Environmental Investigation of Long-Term use of Ship Shoal Sand Resources

Principal Investigator: Gregory W. Stone
Co-Principal Investigators : Richard Condrey, John Fleeger, Syed Khalil
Post-Docs/Doctoral Students: Daijiro Kobashi, Felix Jose, Stanislas F. Dubois, D. Elaine Evers, Carey G. Gelpi, Jr., Mark Grippo

Louisiana State University

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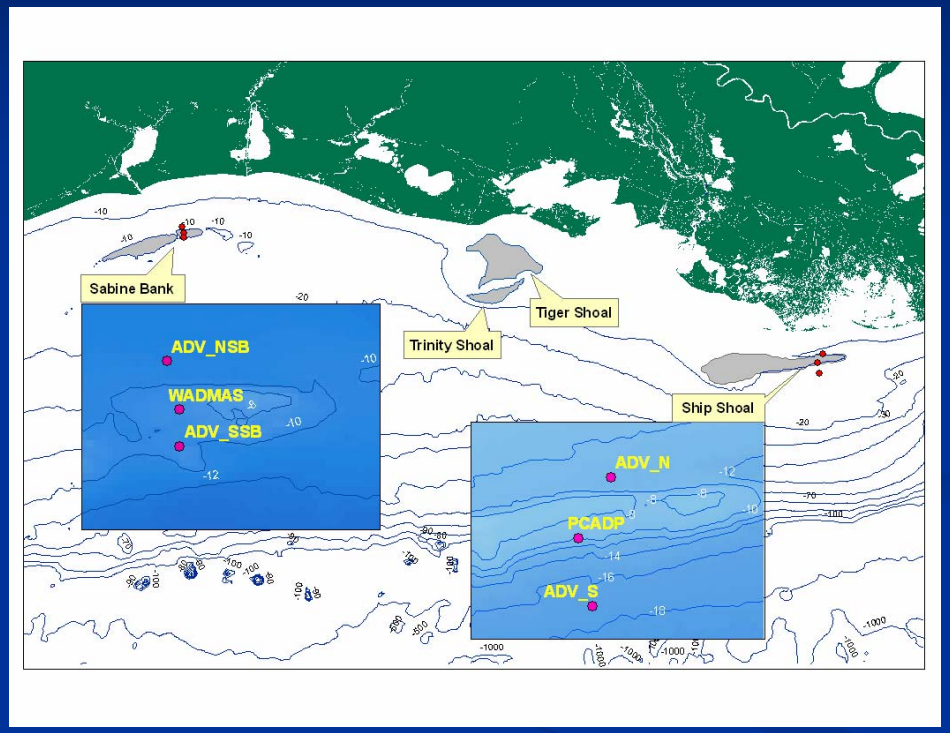
Overall Objectives

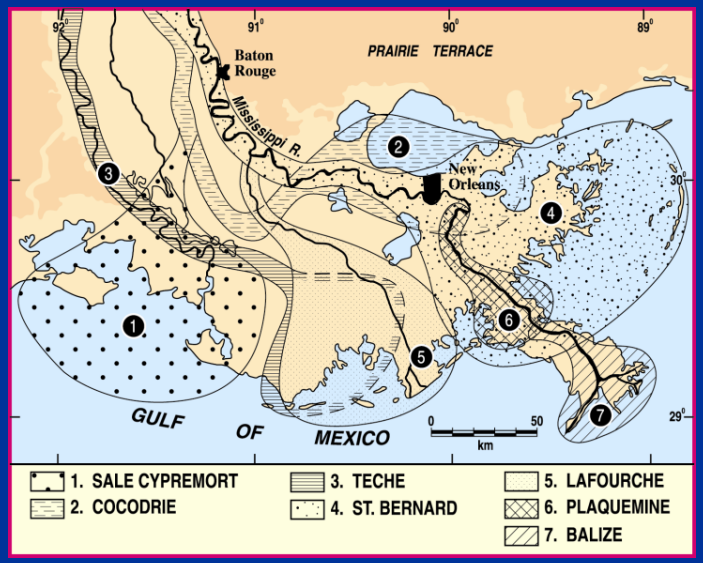
- Quantify potential long-term impacts of mining Ship Shoal for large-scale barrier restoration
- Examine bottom boundary layer physics and sediment transport on Ship Shoal
- Benthic habitat characteristics (meio-/macro-fauna)
- Quantify links between physical, geological and biological processes

Additional Sand Source Investigations on Louisiana Shelf

- Transgressive sand shoals
- Remnants of paleo-late Holocene deltas
- Billions of cubic meters of high quality quartz sand
- Possible high biodiversity
- Wave attenuation, current structure /circulation and sediment transport



Map of Louisiana Sand Shoals



Mississippi River Deltas

Physical Processes

Ultimate Goal

- Quantitatively demonstrate long-term cumulative impacts of waves and currents on shoal bottom sediments, sediment transport and biological processes and predict impacts of sand mining

Methods

- Bottom sediment sampling
- Deployment of oceanographic instruments
  - Acoustic Doppler Velocimeter/Pulse-Coherent Doppler profiler
  - Pressure sensors
  - Turbidity sensors
- Numerical Model Implementation
  - Spectral waves module
  - Hydrodynamic module
  - Sediment transport module for sand/mud (ongoing)

Instrument Deployment

- Acoustic Doppler velocimeter, pressure and two turbidity sensors

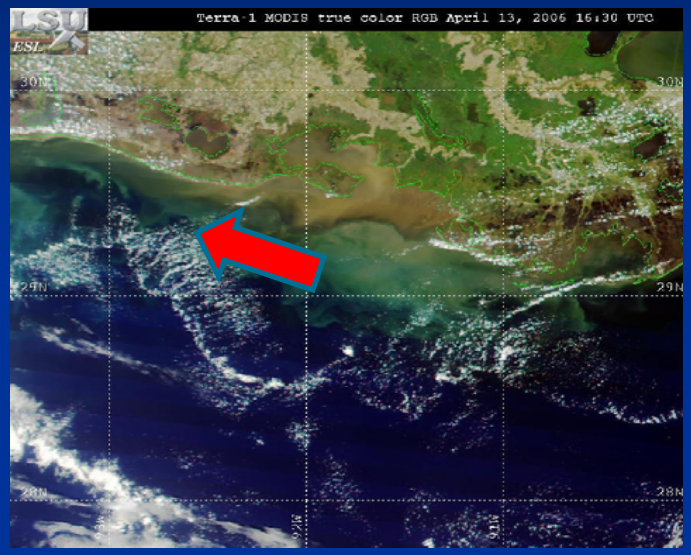
  (both edges of the shoal)
- Pulse-coherent doppler current profiler, pressure and two turbidity sensors (shoal crest)

