20'0"W
92°10'0"W
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91°50'0"W
29°30'0"N
29°20'0"N
29°10'0"N
29°0'0"N
N
W
E
S
CSI-3
Tiger Shoal
Trinity Shoal
0 5 10 20
Km
Isobath in meters

Problem Statement

- Tiger/Trinity shoals proposed as viable sediment resources for restoration of portions of the Louisiana coast
- Frequent deposition of fluvial sediments on Tiger shoal and less influence on Trinity Shoal
- Treatment of heterogeneous bottom sediments

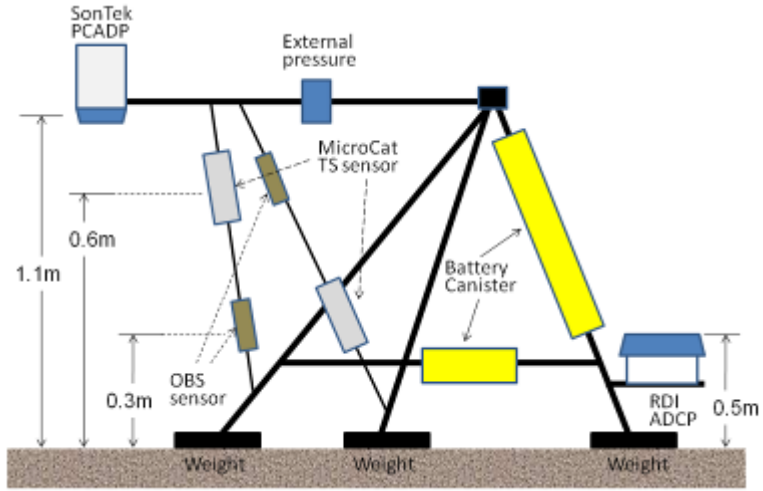
Problem Statement (continued)

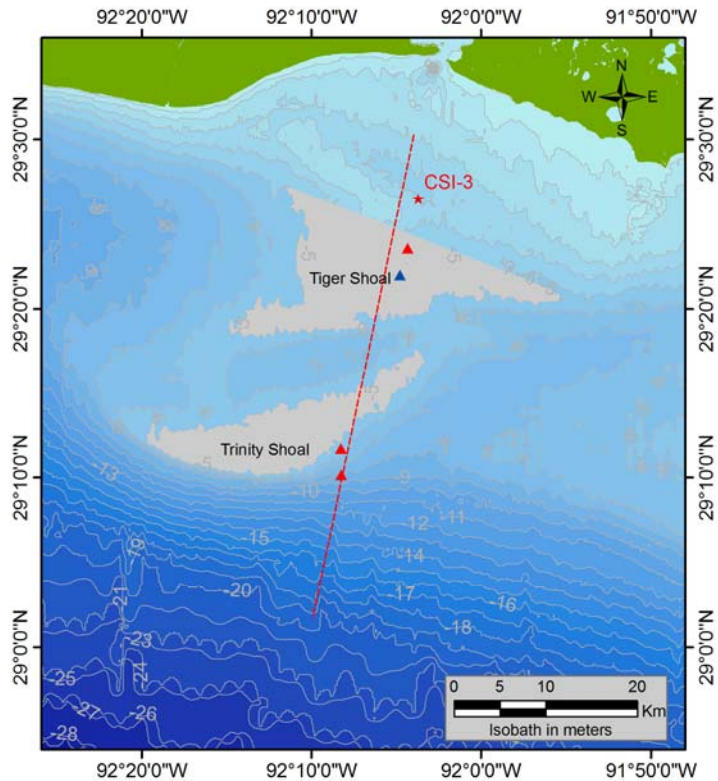
- Field deployments and numerical modeling to examine Bottom Boundary Layer (BBL) dynamics and physical oceanographic processes (Drs. Stone, Kobashi, Jose, and Liu)
- Benthic biological study (Drs. Condrey, Fleeger, Dubois, Gelpi, and Grippo)
- Geology and Geophysics (Dr. Roberts and Syed Khalil)
- Integration of physical and biological results (Team members)

Physical Measurements

Field Deployment

- To examine bottom boundary layer characteristics on Tiger Shoal (3–17 Dec 2008)
- Deployment of a PCADP tripod on Tiger Shoal (blue triangle)
- Thick accumulation of cohesive sediments causes difficulties during deployment/retrieval





