

# Predictive Models to Support Evaluation and Selection of Restoration and Protection Alternatives

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Coastal Protection and  
Restoration Authority of Louisiana



# Introduction

- Prediction and Planning, Coast-Wide Models
  - Recap of 2012 Coastal Master Plan Modeling Effort
  - 2017 Coastal Master Plan
    - Model Improvement Plan
      - Technical Subtasks
- Systems Context
  - High Resolution Physically-Based Multidimensional Models

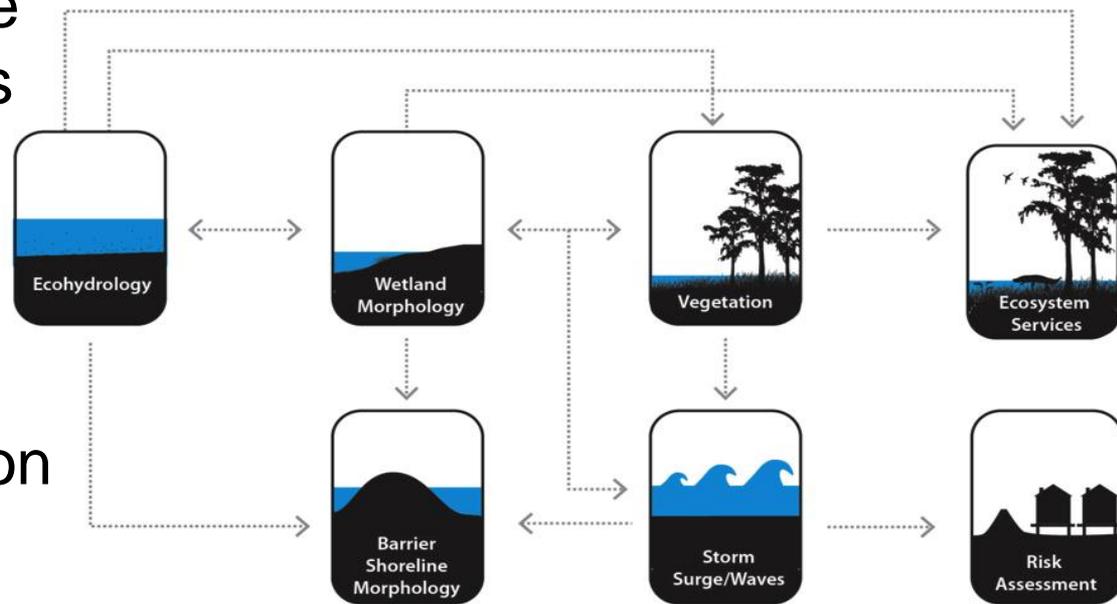


# Recap of 2012 Coastal Master Plan: Modeling Effort

# Recap: 2012 Coastal Master Plan

## *Modeling Effort*

- Team of over 60 science and engineering experts
- 18-month effort
- Evaluated hundreds of restoration and protection projects using seven, separate model suites



# Recap: 2012 Coastal Master Plan

## *Lessons Learned (Modeling)*

- **Model Continuation:** Starting a new modeling effort requires significantly more effort and involves larger learning curves than maintaining/improving an existing effort.
- **Modeling Objectives:** Understanding tradeoffs among level of detail (e.g., number of variables, spatial resolution), availability of data, desired outputs, and uncertainty at the start of the process.
- **Model Integration:** Manual hand-off of outputs leads to time delays and additional errors.
- **Model Validation:** Validation data are unevenly distributed in time and space for many outputs/parameters, resulting in insufficient validation of some models.

# Recap: 2012 Coastal Master Plan

## *Lessons Learned (Modeling)*

- **Model Resolution:** Use of coarse-resolution hydrology models limits the utility of higher resolution models applied to capture other system components (e.g., land area, vegetation).
- **Ecosystem Outcomes:** The analysis focused only on habitat suitability.
- **Quality Review:** The establishment of a codified quality review process at the start of the modeling process is critical to ensuring consistency and reducing errors.



# 2017 Coastal Master Plan: Modeling Needs

# 2017 Coastal Master Plan

## *Key Questions*

- How does project sequencing, integration and timing vary basinwide outcomes?
- What are the keystone projects for each basin?
- What is the spatial distribution and expectations for ecosystem outcomes?



# 2017 Coastal Master Plan

## *Modeling Needs*

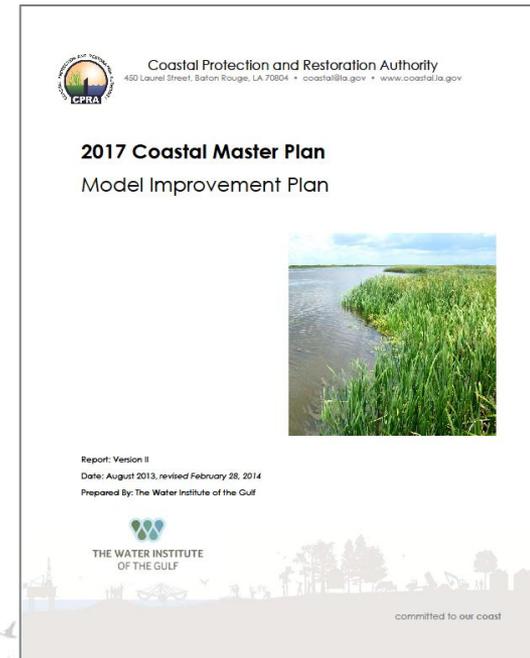
Modeling need	Desired outcome	Spatial scale	Simulation length	Outcomes
<b>Future Without Action</b>	Coastwide effects	Coastwide	50 years	Landscape Changes Ecosystem Outcomes Risk Reduction
<b>Individual Restoration and Protection Projects</b>	Individual project effects	Local / basin	50 years	Landscape Changes Ecosystem Outcomes Risk Reduction
<b>Project Sequences</b> (alternatives including both restoration and protection projects)	Project interactions Basinwide effects	Basin	20-25 years 50 years	Landscape Changes Ecosystem Outcomes Risk Reduction
<b>Draft and Final 2017 Coastal Master Plan</b> (all selected restoration and protection projects)	Plan interactions Coastwide effects	Coastwide	50 years	Landscape Changes Ecosystem Outcomes Risk Reduction

# 2017 Coastal Master Plan: Model Improvement Plan

# 2017 Model Improvement Plan

## Overview

- Living document – current version March 2014
- Available at [www.coastal.la.gov](http://www.coastal.la.gov) in the Library
- Includes:
  - Background & Rationale for Improvements
  - Communication Strategy
  - Roles & Responsibilities
  - External Advice & Review
  - Modeling Strategy & Recommendations
  - Implementing the Model Improvement Plan
  - Schedule