Waves, currents, sediment transport processes

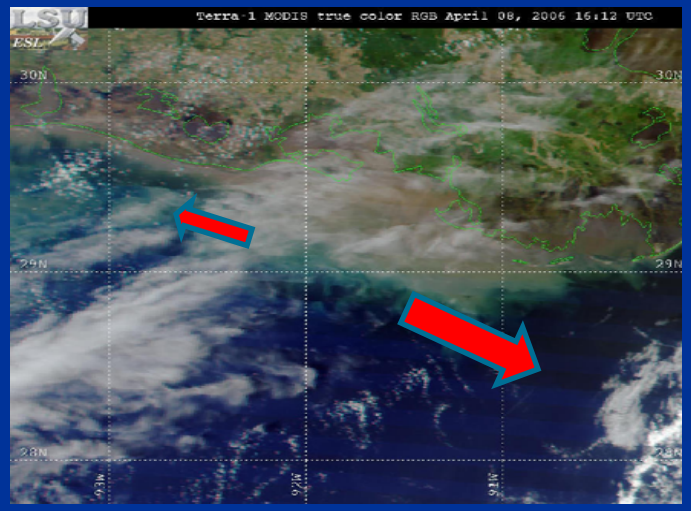
Fluvial Sediment Transport to Shoal

MODIS Satellite Imagery

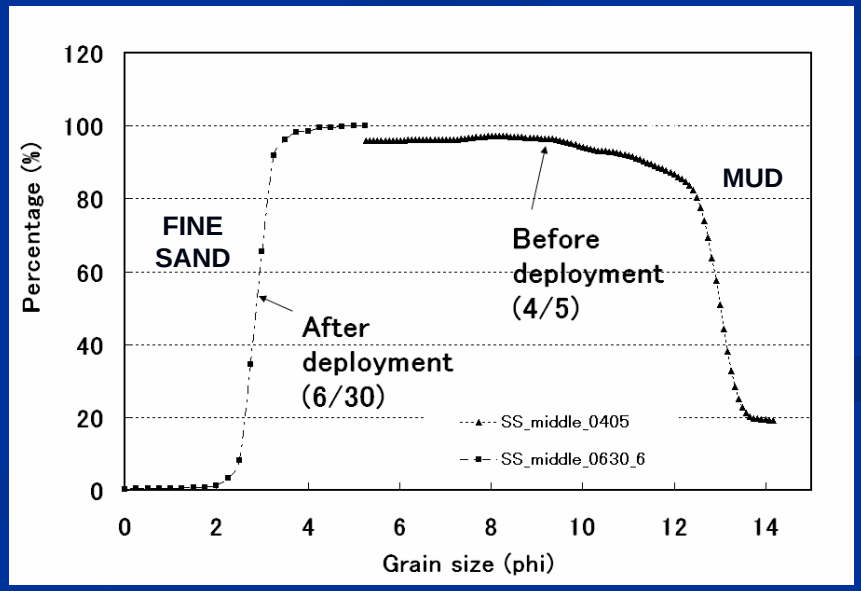
Fair weather



Cold Front

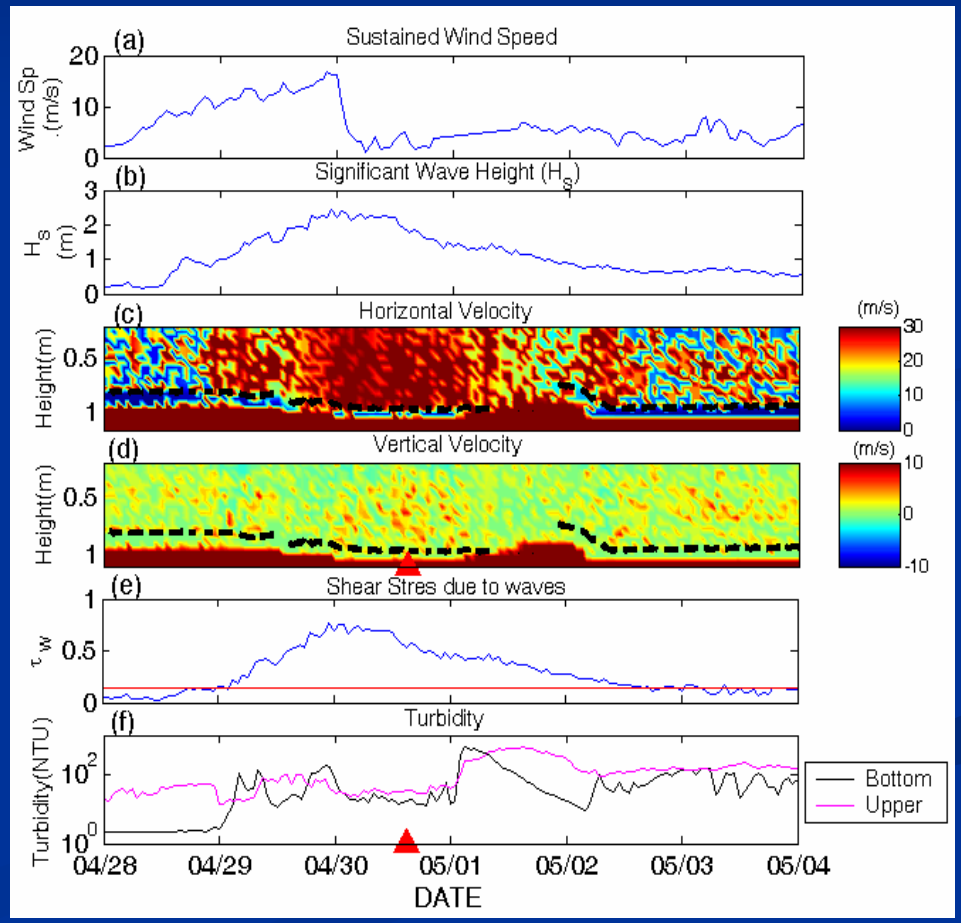


- Bottom sediment heterogeneity (sand/mud mixture)
- Atchafalaya River sediments transported toward the shoal resulting in highly heterogeneous bottom type over time (effects of spring flood and cold fronts)



Storm Wave Impacts on Sediments

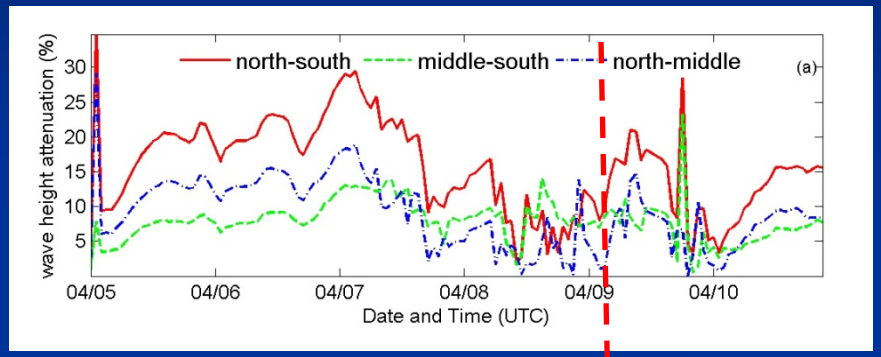
- Storm-induced waves strongly rework bottom sediments (re-suspension, pre-front)
- Re-suspended sediments diffused and mixed throughout the bottom water column (mixing, during storm passage)
- Re-suspended sediments settle during the waning phase of the storm (settling, post-front) → formation of fluid mud layer



Wave Attenuation Over the Shoal

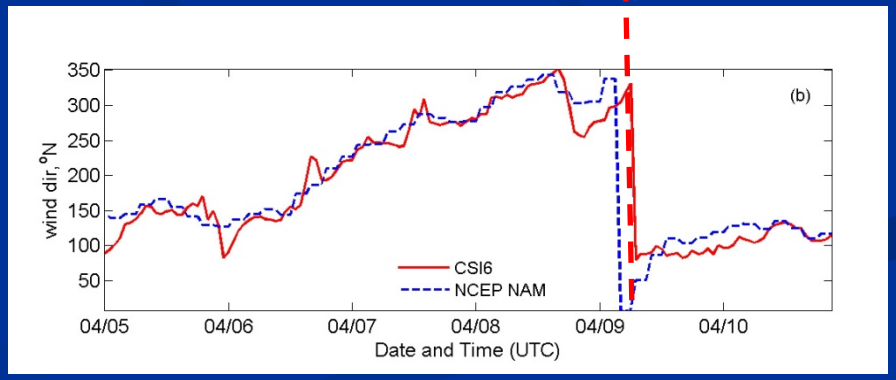
- Waves are attenuated as they cross the shoal offshore-onshore: max 26.7 %
- Greater wave attenuation along the western flank (shallower) than the eastern flank (deeper)
- Higher re-suspension along western than at the eastern flank of shoal