Granulometric Characteristics on Shoal Surface

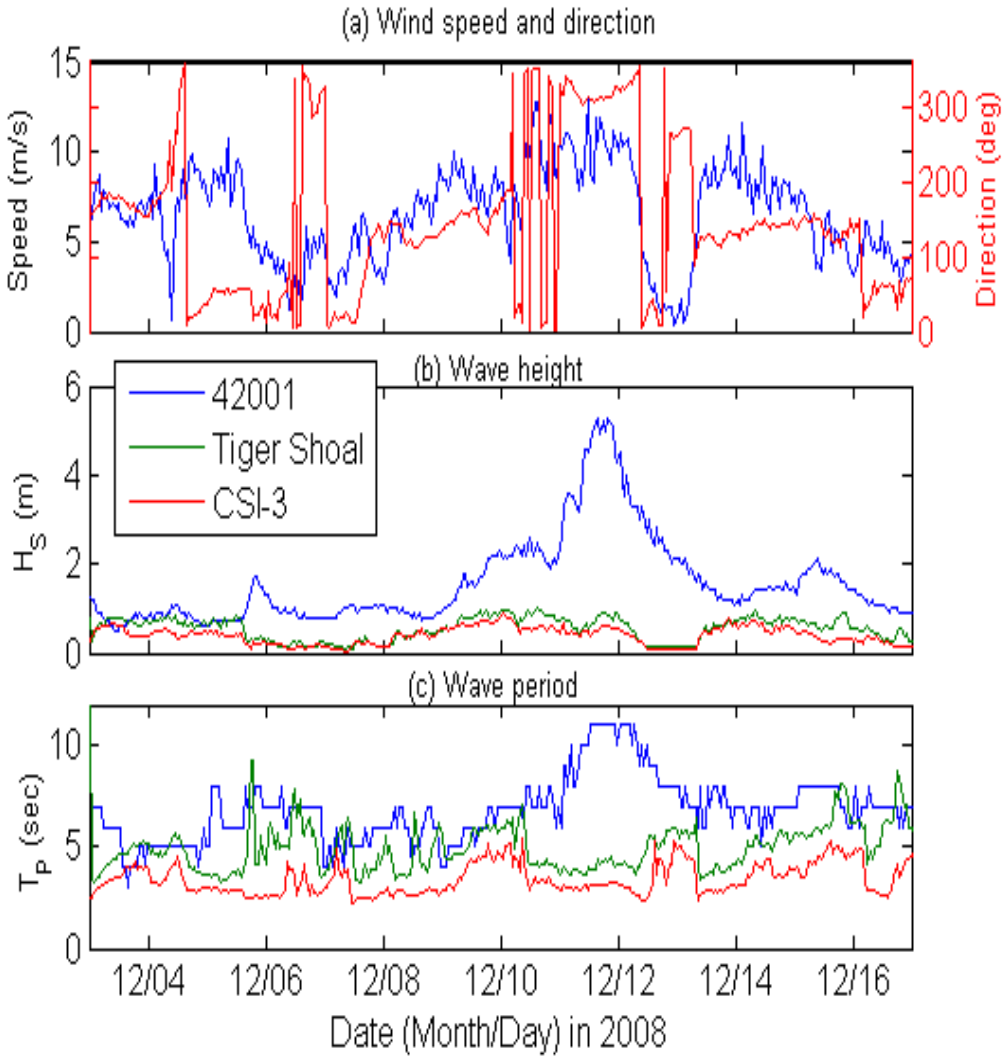
2 weeks

Deployment
Fluid mud

Retrieval
Shelly sand

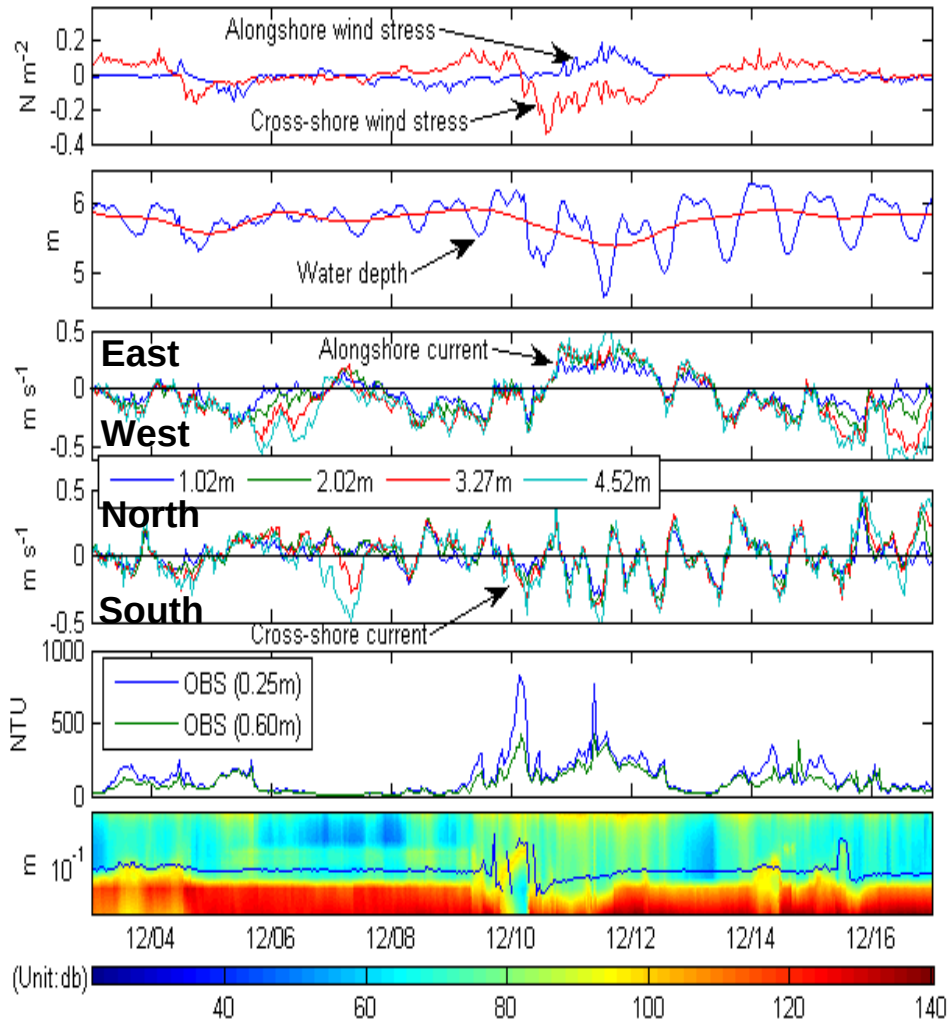
Hydrodynamic Parameters (Waves)

- A strong winter storm on 11 December 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



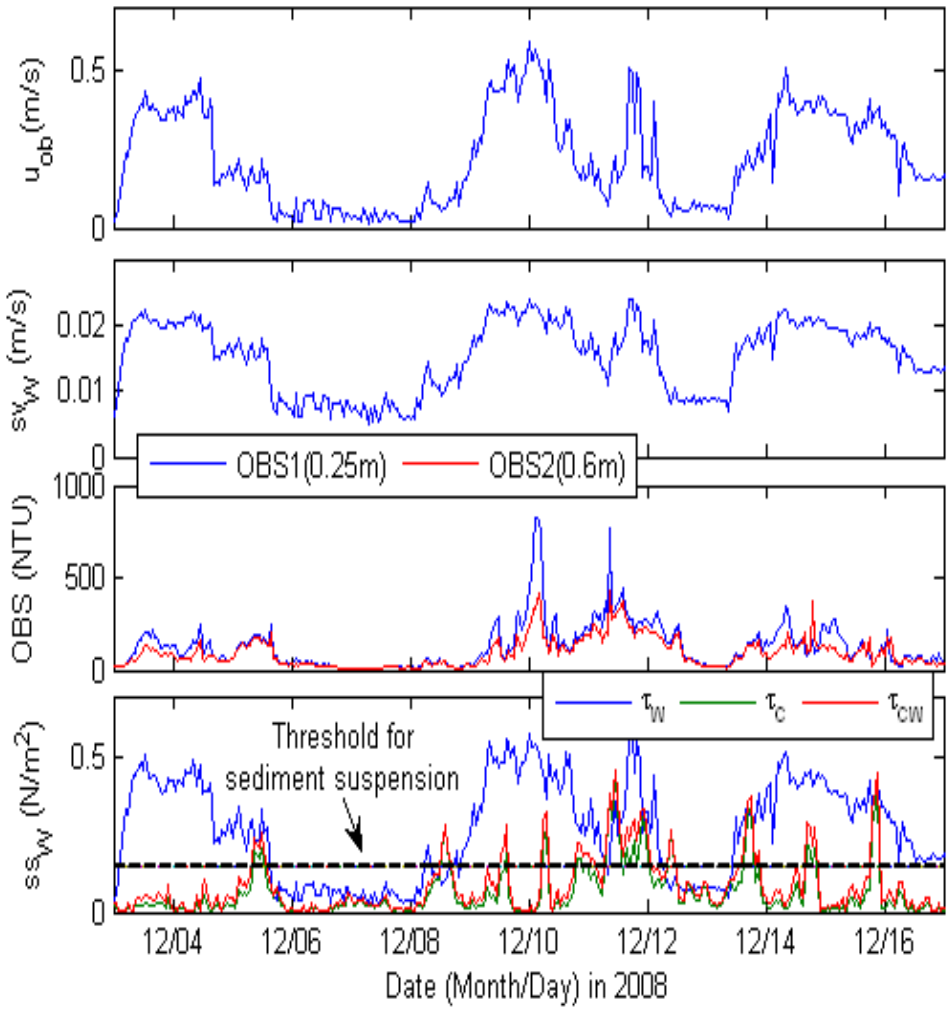
Hydrodynamic Parameters (Water Level, Currents)

- A strong storm on 11 Dec.
- ≈ 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



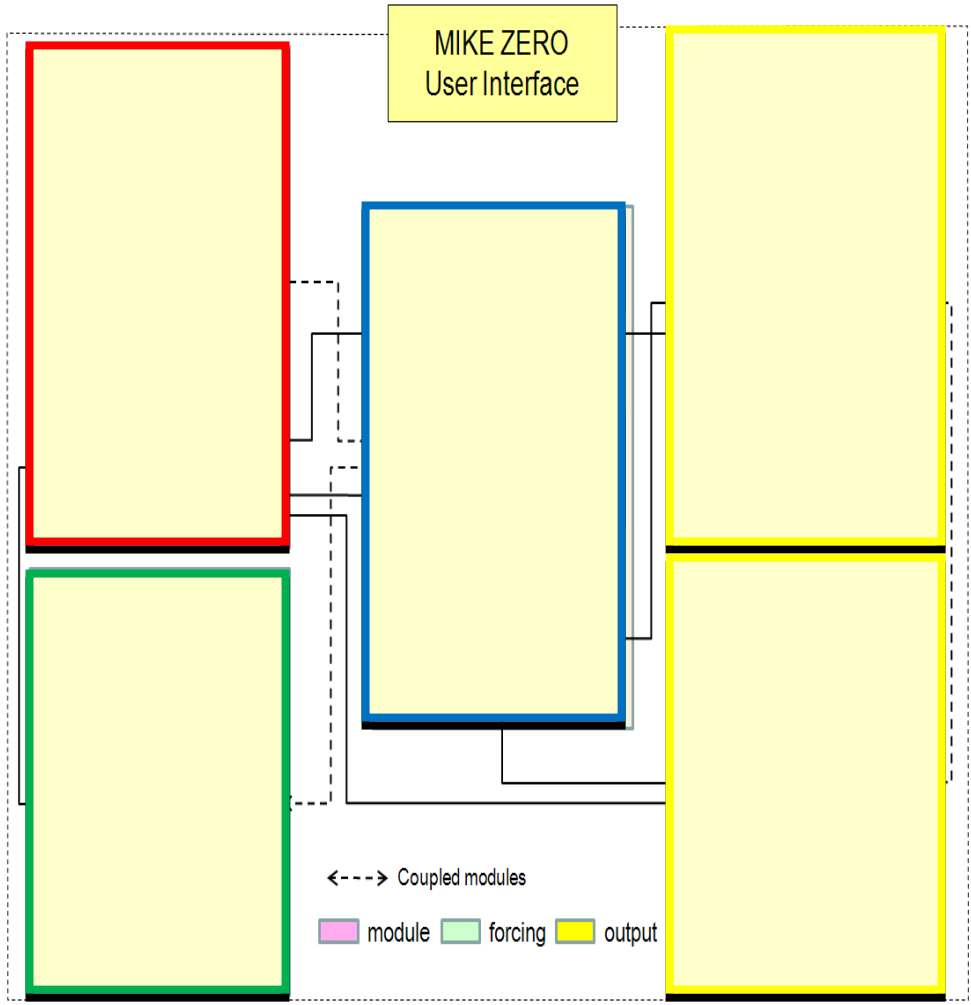
BBL Parameters

- 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 (cf. Kobashi and Stone, in review)
- Influx of fluvial sediments complicate the dynamics
- Difficult to implement sediment transport model



