LOUISIANA'S 2017 COASTAL MASTER PLAN MODELING UPDATE #2

September 22, 2015

Webinar Agenda

Welcome	Mandy Green, CPRA
Overview	Ehab Meselhe, Water Institute
Storm Surge & Waves (ADCIRC/SWAN)	Hugh Roberts, Arcadis
Risk Assessment (CLARA)	Jordan Fischbach, RAND
Hydrology & Water Quality	Eric White, Water Institute
Wetland Morphology	Brady Couvillion, USGS
BIMODE	Gordon Thomson, CB&I
Vegetation	Jenneke Visser, UL Lafayette
Habitat Suitability Indices	Ann Hijuelos, Water Institute
Ecosim with Ecopath	Kim de Mutsert, George Mason University
Additional questions	
Adjourn	

Overview of 2017 Modeling Approach

Ehab Meselhe

Acknowledgements

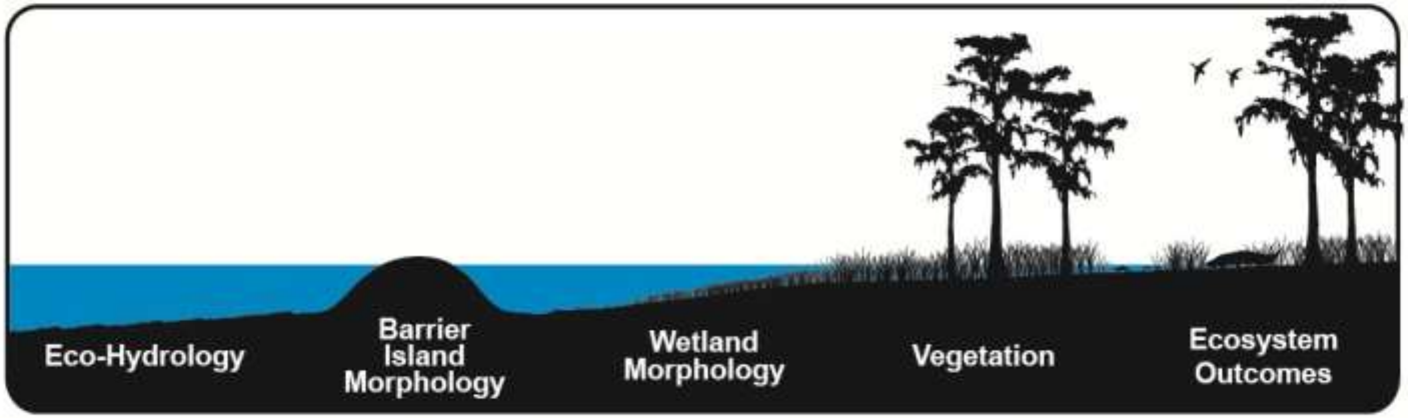
CPRA Lead
- Mandy Green
- Angelina Freeman
- David Lindquist

PM-TAC Team
- Courtney Harris (VIMS)
- John Callaway (USFCA)
- Mike Waldon
- Scott Hagen (LSU)
- Wim Kimmerer (SFSU)