Offshore, inshore, crest of the shoal



Wave height attenuation

Cold front passage

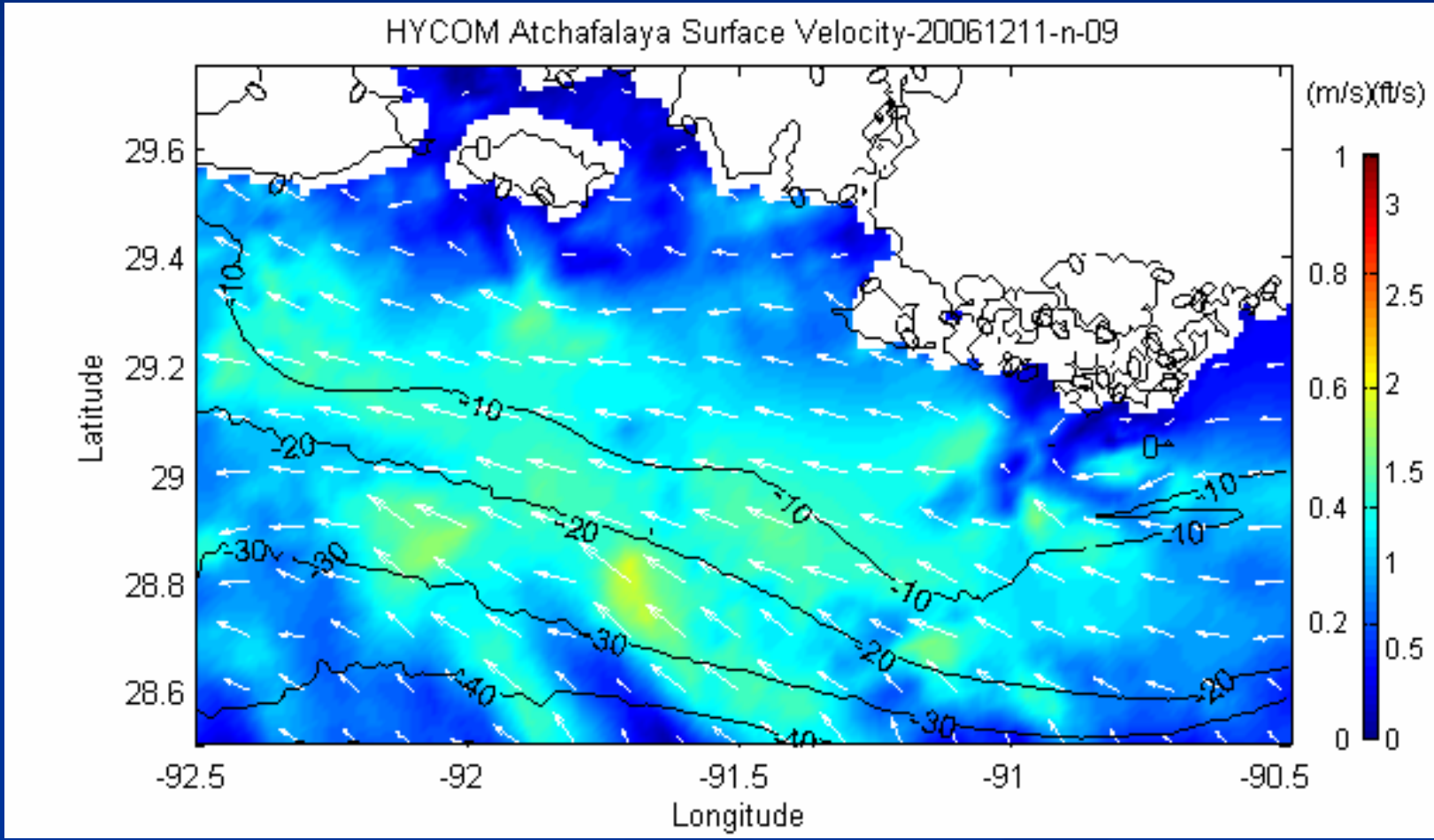


Wind direction

Wave energy dissipation

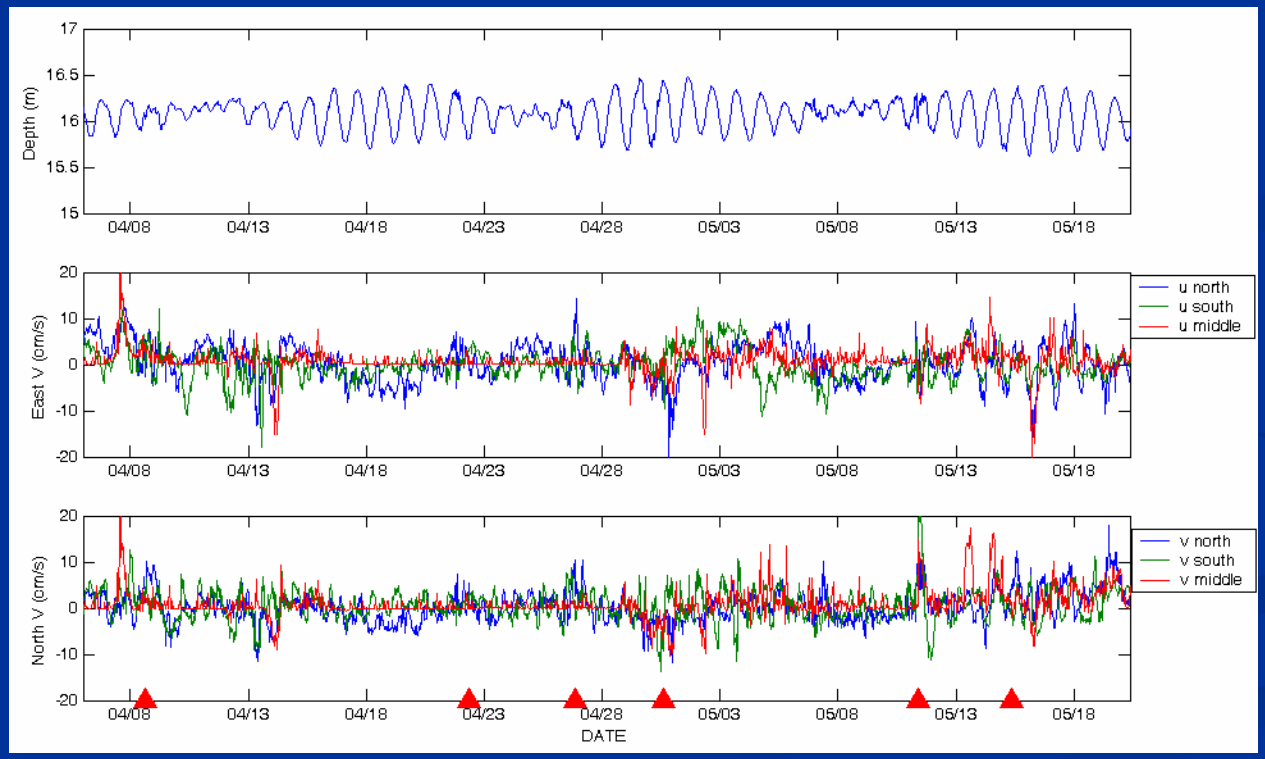
Animation

Current Distribution: Biological Implications?