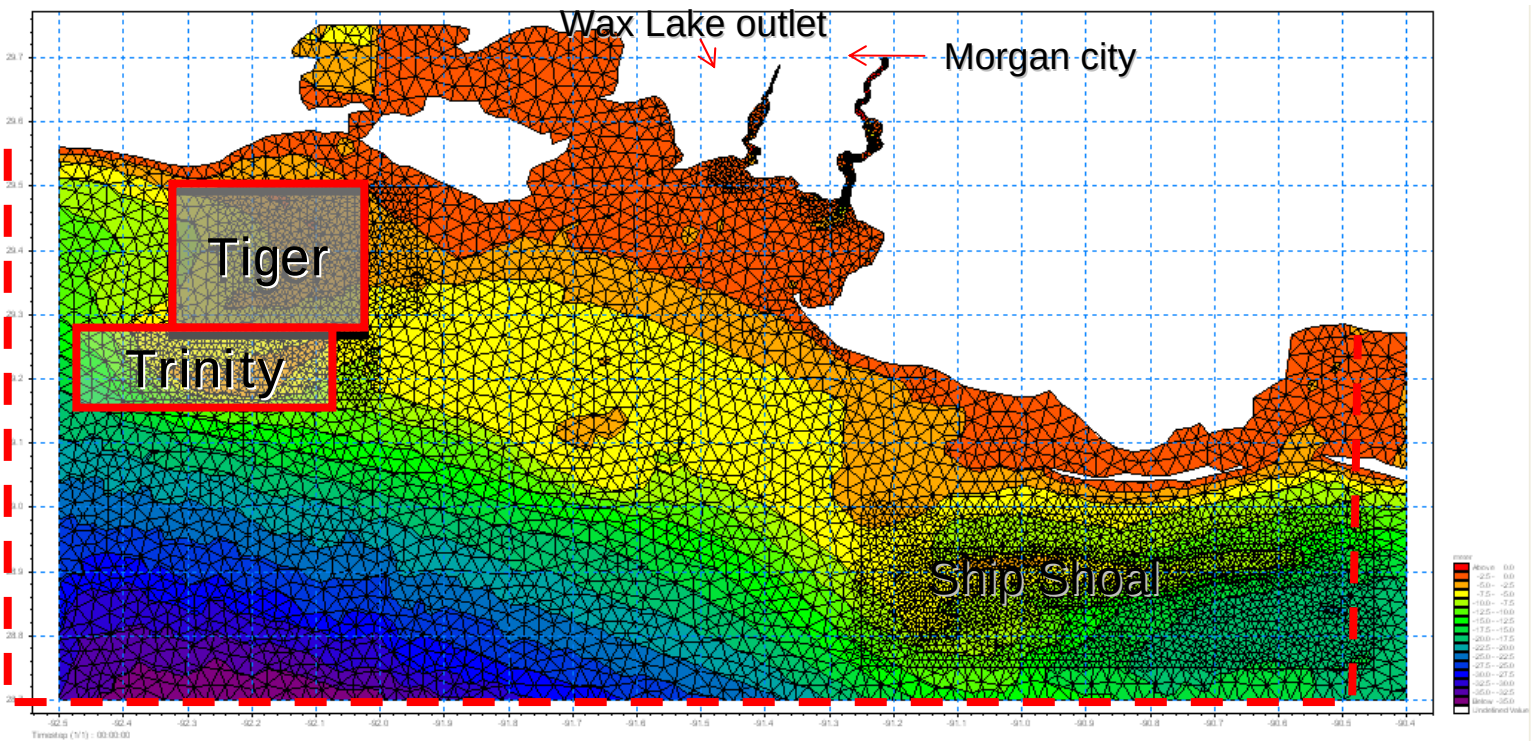
Numerican Modeling
DHI MIKE 21/3

- 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 (ongoing)



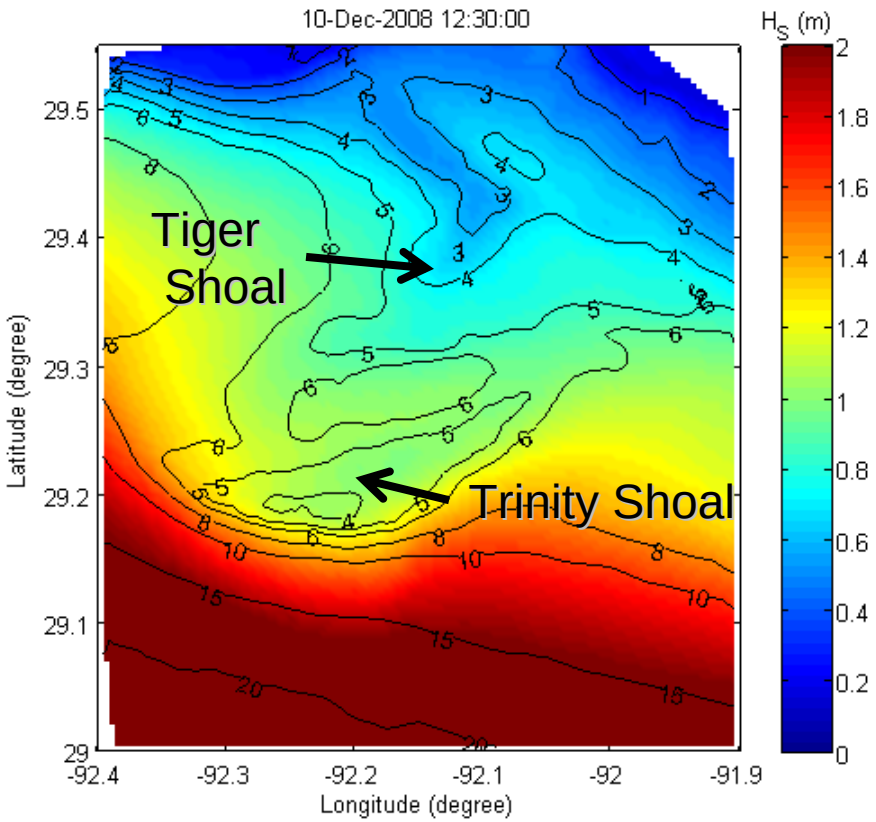
Model Domain

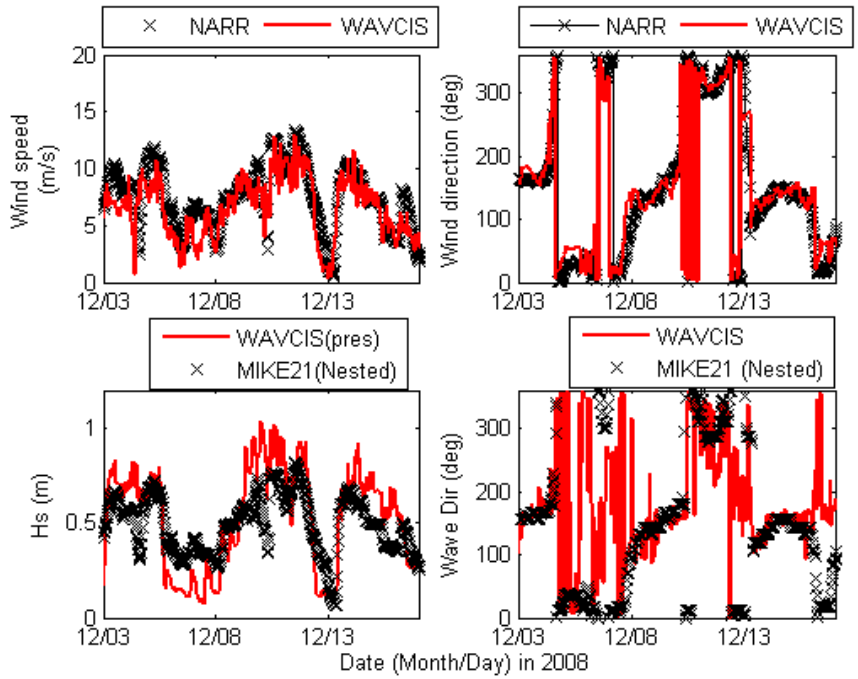
- Cover Atchafalaya shelf, Ship Shoal, Tiger/Trinity shoals
- Fine mesh over Tiger/Trinity shoals
- Incorporate Atchafalaya River sources
- Boundary conditions (Water level for each boundary)