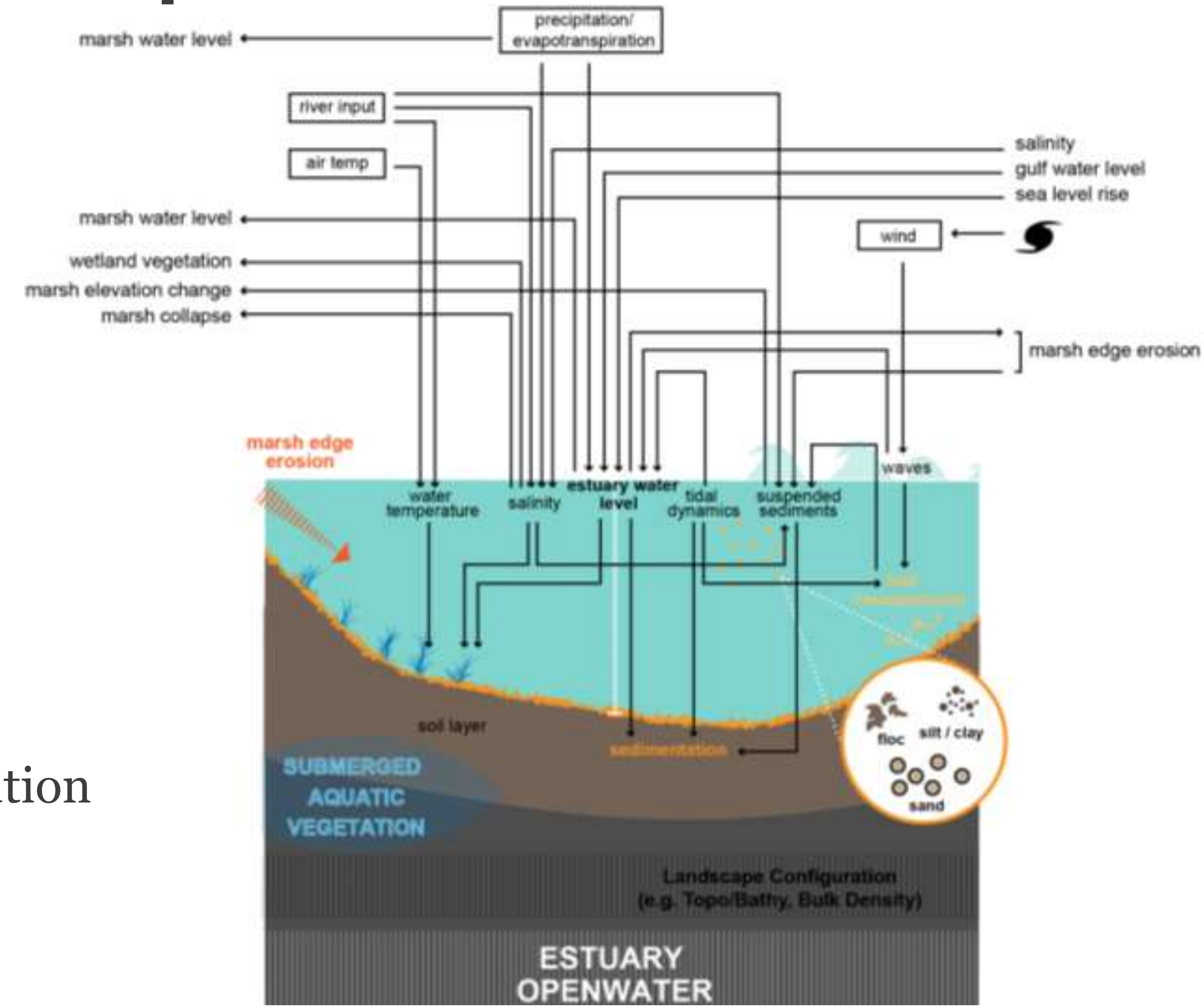
Water Institute Lead
- Denise Reed
- Ehab Meselhe

Modeling Team
- Eric White (WI)
- Ann Hijuelos (WI)
- Yushi Wang (WI)
- Joao Pereira (WI)
- Alaina Grace (WI)
- Scott Hemmerling (WI)
- Leland Moss (WI)
- Alex McCorquodale (UNO)
- Stokka Brown (M&N)
- Jonathan Wang (M&N)
- Mallory Rodrigue (CHF)
- Jenni Schindler (CHF)
- Jenneke Visser (ULL)
- Scott Duke-Sylvester (ULL)
- Paul Leberg (ULL)
- Robert Romaire (LSU)
- Vadim Alymov (CECI)
- Michael Poff (CECI)
- Brady Couvillion (USGS)
- Craig Conzelmann (USGS)
- Hardin Waddle (USGS)
- Kevin Suir (USGS)
- David Johnson (RAND)
- Kenneth Kuhn (RAND)
- Jordan Fischbach (RAND)
- Gordon Thomson (CB&I)
- Zhifei Dong (CB&I)
- Hugh Roberts (Arcadis)
- Zach Cobell (Arcadis)
- John Atkinson (Arcadis)
- Haihong Zhao (Arcadis)
- Kim de Mutsert (GMU)
- Kristy Lewis (GMU)

Integrated Compartment Model (ICM)