Circulation Pattern Over the Shoal

- Tide + local turbulence
- Strong northeast-southwest currents during storms



Depth

East Velocity

North velocity

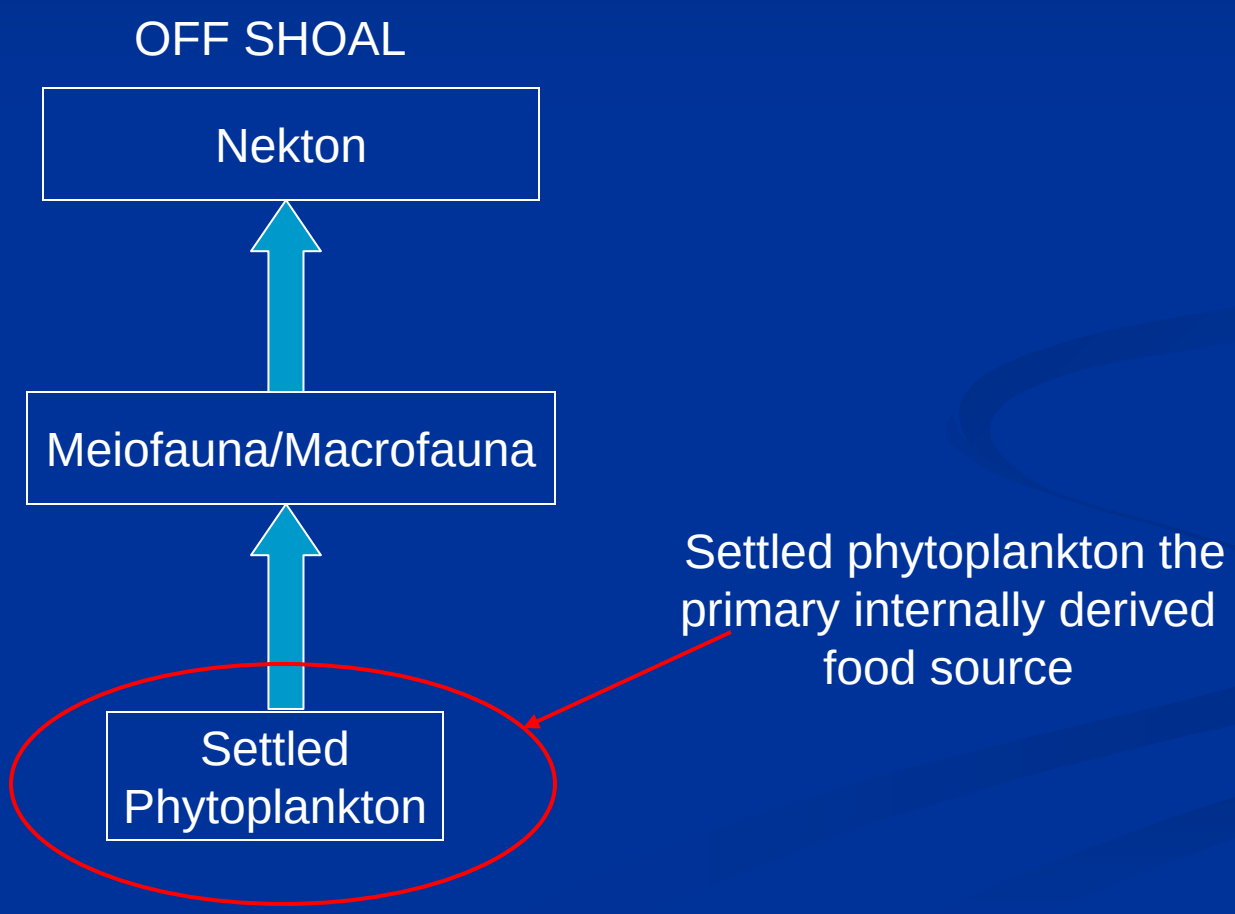
Biological Processes
Objectives

Pre-mining Investigations- Is Ship Shoal Biologically Unique?

- Characterize Ship Shoal's meio/macrofaunal community and habitat use by shrimp and croaker
- The potential for primary production by benthic microalgae (BMA)
- Significance of BMA to the benthic food web on Ship Shoal compared to off-shoal
- Potential impacts of sand mining?