# 2017 Model Improvement Plan

*Collaborative Team of over 70 Experts*

## Modeling Decision Team

Directs and coordinates model improvements and analysis



THE WATER INSTITUTE  
OF THE GULF

## Subtask Leaders and Members:



Experience | Innovation | Results



Ecopath  
Research and  
Development  
Consortium

# 2017 Model Improvement Plan

## *PM-TAC*

- Predictive Models Technical Advisory Committee (PM-TAC) provides ongoing ‘over the shoulder’ guidance & advice
- Will meet 6-8 times over next 3-years with interim webinars
- Interact directly with the modelers

PM-TAC Member	Affiliation	Expertise
John Callaway (Chair)	University of San Francisco	Ecology/Vegetation
Scott Hagen	University of Central Florida	Hydrology/Storm Surge
Brian Harper	US Army Corps of Engineers	Risk assessment
Courtney Harris	Virginia Institute of Marine Science	Hydrodynamics/Sediments
Wim Kimmerer	San Francisco State University	Food Web/Fisheries
Mike Waldon	USFWS (retired)	Hydrology/Water Quality

# 2017 Model Improvement Plan

## *Sources of Improvements*

- Lessons Learned document from 2012 Coastal Master Plan
- Independent peer review of the 2012 technical appendices
- Independent peer review of manuscripts for the JCR Special Issue #67 (Summer 2013)
- Uncertainty Analysis
- Fall 2012 modeling 'brainstorming workshops'

**Louisiana's 2012 Coastal Master Plan Technical Analysis**  
Guest Editors: Natalie Peyronnin and Denise Reed

Journal of Coastal Research  
Special Issue #67

Published by  
JCR  
Coastal Education & Research Foundation

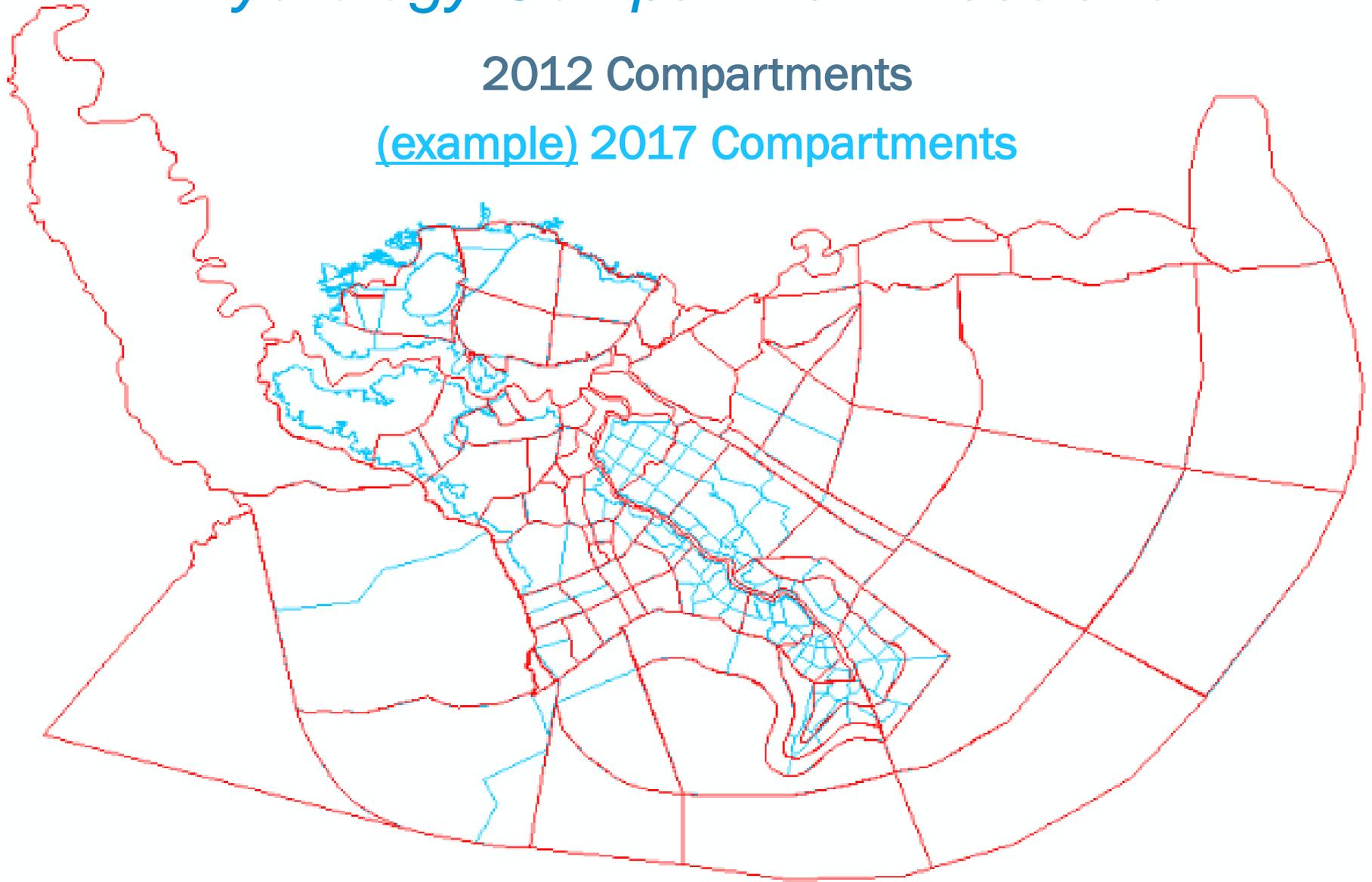
An International Forum for the Littoral Sciences  
Charles W. Finkl  
Editor-in-Chief