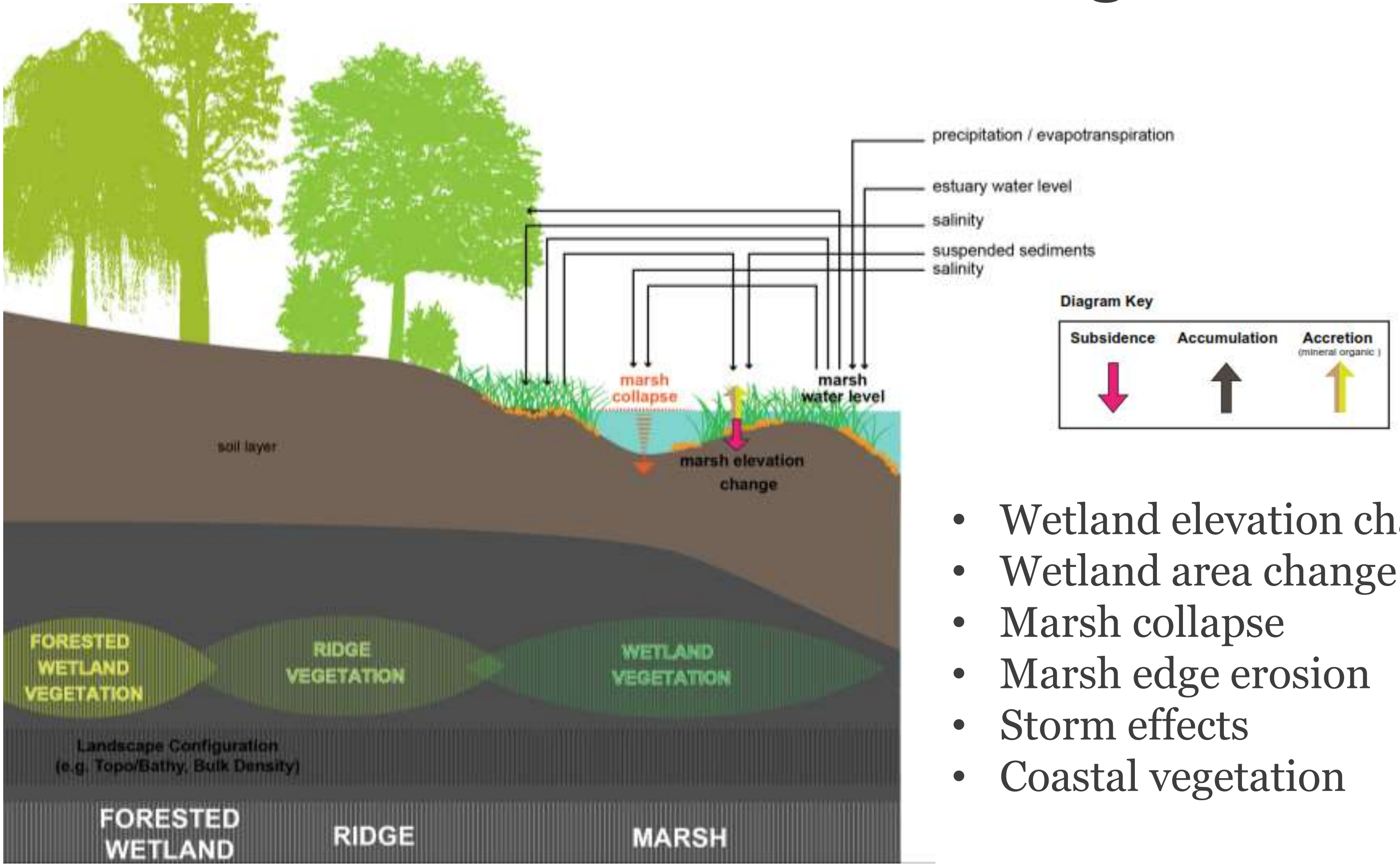


Estuary and Open Water Processes



- Hydrodynamics
- Water quality
- Sedimentation
- Bed resuspension
- Sediment distribution