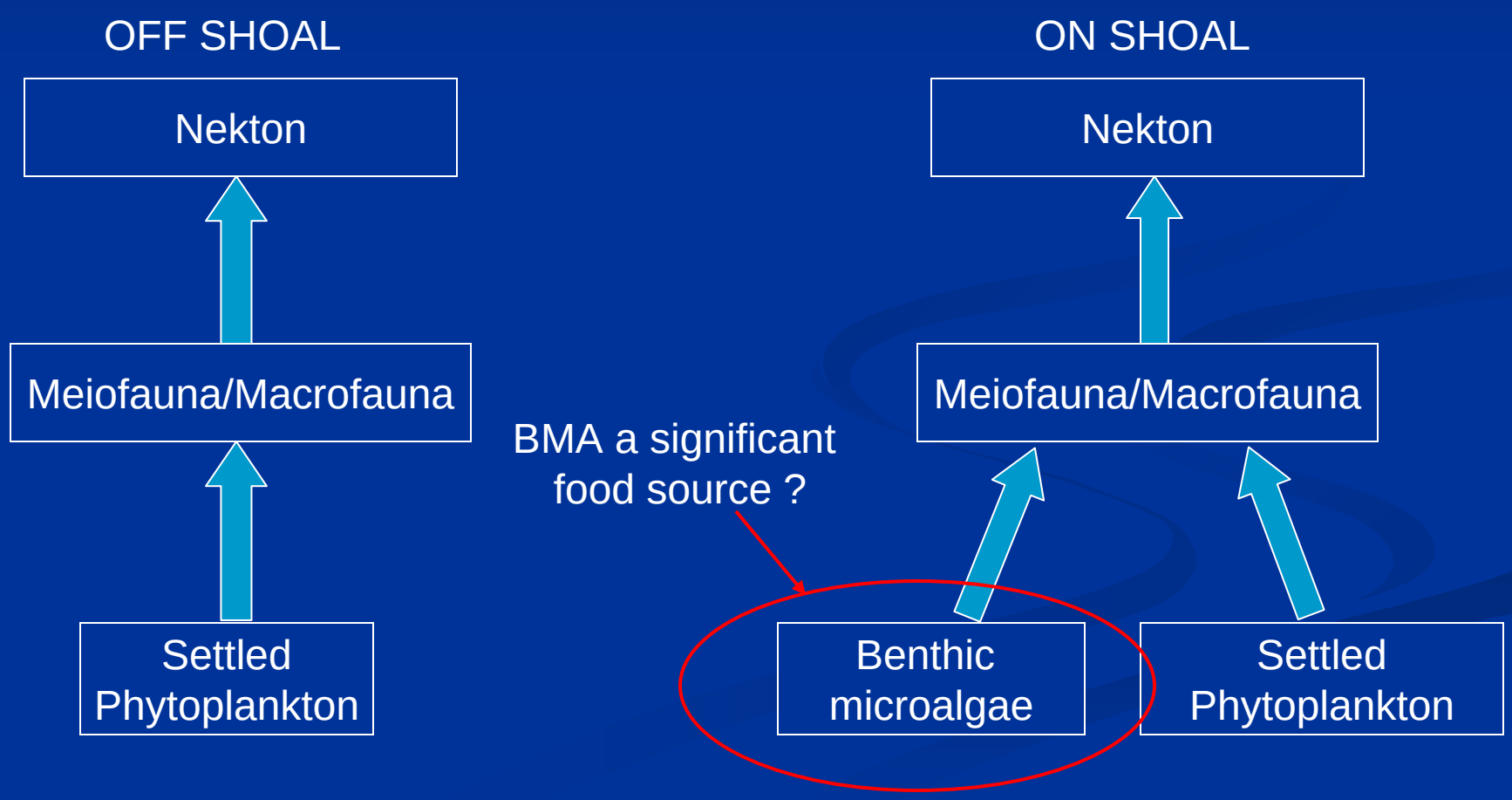
Off-shoal Benthic Food Webs

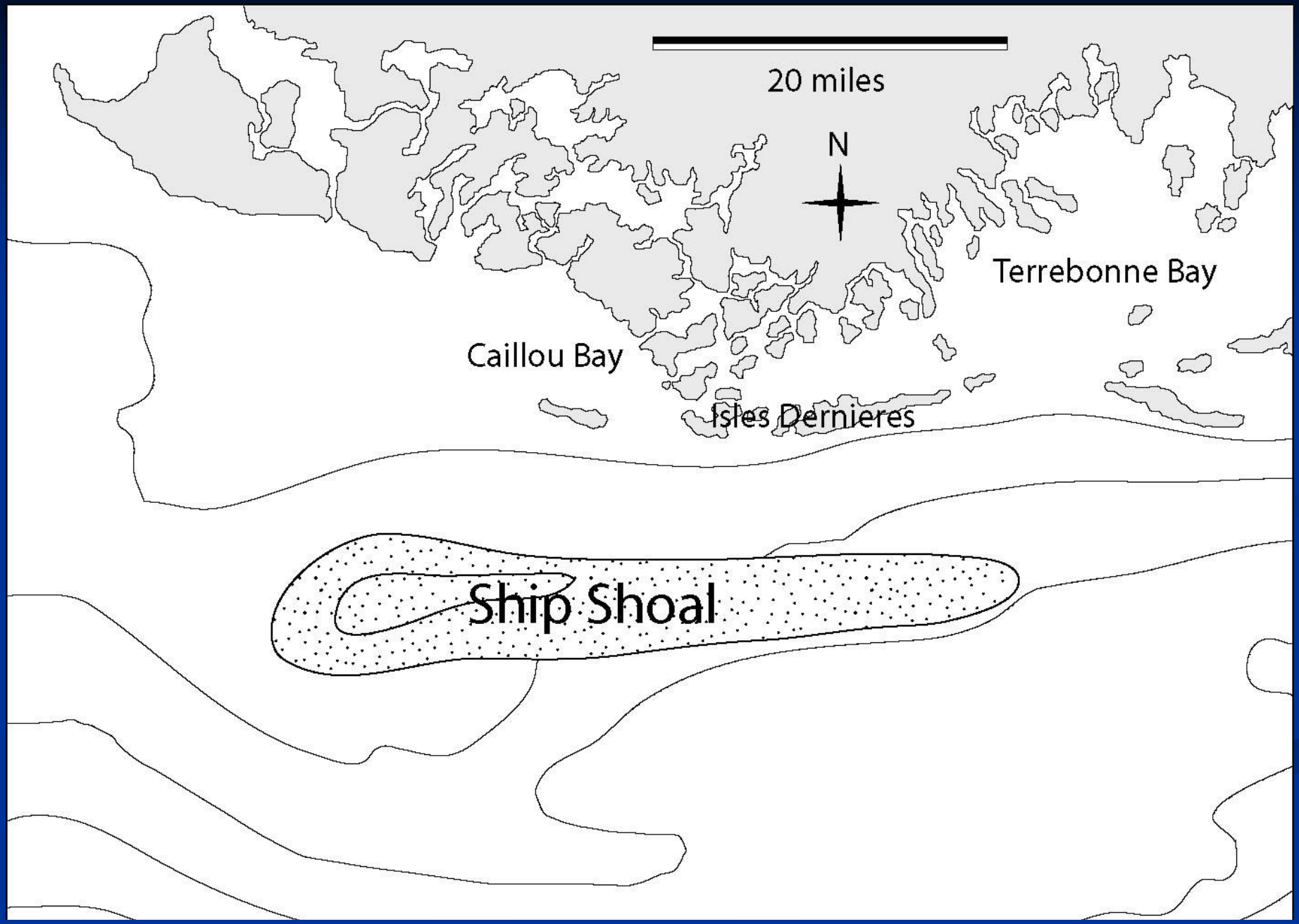
Simplified Benthic Food Webs:



On-shoal Benthic Food Webs

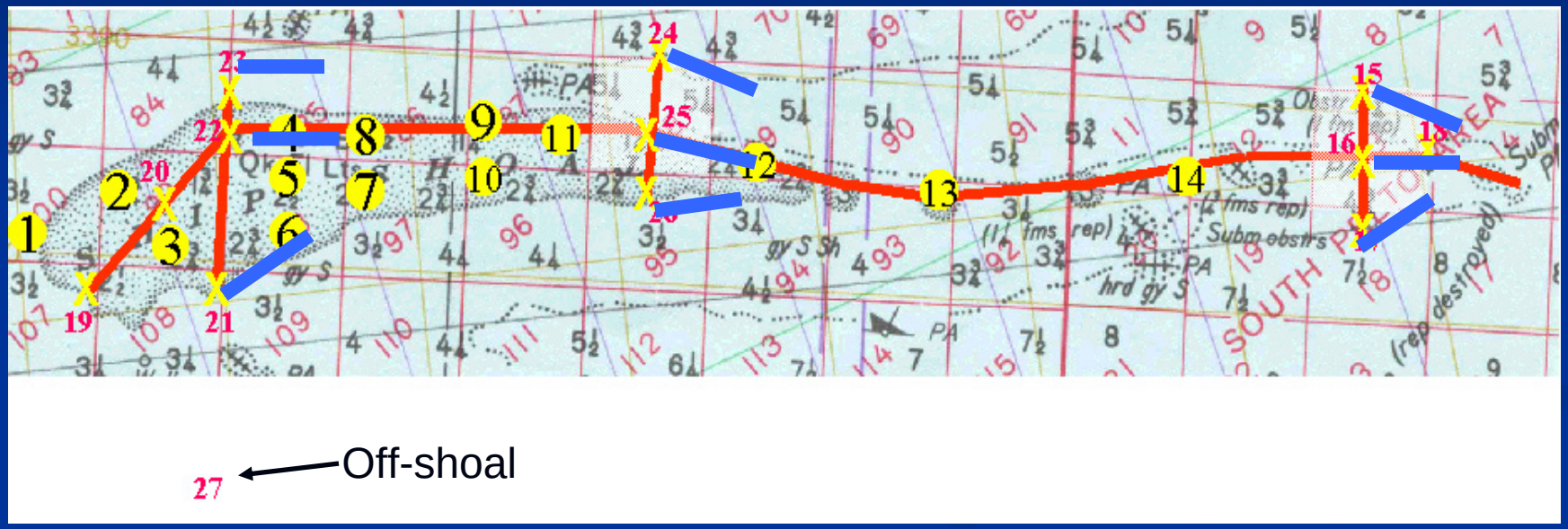
Simplified Benthic Food Webs:




20 miles
N
Terrebonne Bay
Caillou Bay
Isles Dernieres
Ship Shoal

Methods

Benthic and Trawl Stations



- Spring, Summer, and Fall 2005 and 2006
- Benthic habitat surveys (Box cores: 27 stations)
- Trawling (9 sites (blue lines))

Meiofauna

- Major taxon diversity was low.
- Nematodes >94% of samples.
- Temporal, but not spatial, differences in meiofaunal density.
- Off-shoal station generally had lowest meiofaunal densities.