# 2017 Model Improvement Plan

## *Hydrology Compartment Resolution*

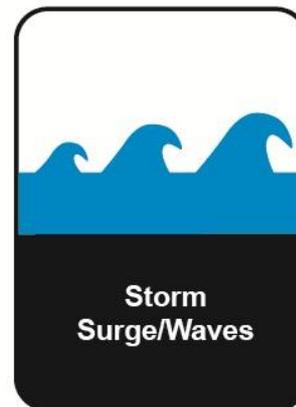
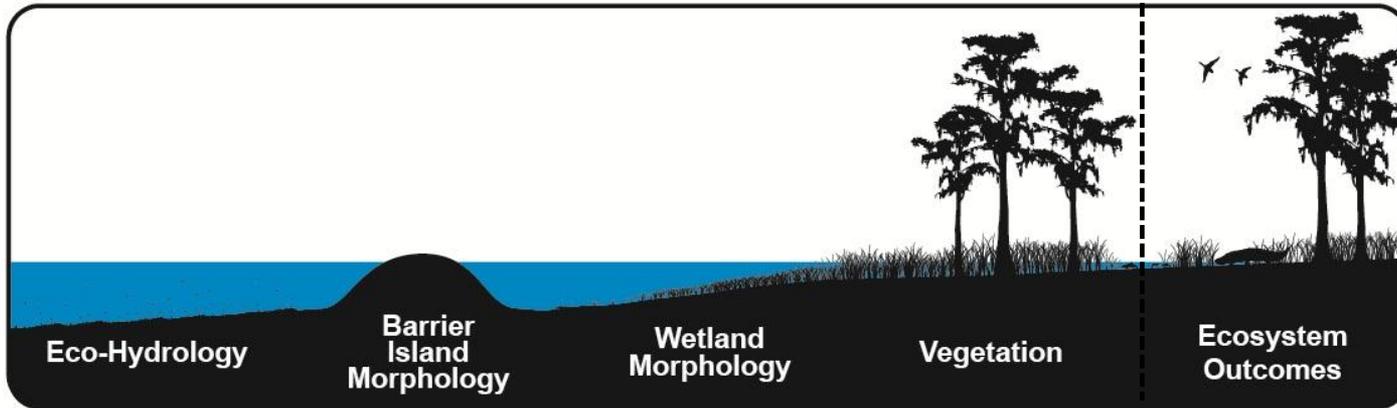
2012 Compartments

(example) 2017 Compartments



# 2017 Model Improvement Plan

## *Integrated Compartment Models (ICMs)*

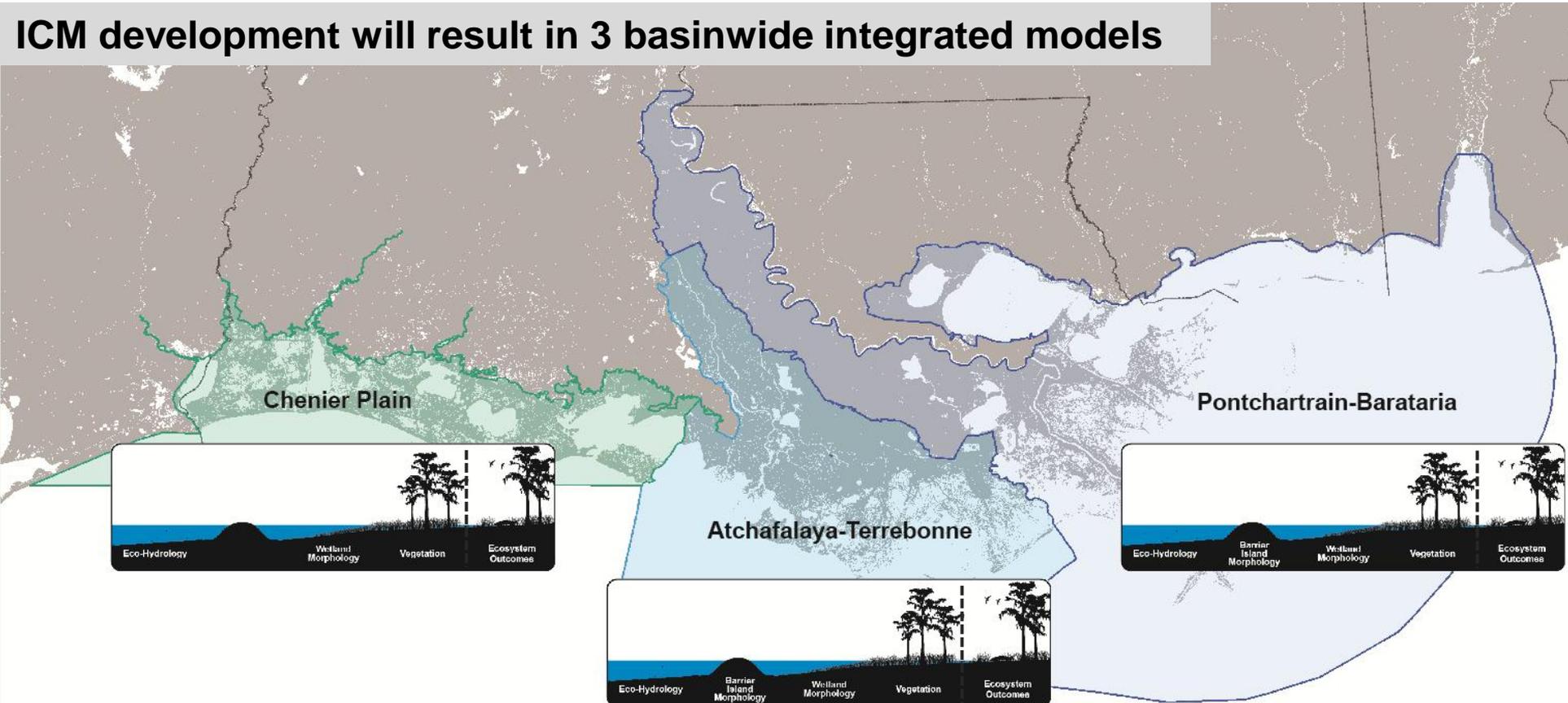


Note: The integration of ecosystem outcomes is TBD

# 2017 Model Improvement Plan

## *Integrated Compartment Models (ICMs)*

ICM development will result in 3 basinwide integrated models

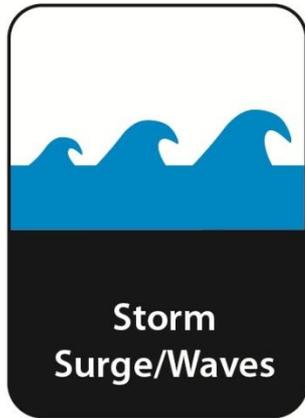


Note: The integration of ecosystem outcomes is TBD



# 2017 Model Improvement Plan

## *Risk Reduction*



- Parametric uncertainty analysis, including a rerun of the joint probability method storm suite (440 storms)
- Grid expansion (MS, TX, northern boundary)
- Updated damage datasets
- Review fragility assumptions
- Expand storm suite – TBD
- Validate for Hurricane Isaac