Model Results (Waves)

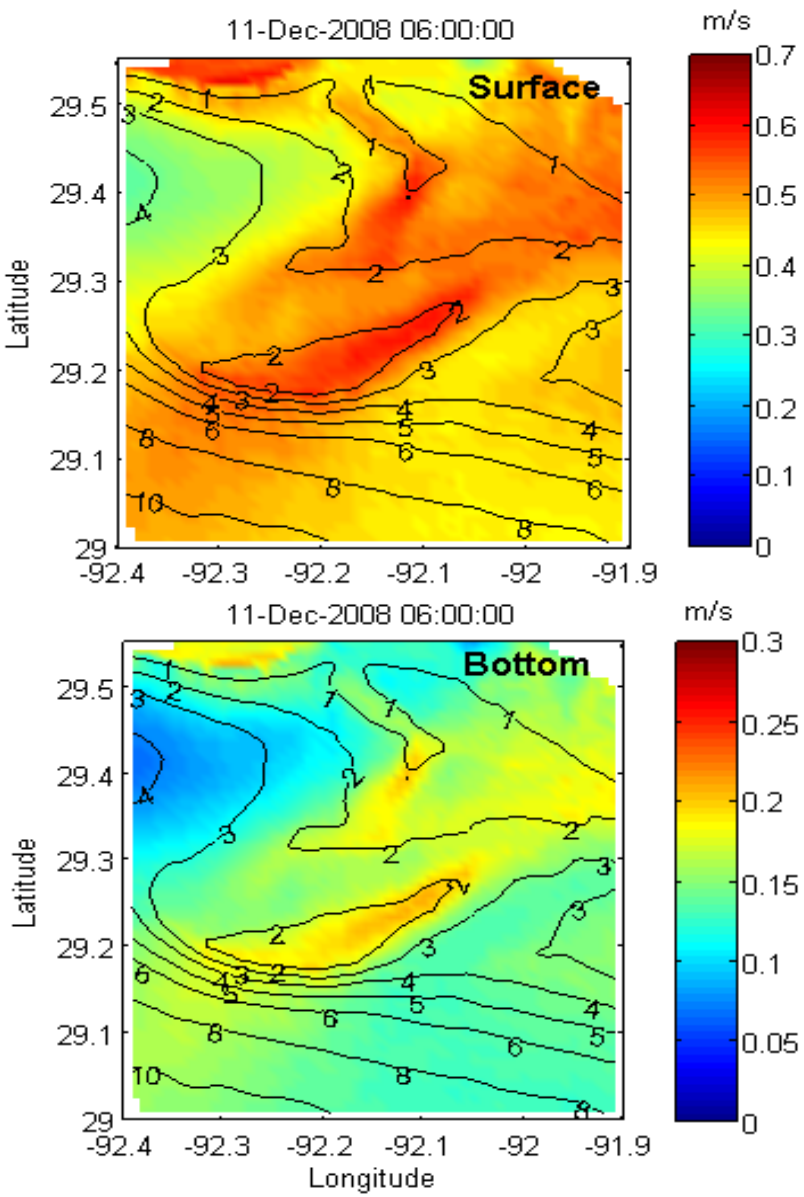
- Wind and bulk wave parameters are in good agreement with *in situ* data

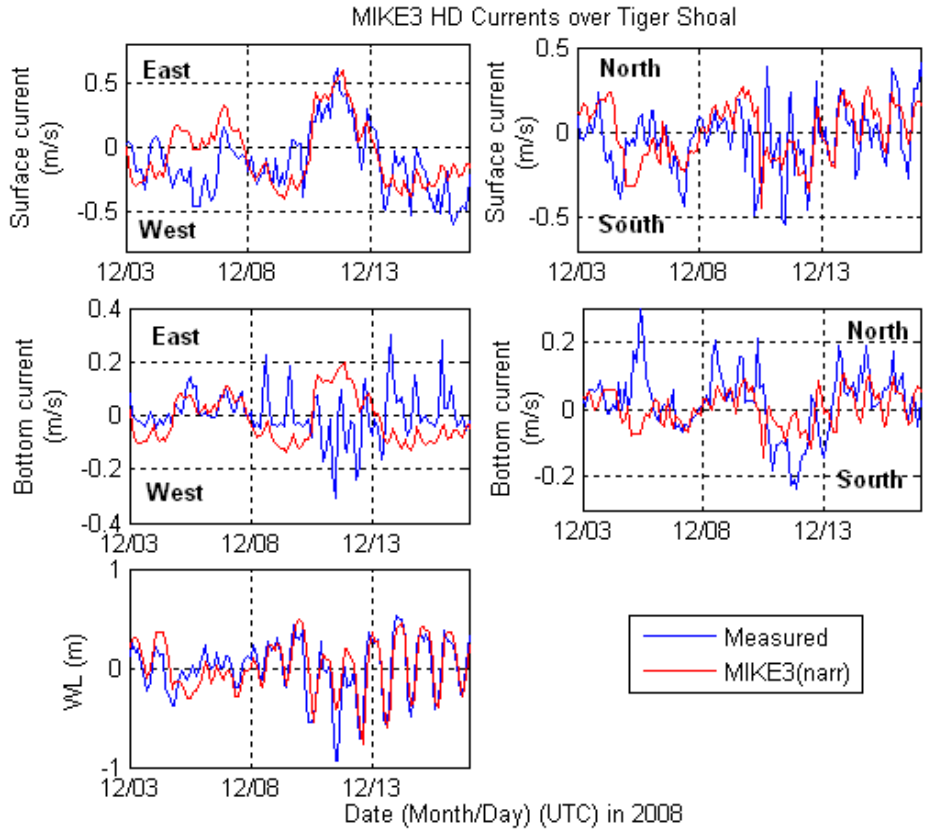




- Wave dissipation seaward of Trinity Shoal
- A contrast between Tiger and Trinity shoals

Model Results (Currents)