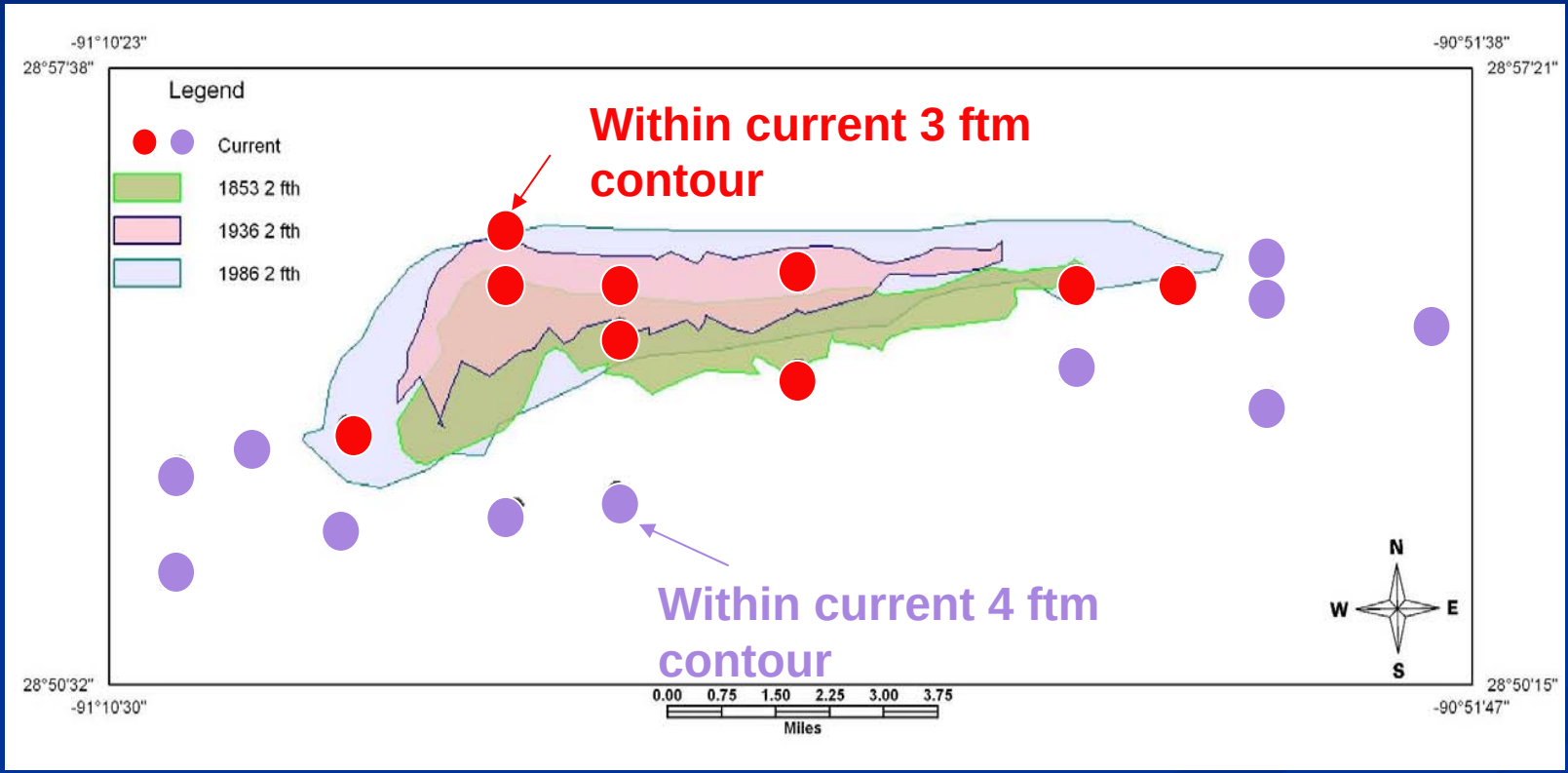
Shrimp and Croaker

- Brown shrimp dominated shrimp catch.
- Croaker and white shrimp found in comparatively low numbers.
- No spatial trends in catch.
- Effectiveness of trawling in shallow water?

Indicators of Primary Production

- Sediment light levels sufficient for benthic photosynthesis (>20% of surface intensity).
- Greater sedimentary algal biomass on the shoal compared to the off-shoal station.
- Benthic algal biomass is greater than phytoplankton biomass over much of Ship Shoal.
- Preliminary analysis suggests benthic algae contains large BMA component not just settled phytoplankton

Comparison of 2 fathom (3.66 m) contours for Ship Shoal Surveys of 1853, 1936, and 1986 with our closest Stations

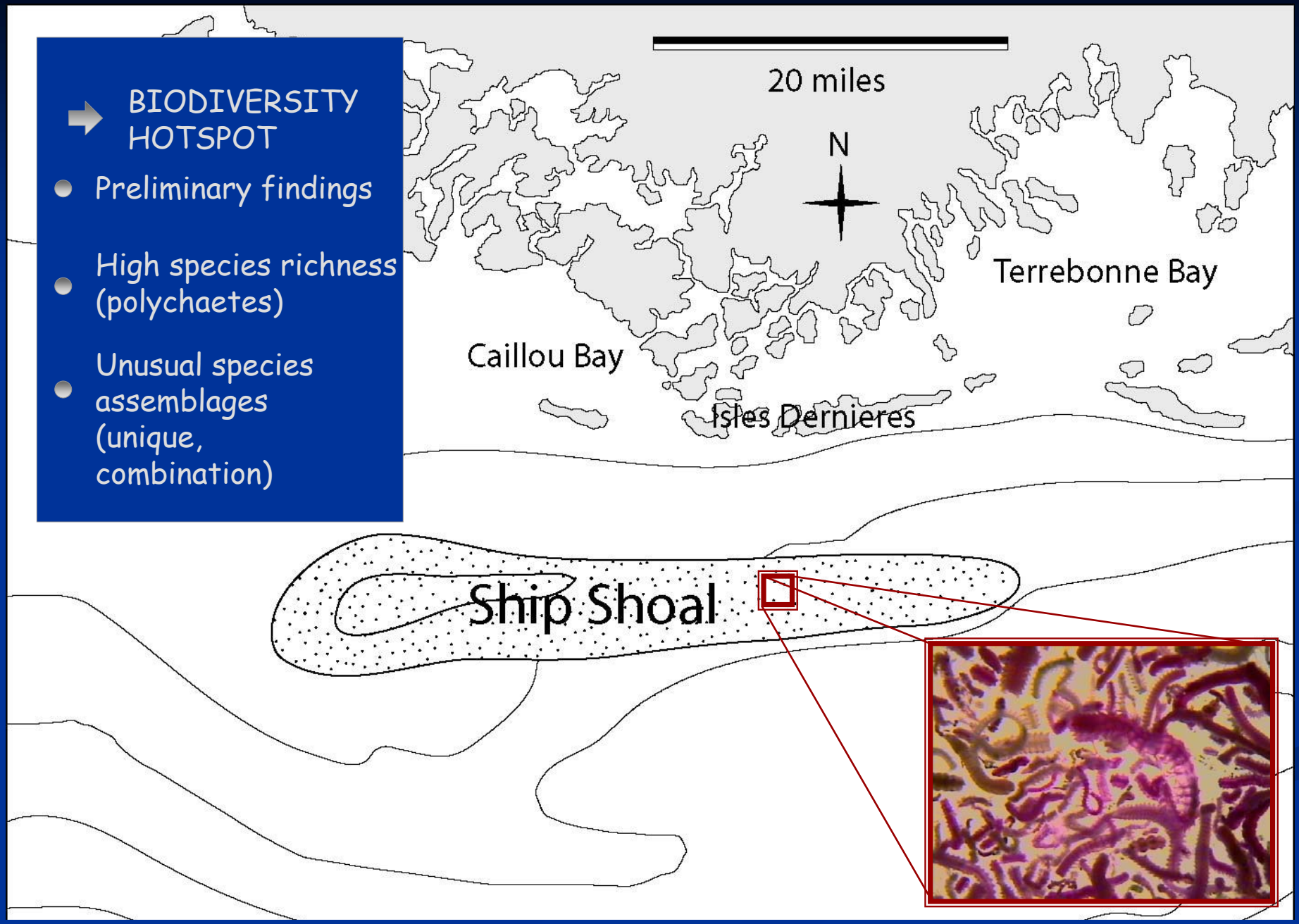


Despite compatibility concerns (List et al. 1994) of vertical and horizontal datums, our stations are approximately 1 fathom deeper.