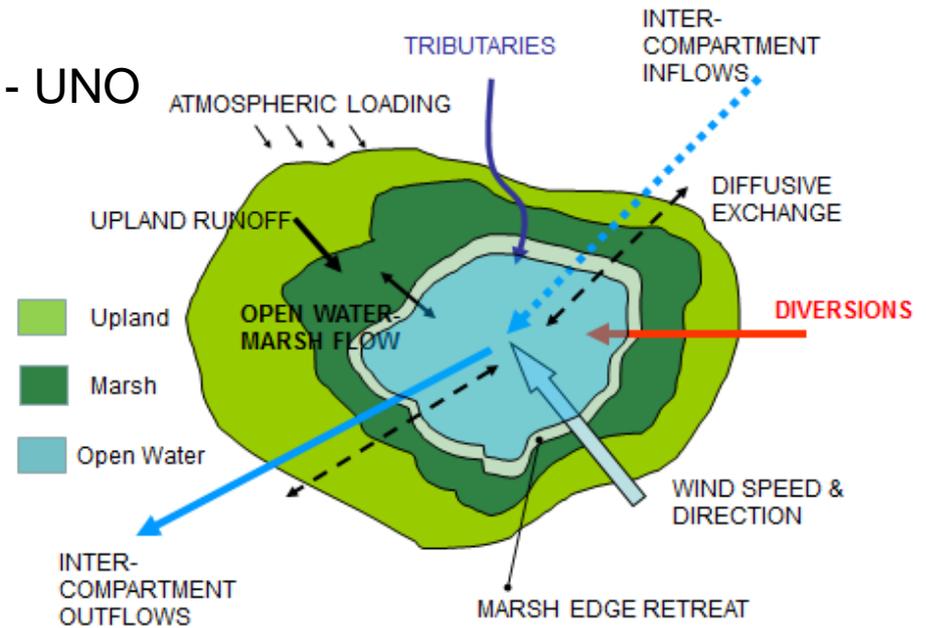
# Model Improvement Plan: Technical Subtasks

# Sediment Distribution

**Objective:** Enhance sediment distribution by developing process-based approaches for distributing sediment within and across model compartments, including storm effects.

## Team:

- Alex McCorquodale (Subtask Leader) - UNO
- Gregg Snedden, Hongqing Wang, Brady Couvillion - USGS
- Jeff Shelden, Mark Dortch - Moffatt & Nichol
- Ehab Meselhe, Ben Roth, Eric White, Denise Reed - Water Institute
- Mark Leadon, Mandy Green, Angelina Freeman - CPRA

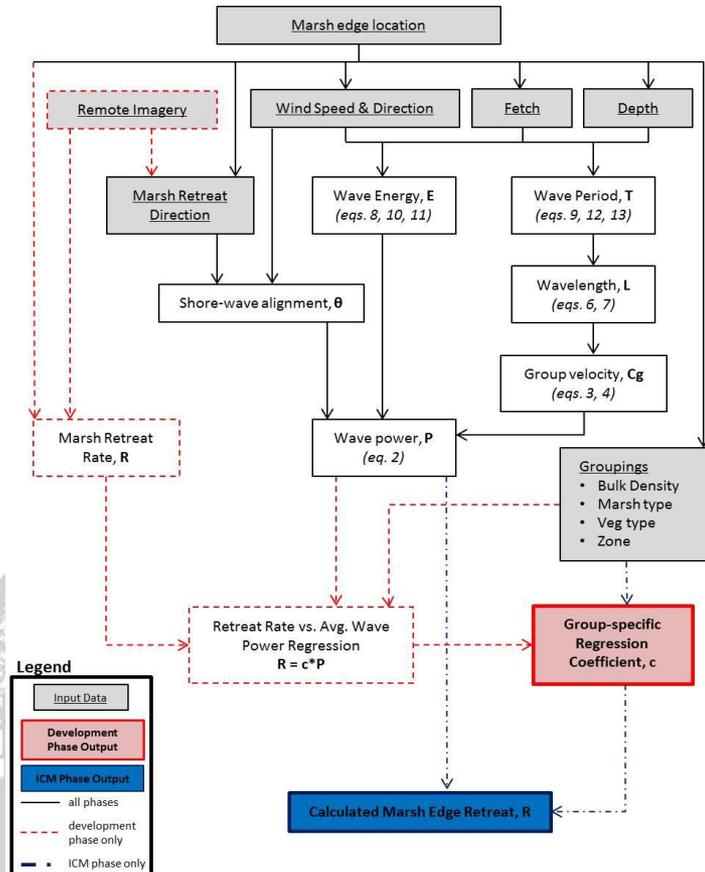


# Marsh Edge Erosion

**Objective:** Develop process-based approach to more realistically capture changes in land/water area (associated with marsh edge erosion) and incorporate the eroded material into the sediment supply.

## Team:

- Mead Allison (Subtask Leader), Ehab Meselhe, Brendan Yuill, Eric White, Denise Reed - Water Institute
- Jim Chen - LSU
- Alex McCorquodale - UNO
- Brady Couvillion - USGS
- Mark Leadon, Mandy Green, Angelina Freeman - CPRA

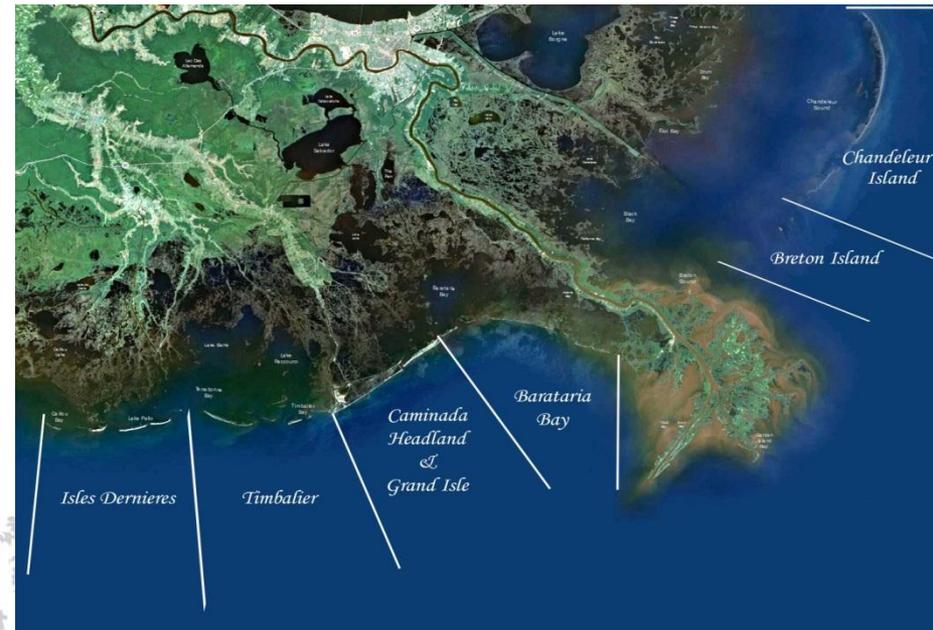


# Barrier Island Model Development

**Objective:** Develop a process-based approach for modeling barrier island dynamics (long-shore, cross-shore, discrete events, etc.).