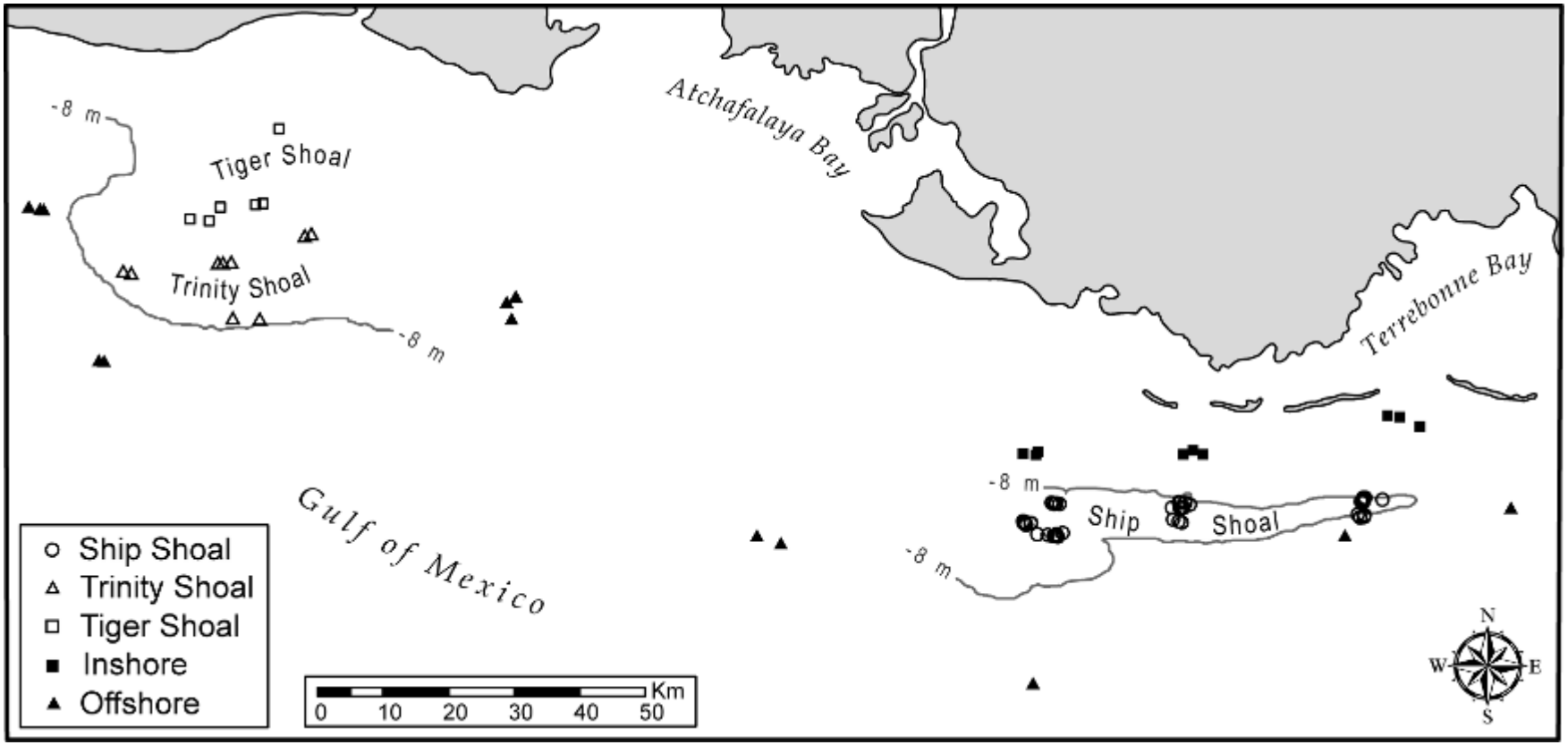


- Good agreement with *in situ* data
- High current over both shoals, expecting sediment flush-out during winter storms

Benthic Biological Study

Biological Overview

1. Ship/Trinity/Tiger Shoal Complex

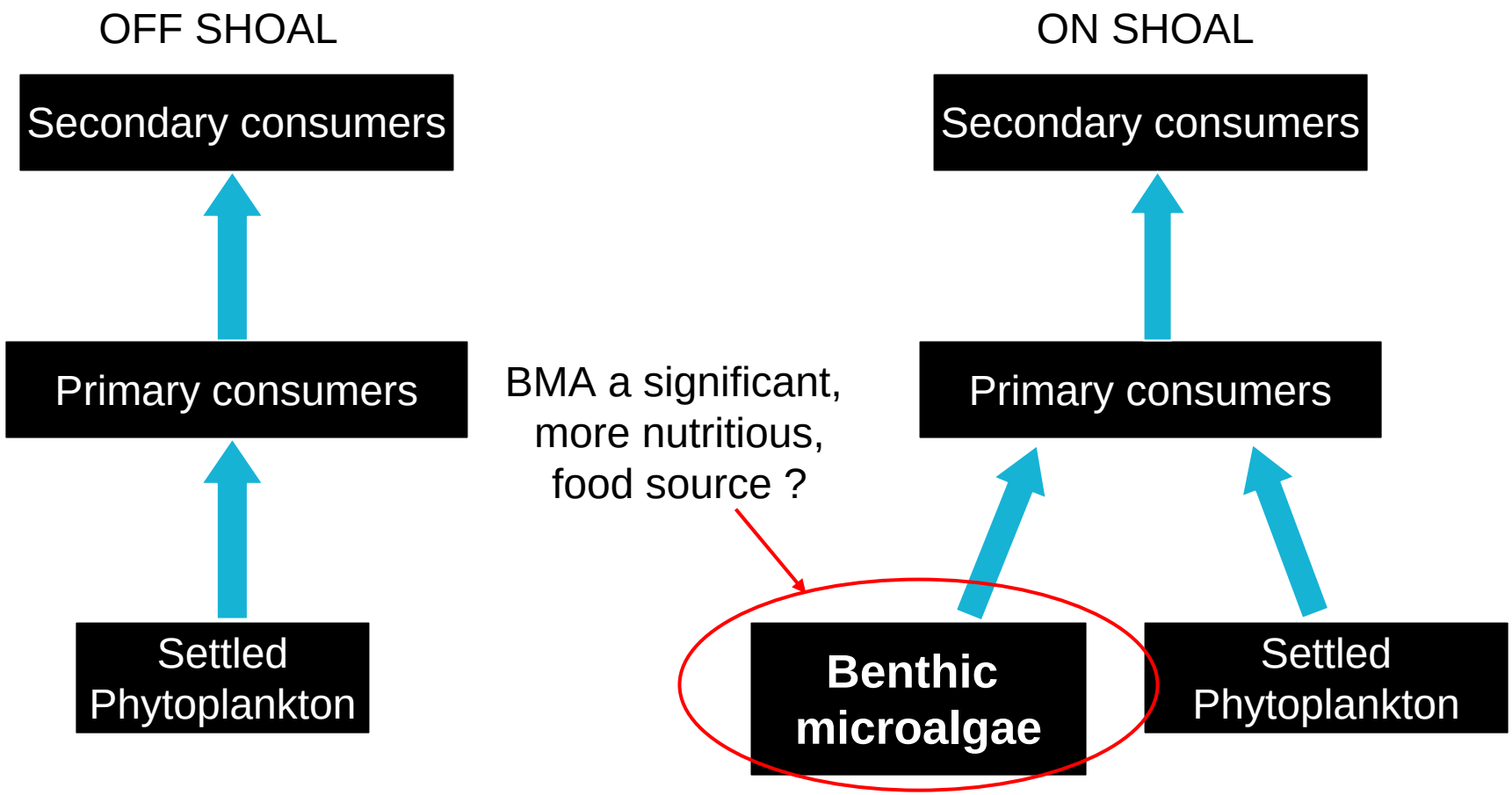


2. BACI approach based on understanding feeding/community ecology

- **a. BMA-infauna-demersals (box core, trawls, gut contents, stable isotopes)**
- **b. Response to physical/chemical/biological gradients**
- **c. New**
  - i. Benthic Microalgae (BMA): relatively unstudied in the Gulf of Mexico
  - ii. Blue crab spawning: in federal waters, continuous during season

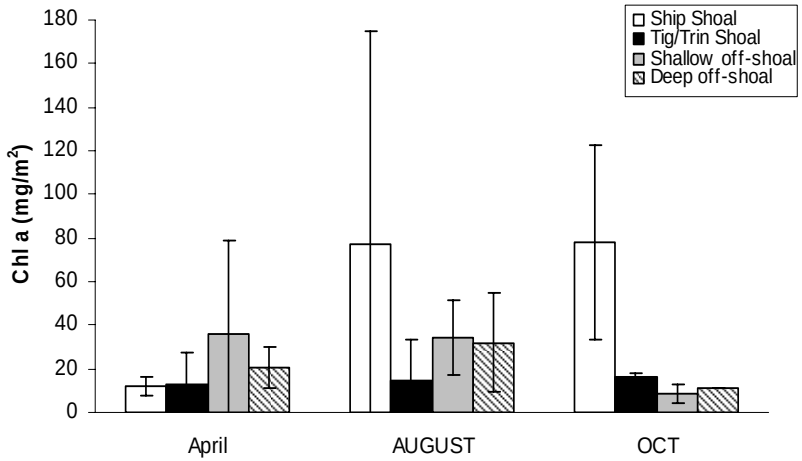
BMA and COASTAL FOOD WEBS

Simplified Benthic Food Web:

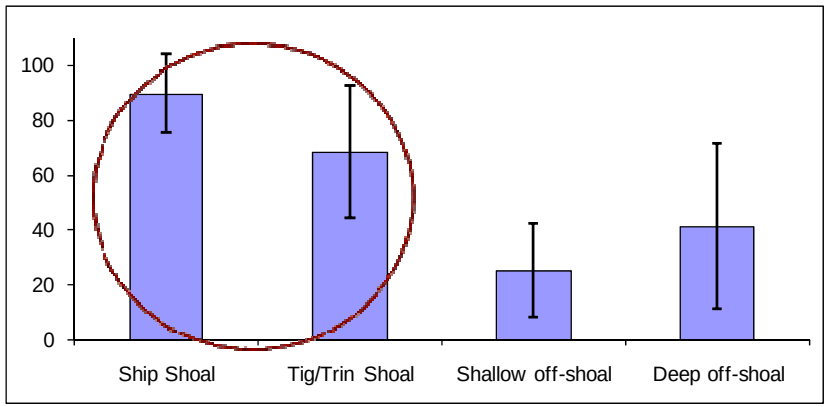


BMA RESULTS

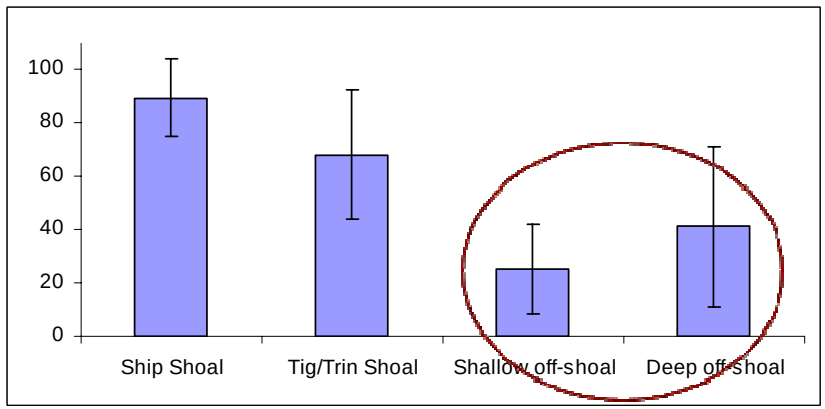
No significant differences in algal (diatom) biomass (chl *a*), but pigments indicate more degraded algae in off-shoal sediments



Percent pennate diatoms (BMA) highest at sandy stations



Percent settled centric diatoms (phytoplankton) highest at muddy stations



INFAUNA

a. Ship Shoal conclusions for 2005–2006 samples

    1. Amphioxus/mole crab community

    2. Biodiversity hotspot.

    3. Hypoxia refuge, likely important in reseeding the surrounding areas following hypoxic events.

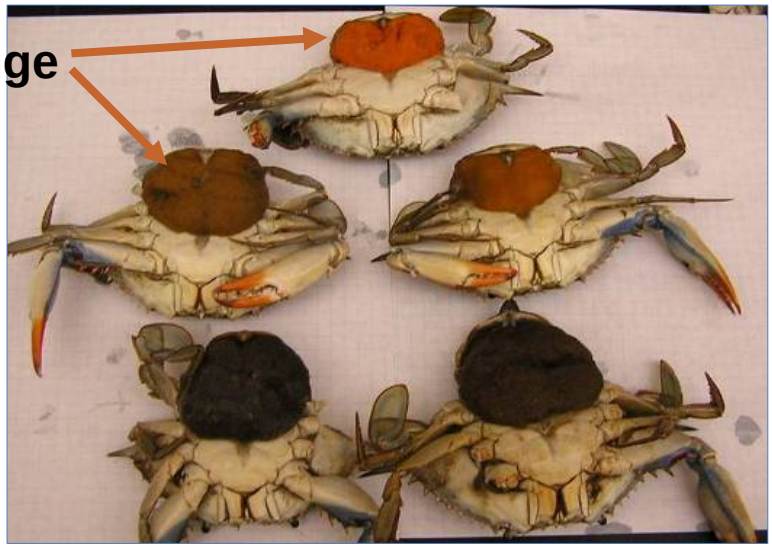
    4. East-west Gulf of Mexico ‘colonization stepping stone’

b. 2007 STTSC samples being analyzed in 2009

MMS-Discovery: Spawning/Hatching Blue Crabs

Ovigerous females

Sponge



Egg development

Non-ovigerous females

Full ovary

Full stomach

Blue Crab Hypotheses

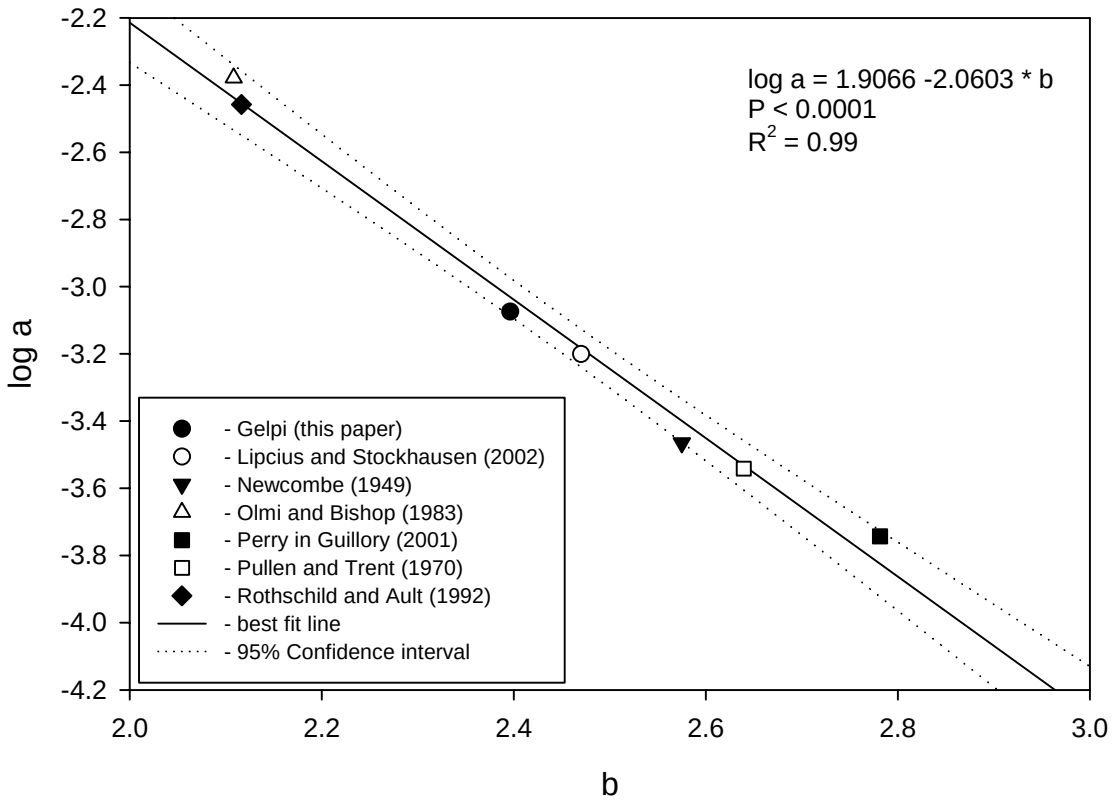
a. National comparisons: no difference in

   condition factor (length-weight)
   fecundity (eggs/female)
   abundance (cpe)

b. STTSC (April–October)

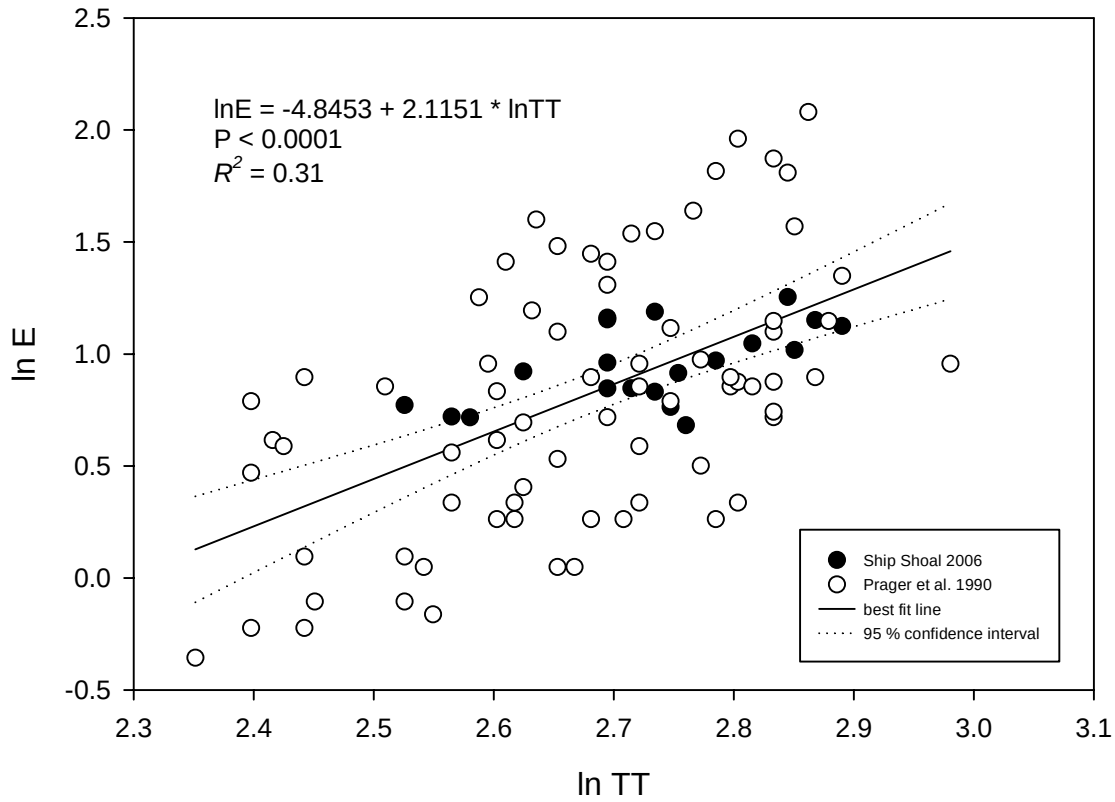
   1. continuous spawning
   2. no area and time differences