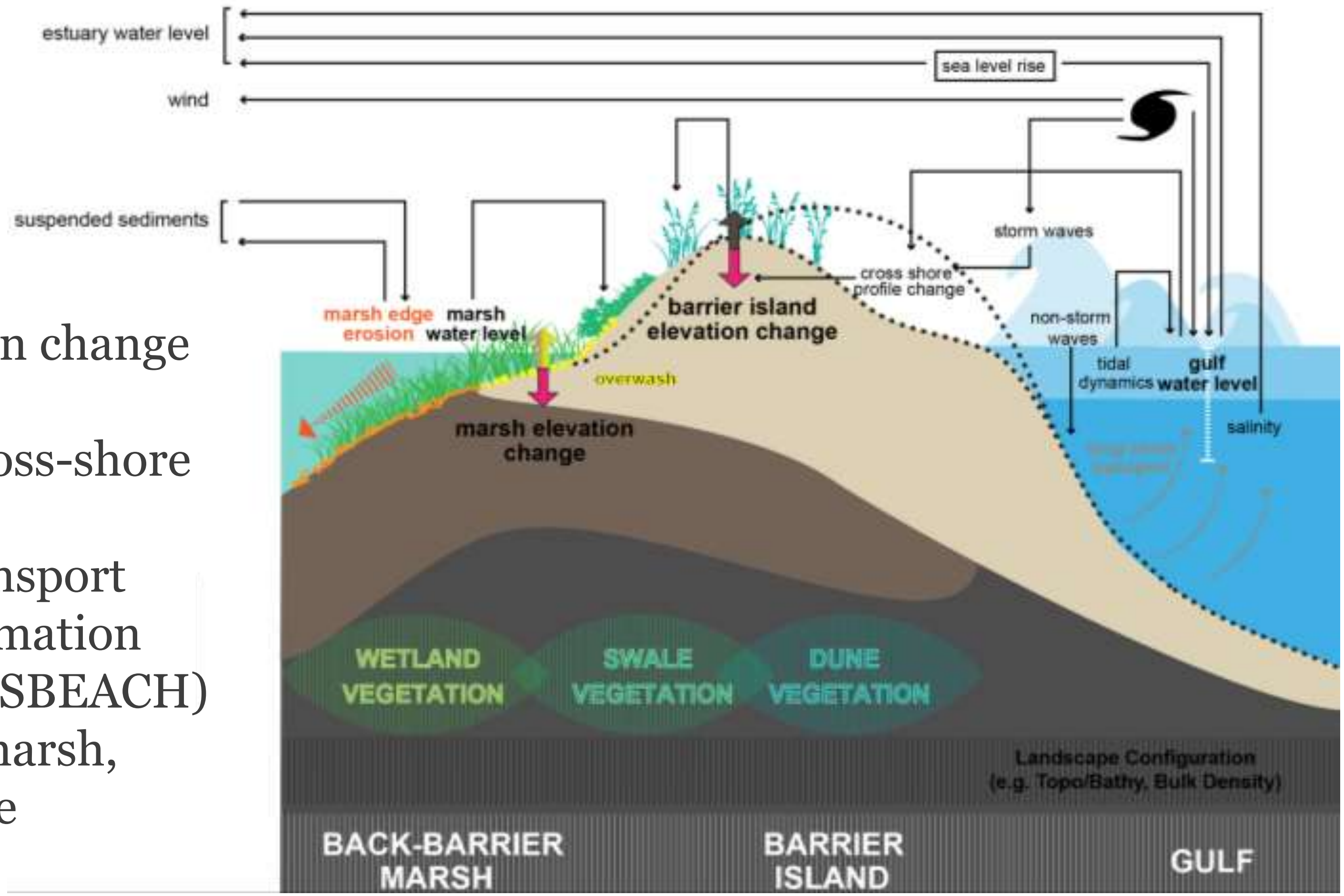
Wetland Processes and Vegetation



- Wetland elevation change
- Wetland area change
- Marsh collapse
- Marsh edge erosion
- Storm effects
- Coastal vegetation

Barrier Island Processes

- Island elevation change
- Breaching
- Overwash / cross-shore profile change
- Longshore transport
- Wave transformation
- Storm effects (SBEACH)
- Back-barrier marsh, dune and swale vegetation



Fish and Shellfish

- 19 fish, shellfish, and wildlife Habitat Suitability Indexes (HSIs)
  - Statistical analysis
  - Revised equations from 2012
  - Added several new HSIs
  - Coded into the ICM