## Team:

- Michael Poff (Subtask Leader) - Coastal Engineering Consultants
- Ioannis Georgiou and Mark Kulp - UNO
- Gordon Thomson, Zhifei Dong,  
Samantha Danchuk - CB&I
- Dirk-Jan Walstra - Deltares
- Mark Leadon, Darin Lee,  
Mandy Green – CPRA
- Ehab Meselhe - Water Institute

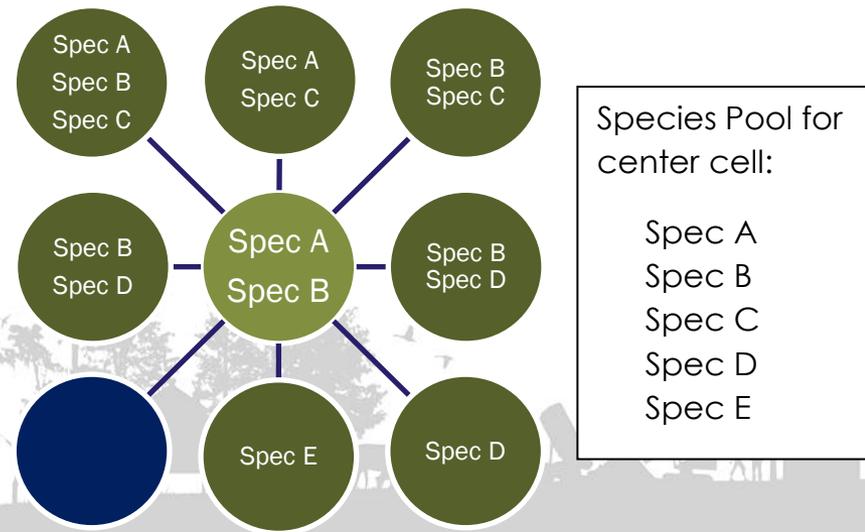


# Additional Vegetative Communities

**Objective:** Improve 2012 model code by developing strategies to include swamp, bottomland hardwoods, ridge, dune, and swale species. Improve transitions to and from floating marsh, and include dynamics for establishment and dispersal.

## Team:

- Jenneke Visser (Subtask Leader), Scott Duke-Sylvester, Mark Hester, Jonathan Willis, Whitney Broussard - ULL
- Brady Couvillion, Holly Beck - USGS
- Gary Shaffer - SELU
- Ehab Meselhe - Water Institute
- Mandy Green - CPRA



# Ecosystem Outcomes (Community Model)

**Objective:** Determine how select combinations of restoration projects in Louisiana basins affect the distribution and biomass of fish and shellfish over 20 and 50 years using a community modeling approach (Ecosim/TroSim).

## Team:

- Kim de Mutsert (Subtask Leader) and Kristy Lewis  
- George Mason University
- Jeroen Steenbeek and Joe Buszowski –  
Ecopath Research and Dev. Consortium
- Scott Milroy - USM
- David Lindquist - CPRA

*Note: Fish and shellfish strategy document completed by Shaye Sable (Dynamic Solutions) and Kenny Rose (LSU)*

Model	Coast 2017 Ecopath	Coast 2017 Ecosim	Coast 2017 TroSim	Coast 2017 Ecospace
<b>Spatial Scale</b>	N/A; but represents Barataria and Pontchartrain Basins	Point model representing Barataria and Pontchartrain Basins; more 'points' in basins can be simulated	Point model representing Barataria and Pontchartrain Basins; more 'points' in basins can be simulated	Barataria and Pontchartrain Basins (Figure 7)
<b>Resolution</b>	N/A; virtual representation of ecosystem	Point model	Point model	1 km <sup>2</sup> grid cells
<b>Time step</b>	N/A	Monthly	Daily	Monthly
<b>Scenarios</b>	Used as start at each scenario; 1995-2000 data used as base	Restoration scenarios and future w/o action as temporal drivers, 20 and 50 year scenarios	Restoration scenarios and future w/o action as temporal drivers, 1 and 5 year scenarios	Restoration scenarios and future w/o action as spatial and temporal drivers, 20 and 50 year scenarios
<b>Movement</b>	No	No	No	Yes
<b>Fisheries</b>	Yes; fleets and landings included	Yes, and effort can be changed through time	Not currently; can be added as a biomass loss term	Yes, and effort changes spatially based on revenue
<b>Environmental drivers</b>	N/A	Temporal changes in habitat as well as physical parameters affect species biomass	Temporal changes in habitat as well as physical parameters affect species biomass	Spatial and temporal changes in habitat as well as physical parameters affect species biomass and spatial

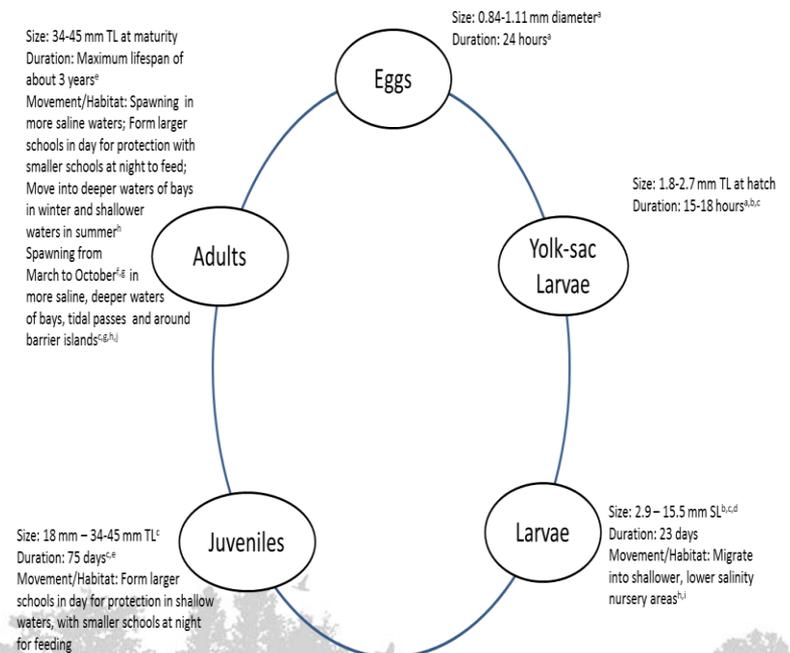
# Ecosystem Outcomes (HSI)

**Objective:** Improve and/or develop Habitat Suitability Index (HSI) models for a variety of fish, shellfish and wildlife species.