Condition Factor (National)



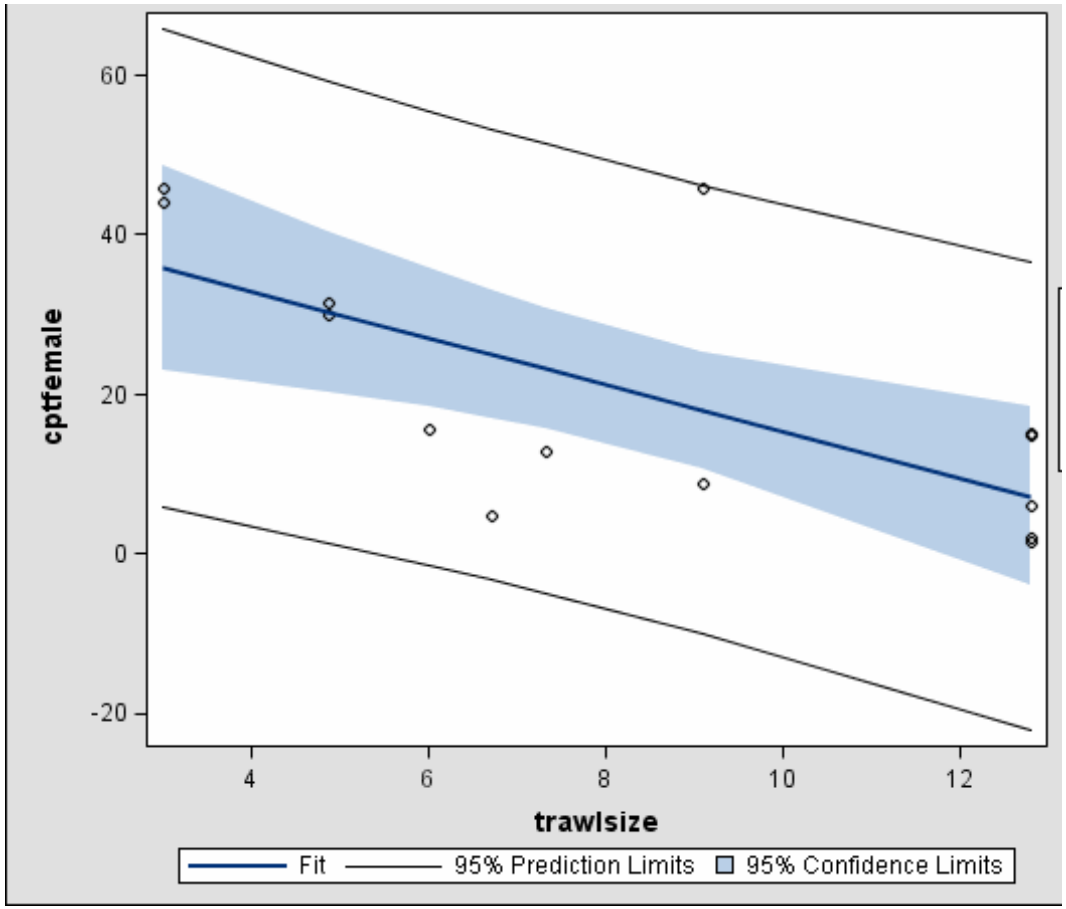
No difference

Fecundity (National)



No difference

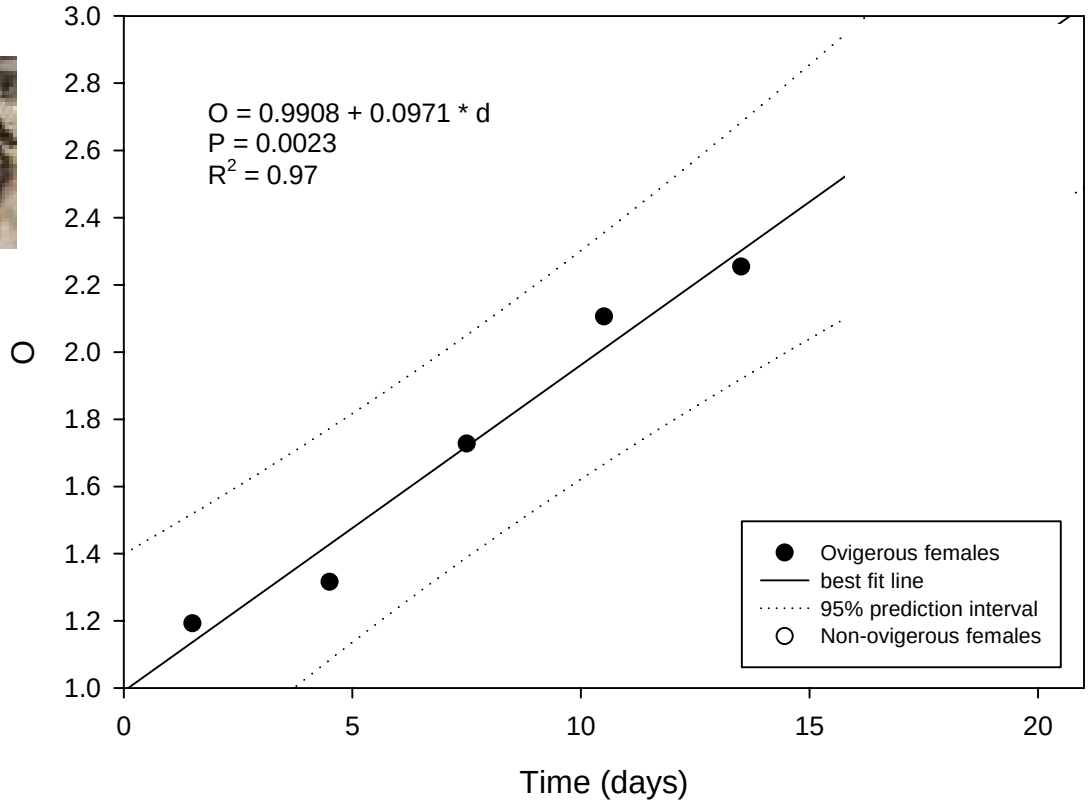
Abundance (National)