Biological concerns—eventual loss of benthic primary productivity impacts on blue crabs, shrimp and sea trout

BIODIVERSITY HOTSPOT

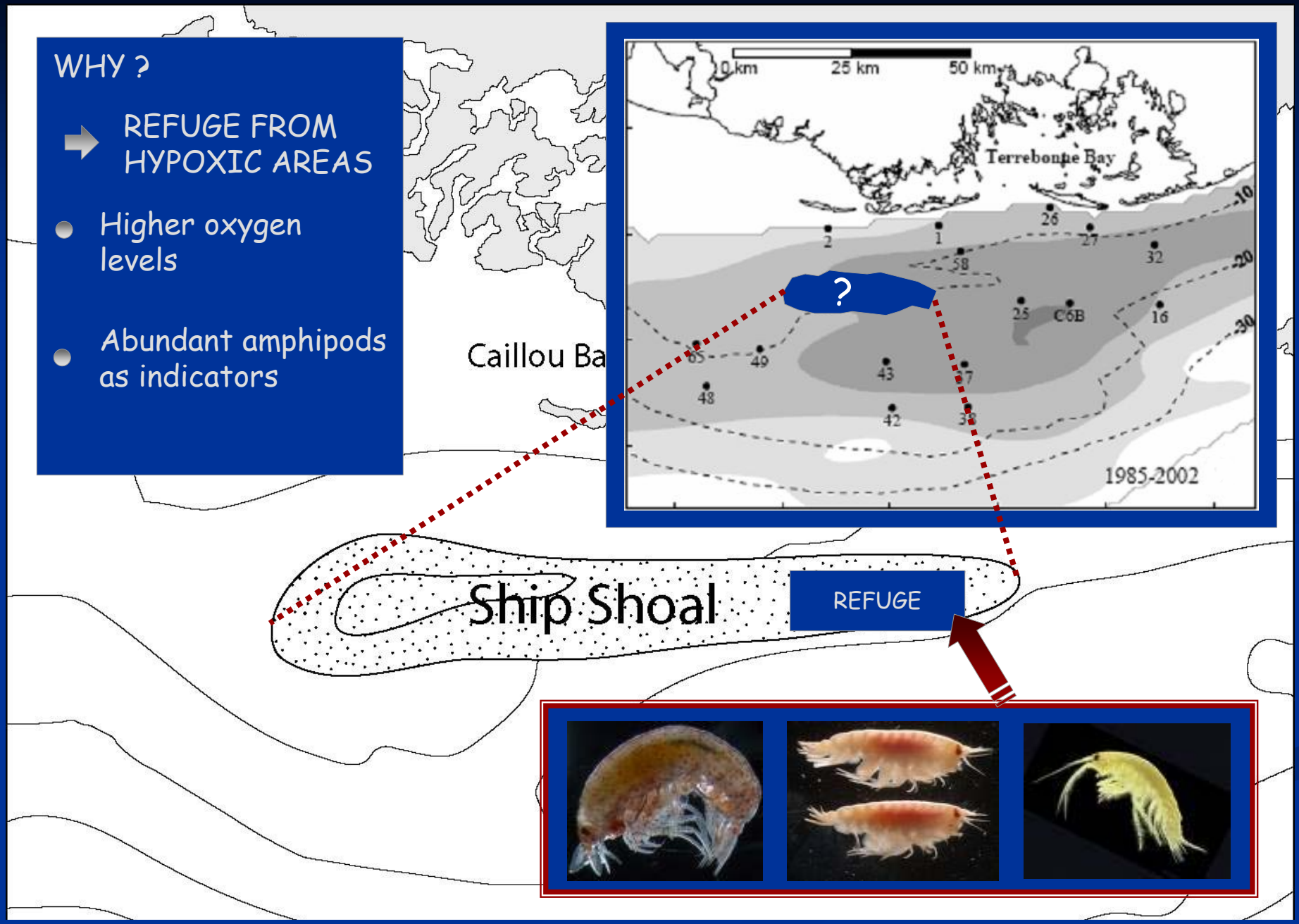
- Preliminary findings
- High species richness (polychaetes)
- Unusual species assemblages (unique, combination)



WHY ?

➡ REFUGE FROM HYPOXIC AREAS

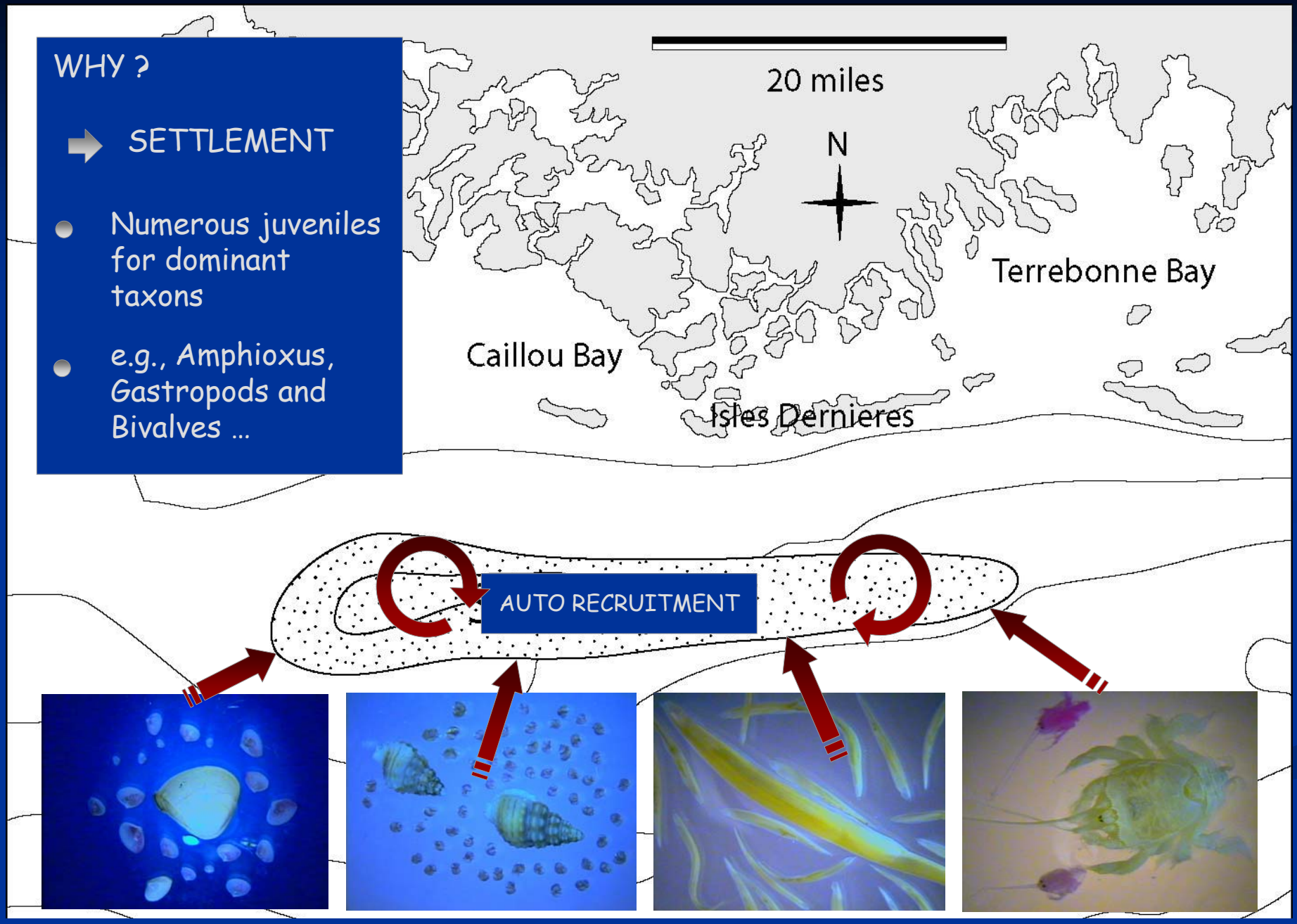
- Higher oxygen levels
- Abundant amphipods as indicators



WHY ?