## Team:

- Buddy Clairain (Subtask Leader)  
and Stokka Brown - Moffatt & Nichol
- Paul Leberg - ULL
- Robert Romaine - LSU AgCenter
- Hardin Waddle - USGS
- Meg O'Connell - UNO
- Shaye Sable - Dynamic Solutions
- Ann Hijuelos, Leland Moss,  
Denise Reed - Water Institute
- David Lindquist - CPRA

Bay Anchovy Life Cycle



# Input Data Sets/Boundary Conditions

**Objective:** Improve previous input datasets and boundary conditions by updating 2012 MP input data, generating new approaches where possible (e.g., spatial rainfall), and using new approaches for handling missing datasets.

## Team:

- Stokka Brown (Subtask Co-Leader), Jeff Sheldon, Mark Dortch, Stokka Brown, Maarten Kluyjver - Moffatt & Nichol
- Brady Couvillion (Subtask Co-Leader), Holly Beck - USGS
- Ehab Meselhe - Water Institute
- Mark Leadon, Mandy Green - CPRA



# Future Scenarios

**Objective:** Develop new future scenarios based on new data/knowledge regarding potential future changes and model sensitivity.

**Team:**

- Ehab Meselhe (Subtask Leader), Mead Allison, Denise Reed, Eric White, Melissa Baustian, Brendan Yuill - Water Institute
- Brady Couvillion, Holly Beck, Hongqing Wang, Bill Sleavin - USGS
- Jenneke Visser, Scott Duke-Sylvester, Emad Habib - ULL
- Jenni Schindler, Mallory Rodrigue, Robert Miller - Fenstermaker
- James Pahl, Mandy Green - CPRA

Factors	Plausible Range OVER 50 YEARS
▶ Sea Level Rise	0.12 m to 0.65 m of sea level rise over 50 years
▶ Subsidence (varies spatially)	0 to 35 mm/yr
▶ Storm Intensity	0% to +30%
▶ Storm Frequency	-20% to +10%
▶ River Discharge / Sediment Load	-7% to + 14% (annual mean discharge, adjusted for seasonality)
▶ River Nutrient Concentration (Nitrogen and Phosphorus)	-45% to +20%
▶ Rainfall (varies spatially)	Historical monthly range
▶ Evapotranspiration (varies spatially)	+/-1 standard deviation of historical monthly range
▶ Marsh Collapse Threshold	Swamp salinity: 4-7 ppt Fresh marsh salinity: 6-8 ppt Intermediate marsh inundation: 31-38 cm depth Brackish marsh inundation: 20-26 cm depth Saline marsh inundation: 16-23 cm depth

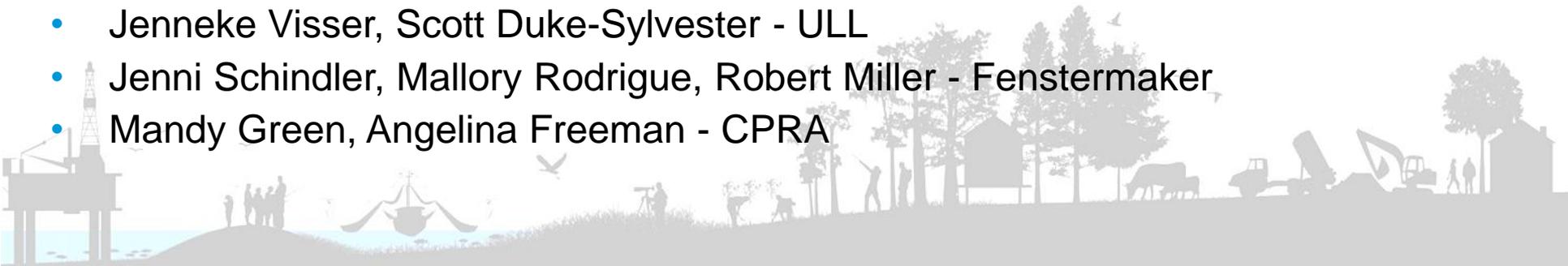


# Integrated Compartment Model Development

**Objective:** Integrate 2012 eco-hydrology, wetland morphology, and vegetation models, incorporate newly developed processes, and increase spatial resolution

## Team:

- Ehab Meselhe (Subtask Leader), Eric White, Mead Allison, Denise Reed - Water Institute
- Alex McCorquodale - UNO
- Jonathan Wang, Maarten Kluyjver, Jeff Sheldon, Mark Dortch - Moffatt & Nichol
- Brady Couvillion, Holly Beck, Hongqing Wang, Gregg Snedden, Bill Sleavin - USGS
- Gordon Thomson (and team) - CB&I
- Jenneke Visser, Scott Duke-Sylvester - ULL
- Jenni Schindler, Mallory Rodrigue, Robert Miller - Fenstermaker
- Mandy Green, Angelina Freeman - CPRA



# Storm Surge and Risk Assessment

**Objective:** Enhance aspects of modeling tools that were used in 2012 MP (ADCIRC and UnSWAN for surge and waves; CLARA for risk assessment) and gain a better understanding of parametric uncertainty.

## Team:

- Hugh Roberts (Subtask Leader), John Atkinson, Zach Cobell, Haihong Zhao, Shan Zou, Brian Lindberg, Alex Trahan - Arcadis
- Jordan Fischbach (Subtask Leader), Kenneth Kuhn, David Johnson, Ricardo Sanchez, David Manheim, Charles Stelzner - RAND Corp.
- Ehab Meselhe, Denise Reed - Water Institute
- Mark Leadon, Mandy Green - CPRA