No area difference

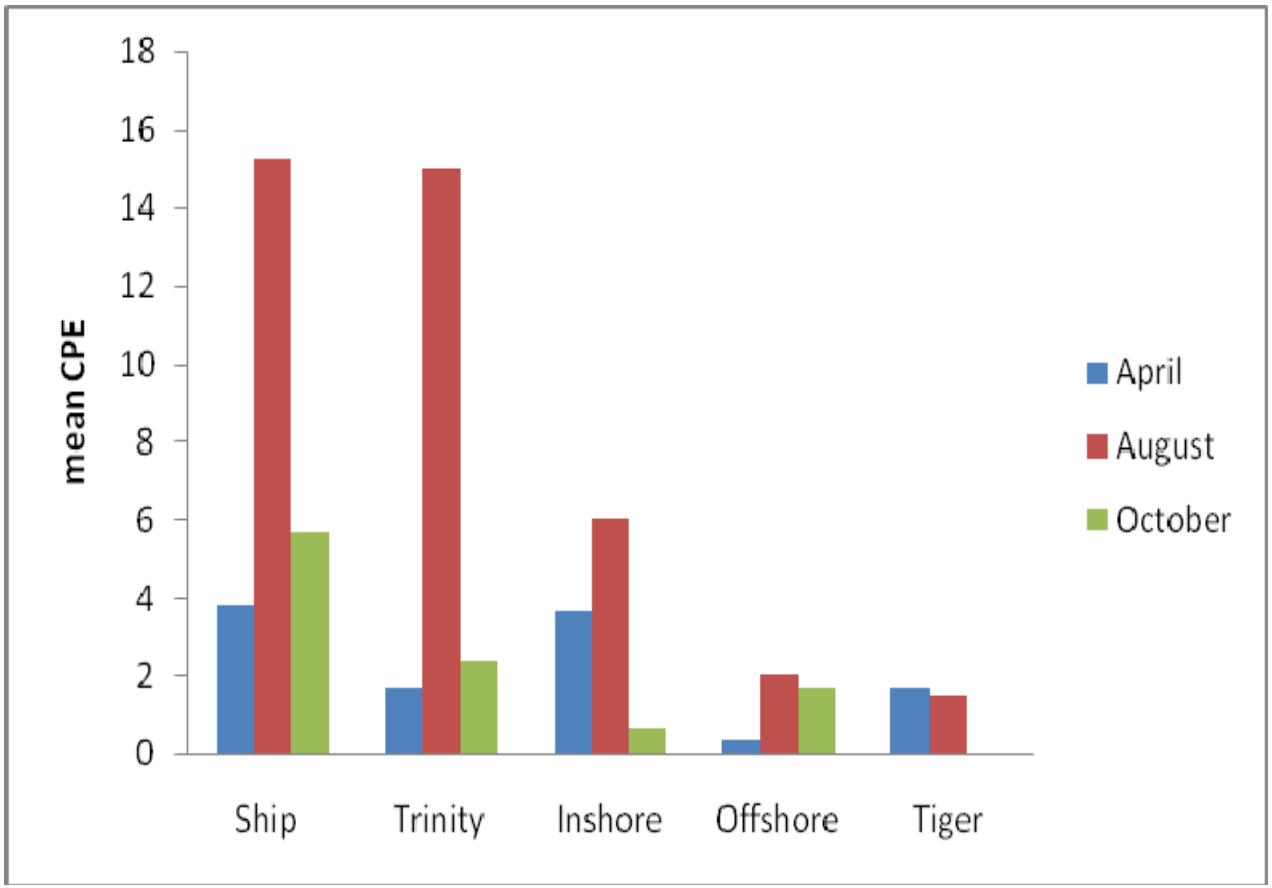
Differences due to either size of trawl or historic time

Spawning (STTSC, April – October)



Continuous

Area and Time Differences (STTSC, April–October)

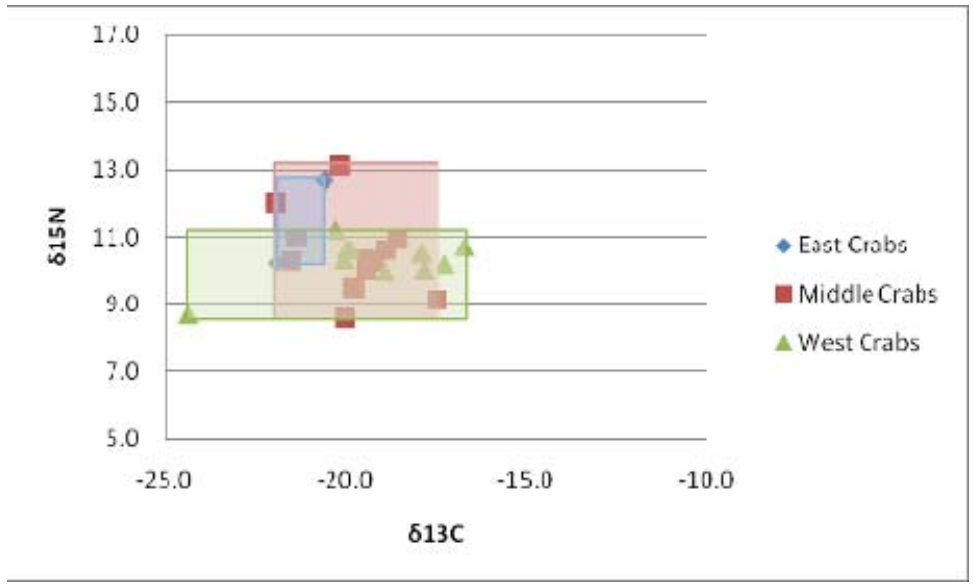


August peak on Trinity and Ship shoals

2009: Complete BMA-based Food Web Investigation: Example 2006 Ship Shoal Blue Crab/Infauna Prey Results

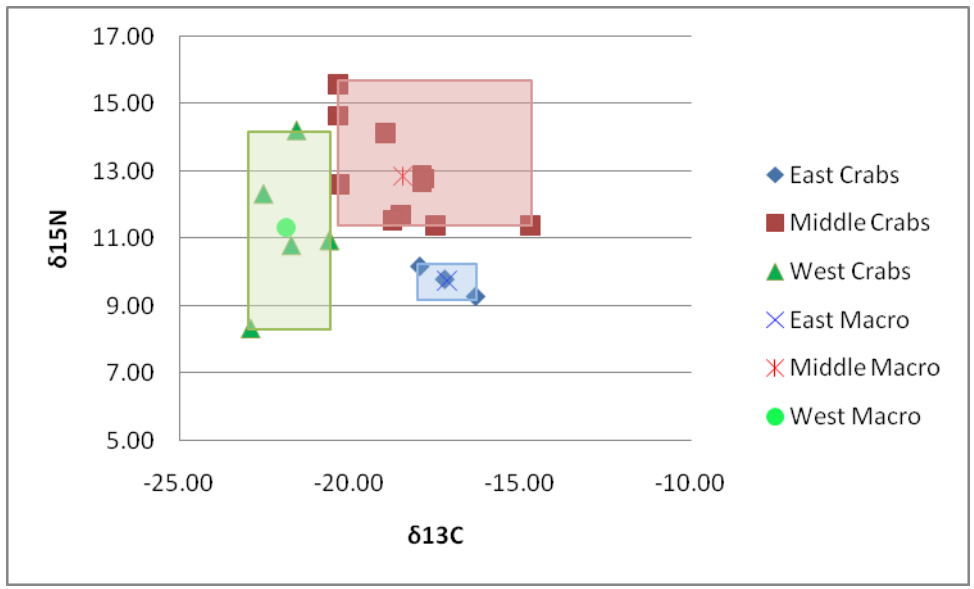
May: Blue crab values not segregated.

Newly arrived crabs?



August: Blue crab values segregated and reflect segregated macrofauna signals.

Crabs resident on specific areas of shoal?



Sand Mining Implications/Considerations

BMA

- High biomass of nutritious BMA on TT and SS
  - appears unique to shoals
  - likely typical of shallow, sandy shoals in north central GOM
- Sand mining could have adverse impacts on BPP:
  - by increasing depth (lower light)
  - changing sediment characteristics from sand to silts

INFAUNA

- Biodiversity hotspot
- Hypoxia refuge, important in reseeding (hypoxic events).
- East-west Gulf of Mexico ‘colonization stepping stone’

Blue crabs

- Louisiana currently #1 US blue crab fishery
- Continuous spawning ground on STTSC, April–October
- Dependent on local STTSC resources

2009 – Continue to integrate the physical and biological findings within the context of sand mining for coastal restoration as prospective sediment mining sites are identified

Overall Conclusions

- In winter, Tiger Shoal experienced dramatic changes in bed characteristics
- Sediment re-suspension on Tiger/Trinity shoals was profound in winter
- Likely strong contrast with spring high river discharge regime (ongoing)

Future Research Plan

- Two field deployments (January, April) on both Tiger/Trinity shoals (A total of four tripods + CSI-3)
- Influence of Atchafalaya freshwater and sediments on Tiger/Trinity shoals as well as implementation of mud transport model
- Model implementation with accurate bathymetry (from DeWitt Braud, Syed Khalil)
- Run the models for post-mining bathymetries that reflect proposed restoration scenarios
- Contrast on and off-shoal benthic food web supports
- Blue crab larval transport study
- Attend national/international conferences
- Submit peer-reviewed journals

Reference

Kobashi, D., G.W. Stone, S.M. Khalil, and S.M. SiadatMousavi. In preparation. Impacts of sand removal from a shore-parallel Holocene transgressive shoal on hydrodynamics and sediment transport, south-central Louisiana, U.S.A.