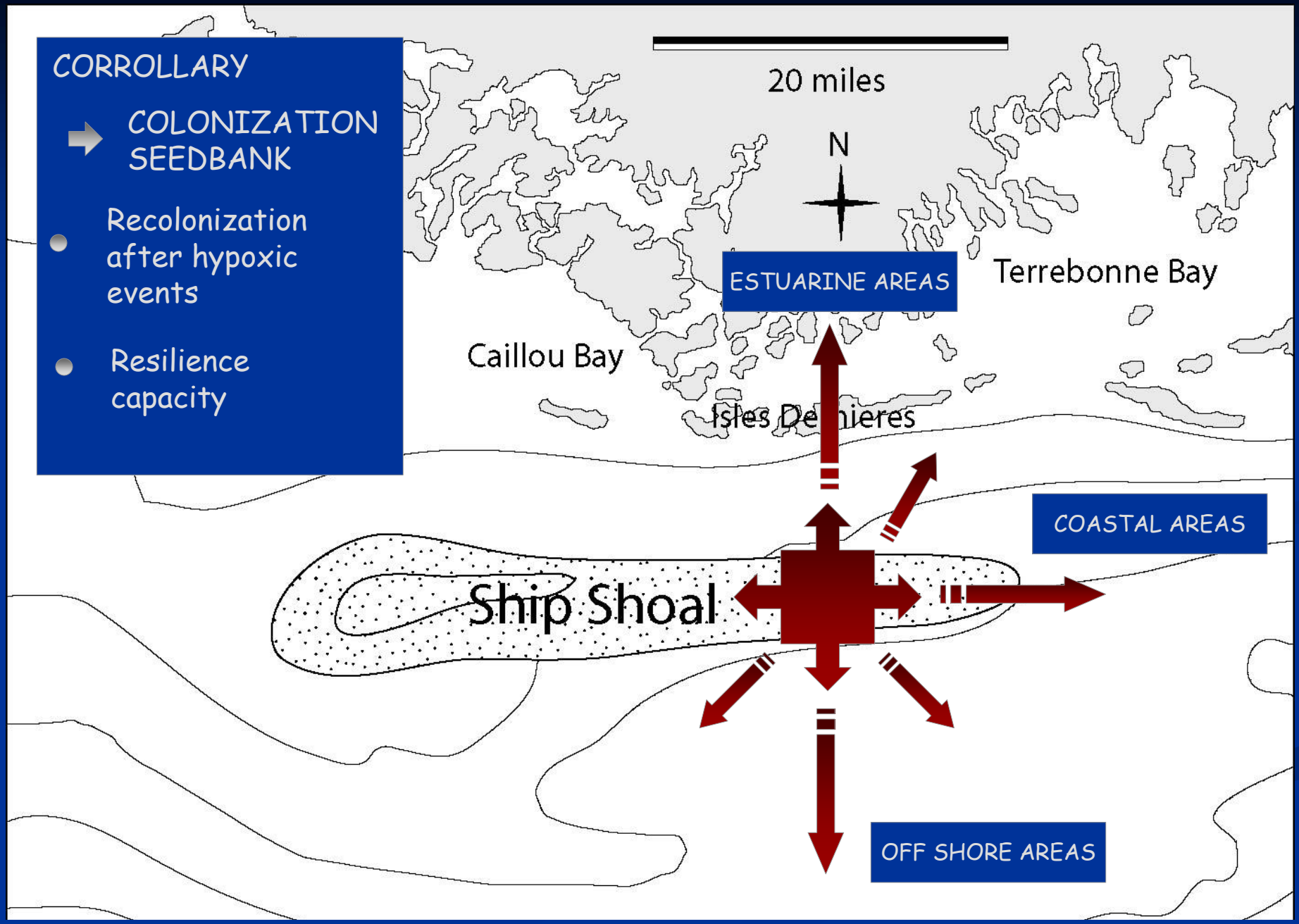
➡ SETTLEMENT

- Numerous juveniles for dominant taxons
- e.g., Amphioxus, Gastropods and Bivalves …

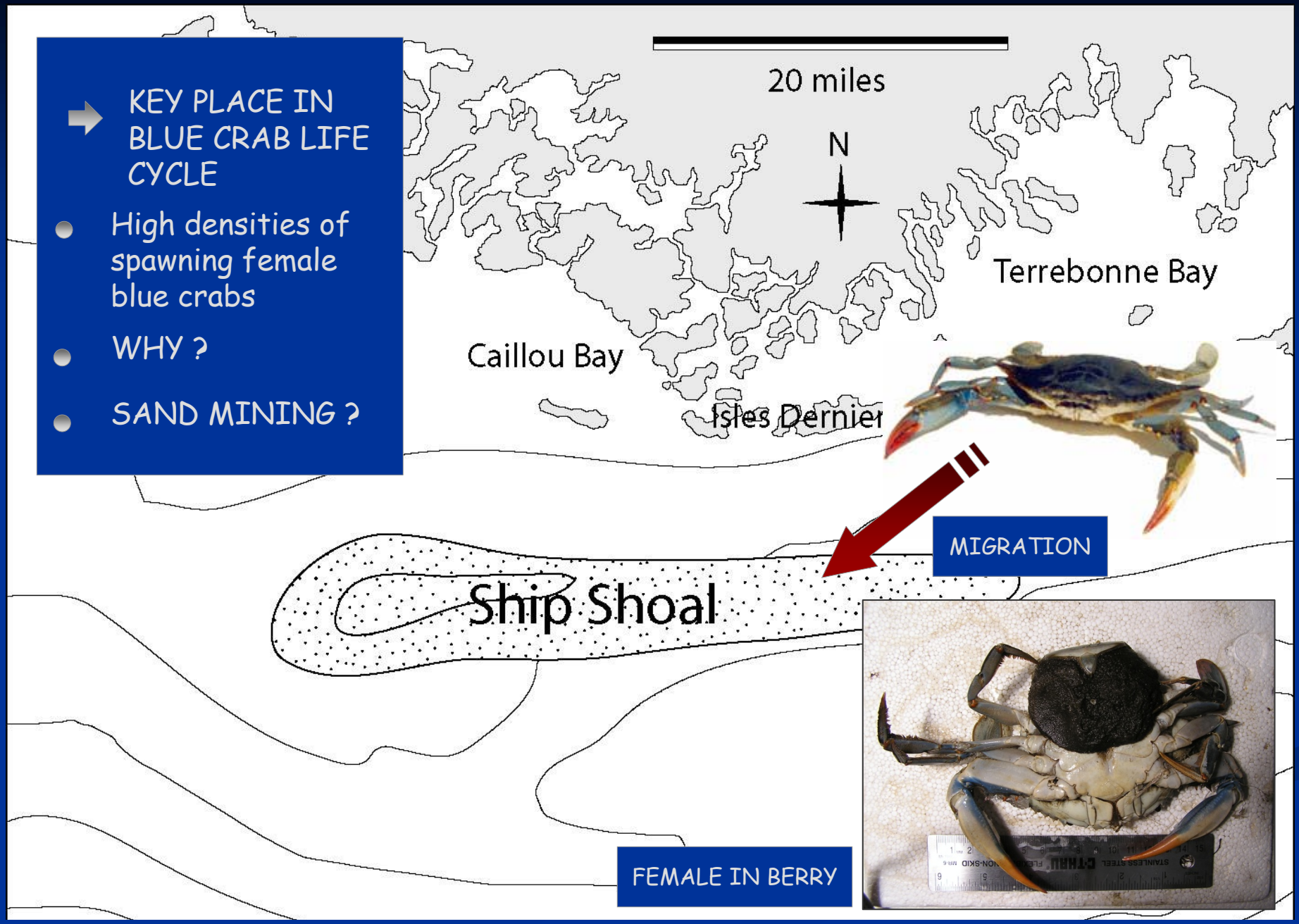


CORROLLARY

- COLONIZATION SEEDBANK
- Recolonization after hypoxic events
- Resilience capacity



- KEY PLACE IN BLUE CRAB LIFE CYCLE
- High densities of spawning female blue crabs
- WHY ?
- SAND MINING ?



Preliminary Conclusions

- Storm waves strongly rework heterogeneous bottom sediments, and vertical erosion of 20 cm was measured during one deployment
- Fluvial sediments from the Atchafalaya River forms fluid mud layers on the shoal during fair weather and waning phases of storms
- Ship Shoal is a physically unique habitat with potentially unique biological structure and function.
- Unlike off-shoal areas, benthic primary production may be a significant food source for organisms on Ship Shoal.
- Ship Shoal appears to be a biological hotspot for high species richness (polychaetes) and unusual species assemblages (unique, combination)
- An important area for larval recruitment: auto recruitment for the shoal, and resilience capacity of system (especially after disturbance)