# COMMITTED TO OUR COAST



## Modeling Decision Team

**CPRA:** Mandy Green and Angelina Freeman

**The Water Institute:** Ehab Meselhe, Denise Reed, and Alaina Owens

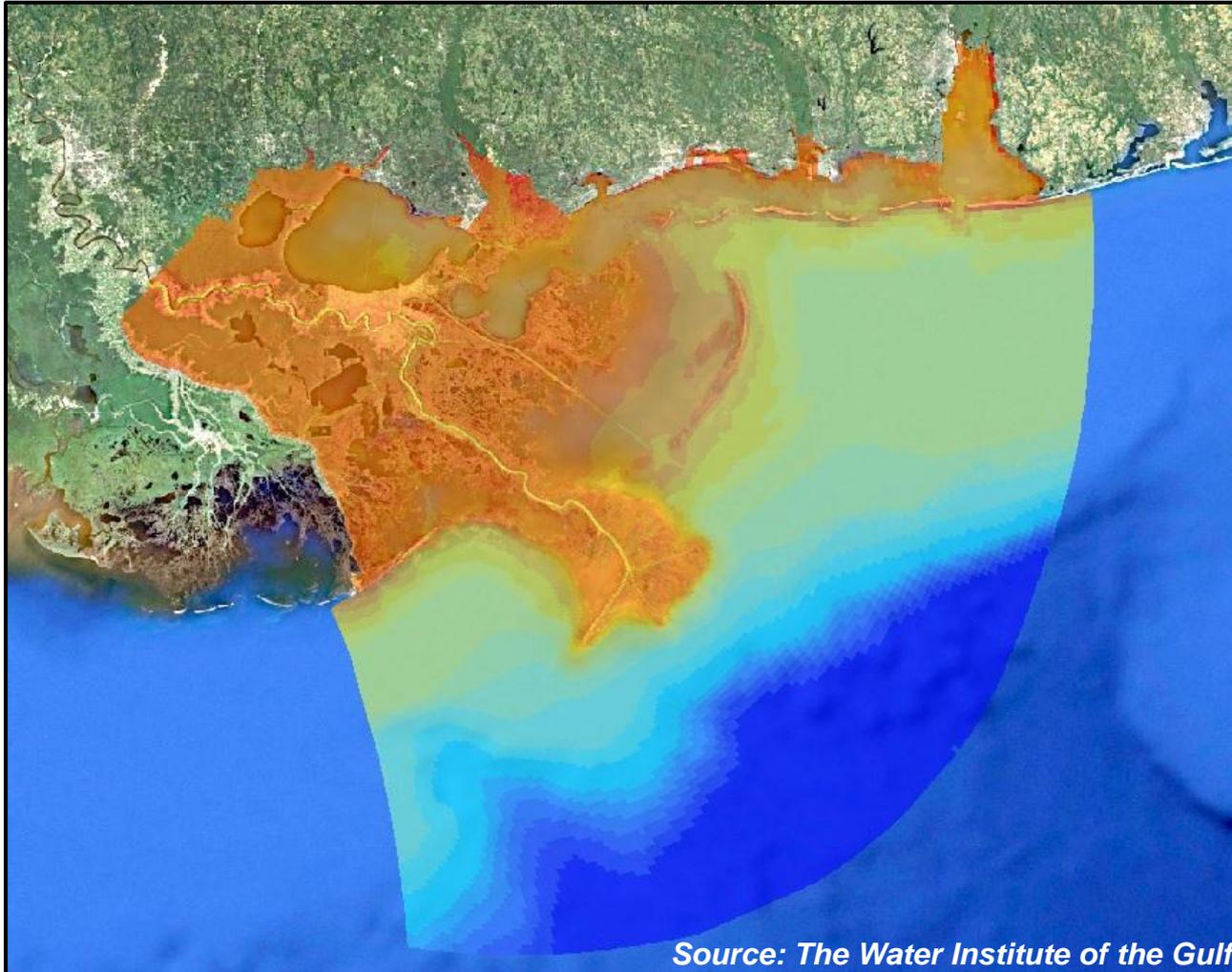


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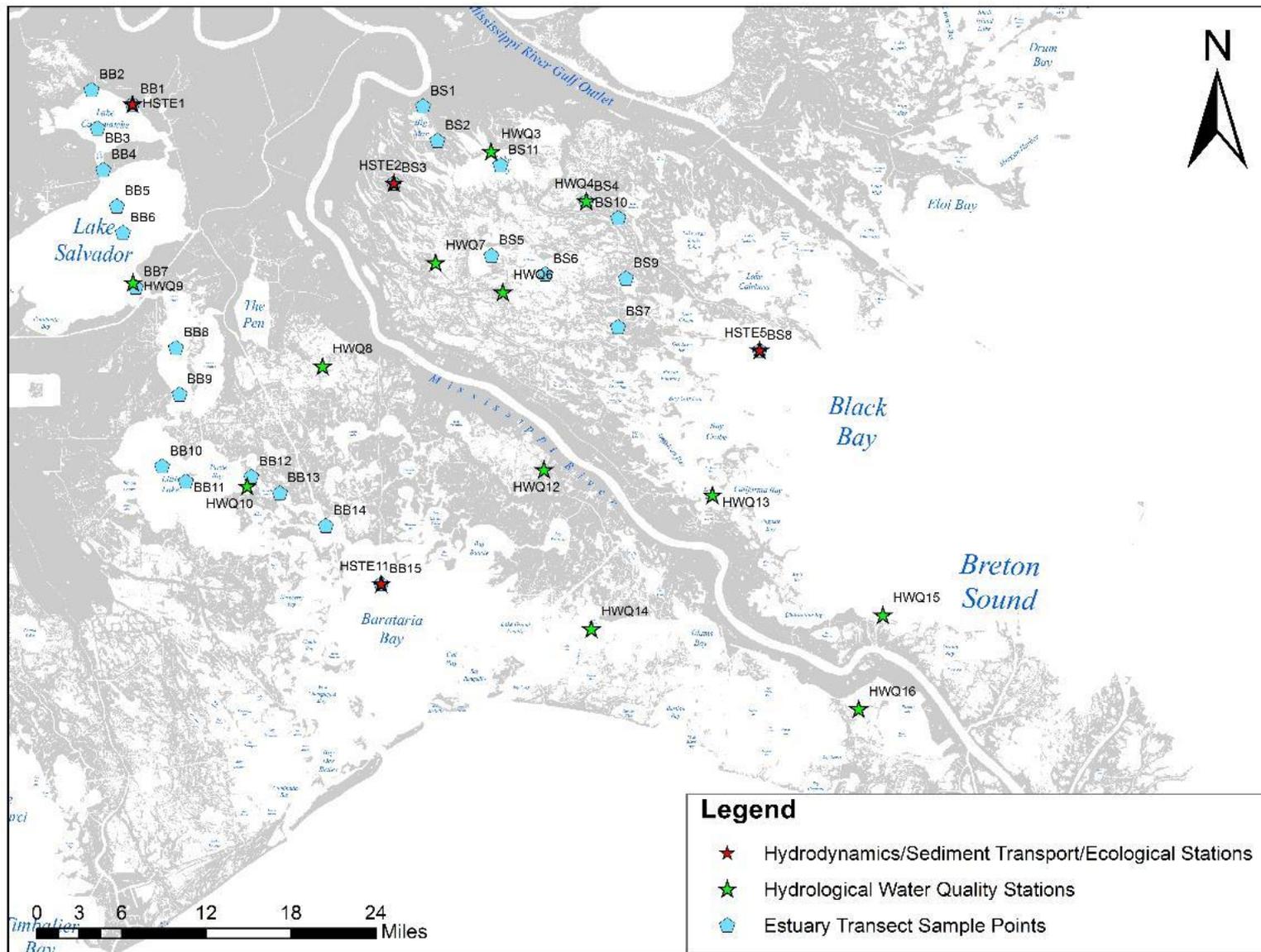
# **System-Wide : High Resolution Models**

# Basin-Wide Model Development (Delft 3D)



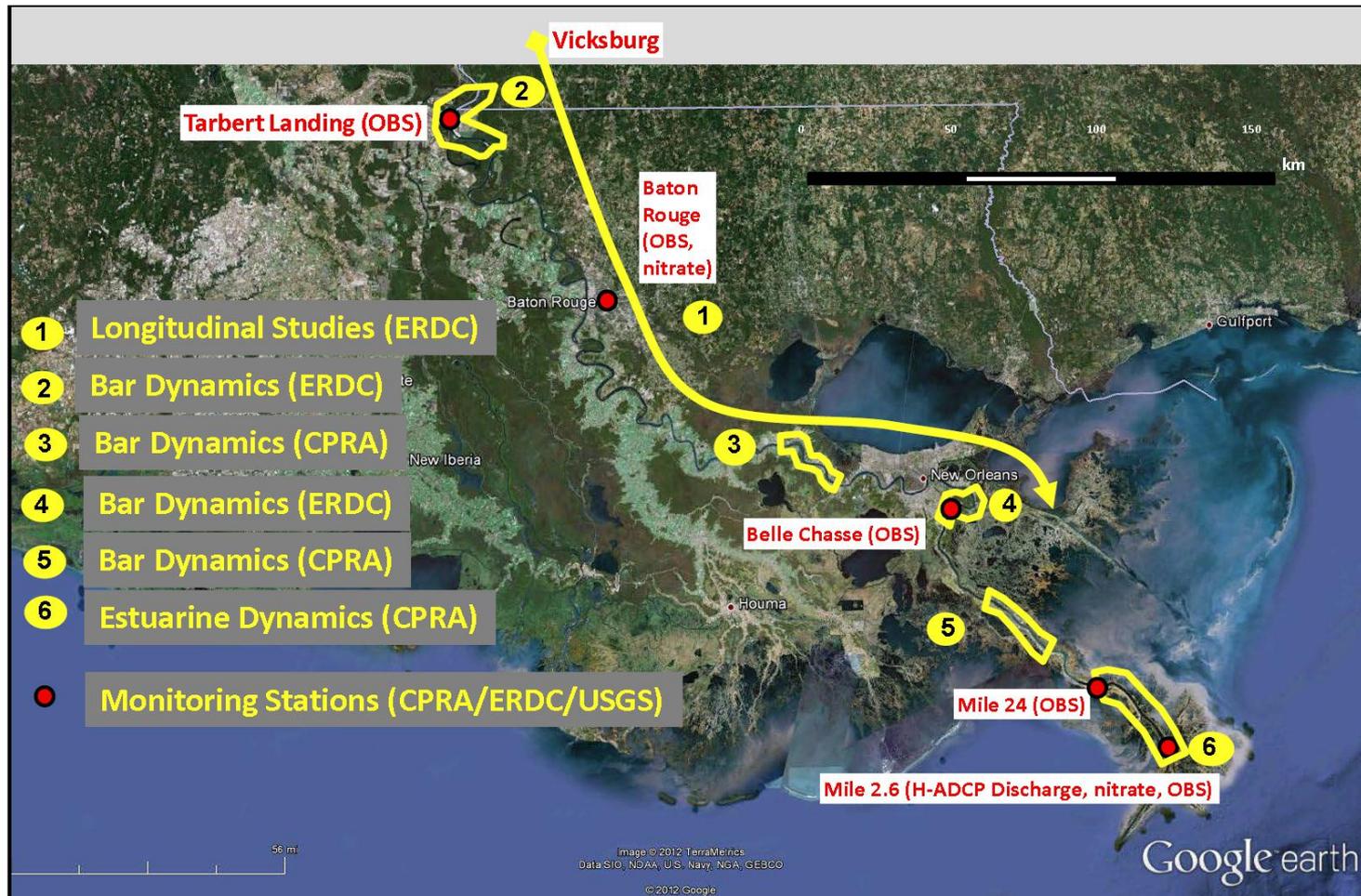
Model Domain of Integrated Hydrodynamic, Morphological, and Nutrient Dynamics

# Estuarine Data Collection Locations



Source: The Water Institute of the Gulf

# MRHDMS Data Collection Study Design



*Mead Allison, The Water Institute of the Gulf  
Thad Pratt, The Corps of Engineers*

# LCA Mississippi River Hydrodynamic and Delta Management Study

*Use Mississippi River resources (freshwater, sediment, and nutrients) to restore and sustain a healthy, diverse coastal ecosystem while balancing multiple authorized uses including navigation, flood risk reduction, and ecological restoration.*



# LCA MRHDMS Team



**Biedenharn Group,  
LLC**

**Mobile Boundary Hydraulics**



**Over 30 Federal, State, Academic,  
and Private Scientists and Engineers**

# Summary and Conclusions

- Predictive Modeling Tools
  - Integral to CPRA's large-scale and long-term planning effort
  - Commitment to maintain and improve suite of modeling tools
- Planning-Level and High-Resolution Models
  - 2017 Master Plan
  - Project-Specific Models
  - Mississippi River Hydrodynamic and Delta Management
  - Basin-Wide
- Systems Context





**Questions?**

# 2017 Model Improvement Plan

## *Summary of Improvements*

- Primary Improvements:
  - Increase the spatial resolution of the hydrology compartments
  - Integrate model components, where possible, to reduce manual data transfer and increase efficiency
  - Include additional processes (e.g., sediment distribution, marsh edge erosion, etc.)
  - Enhance the methodology used for ecosystem outcomes
- Three Overarching Model Components
  - Integrated Compartment Models (landscape)
  - Ecosystem Outcomes (fish, shellfish, wildlife, and other outcomes)
  - Risk Reduction (storm surge / wave and risk assessment)