- EwE (Ecopath with Ecosim)
  - Community fish and shellfish model
  - Dynamically coupled to the ICM

Fundamental ICM Code Improvements

- Code integration
  - Allows for annual (faster, in some cases) communication across:
    - Hydrology
    - Morphology
    - Vegetation
    - Barrier islands
    - HSIs are integrated, but do not feedback to the ICM
  - No need for manual data transfers
- Linkage to EwE
- Enhanced spatial resolution (hydrology and morphology)
- All regions are coded in an identical manner; can run coast wide or by region

Storm Surge & Waves – ADCIRC+SWAN

- Using newer ADCIRC and SWAN versions
- Extended model boundary
- Added polders (new land areas) into model domain
- Improved levee elevations
- Revalidated Hurricanes Ike, Gustav, Rita, and Katrina
- Evaluated large storms and high ESLR to help set spatial boundary for Risk Assessment model
- Simulated the entire suite of FEMA Louisiana storms (440) to select expanded storm suite for modeling

Coastal LA Risk Assessment Model (CLARA)

- Built on 2012 Coastal Master Plan modeling efforts
- Incorporated parametric uncertainty
- Updated geospatial domain and unit of analysis
- Updated datasets
- Improved fragility assumptions
- Improved economic damage module
- Expanded storm suite

Boundary Conditions & Landscape Data

- Boundary Conditions
  - Hydrology (updated through late 2014)
  - Water quality (updated through late 2014)
  - Tropical cyclones (synthetic history with 23 storms, 11 major hurricanes)
- Landscape Data
  - DEM (late 2014) based on LA Coastal National Elevation Database (LACoNED)
  - Vegetation base map (2014) 2013 helicopter survey as training for a remotely sensed classification

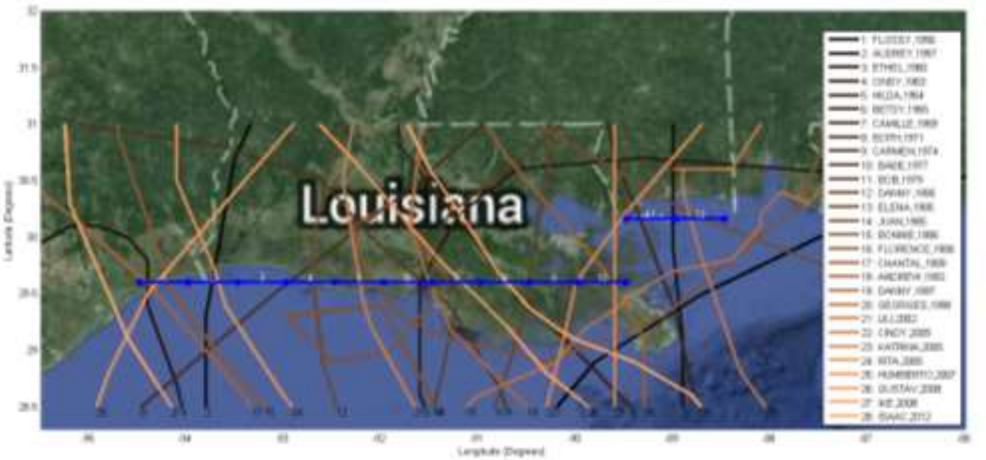
Storms in the ICM Boundary Conditions

(1) Identify historical hurricane strikes (1950-2013)

(2) Locate ‘matching’ synthetic storms

(3) Apply storms as forcings in the 50-year ICM model runs (23 storms; 11 major hurricanes)

(4) Impacts to the landscape, including islands



Developing Future Scenarios

- Revisited 2012 Coastal Master Plan Future Scenarios effort
  - selected variables relevant to the 2017 analyses
  - identified whether plausible ranges should be modified using recent literature, data, and other information
- Designed focused numerical experiments and performed analysis to assess the response of key ICM output
- Evaluated model outputs for land change over 50 years
- Identified three scenarios (combination of values of environmental variables)
- Values are relevant to each environmental variable and may therefore refer to a time series or a spatial map, as appropriate

Evaluating Future Scenarios

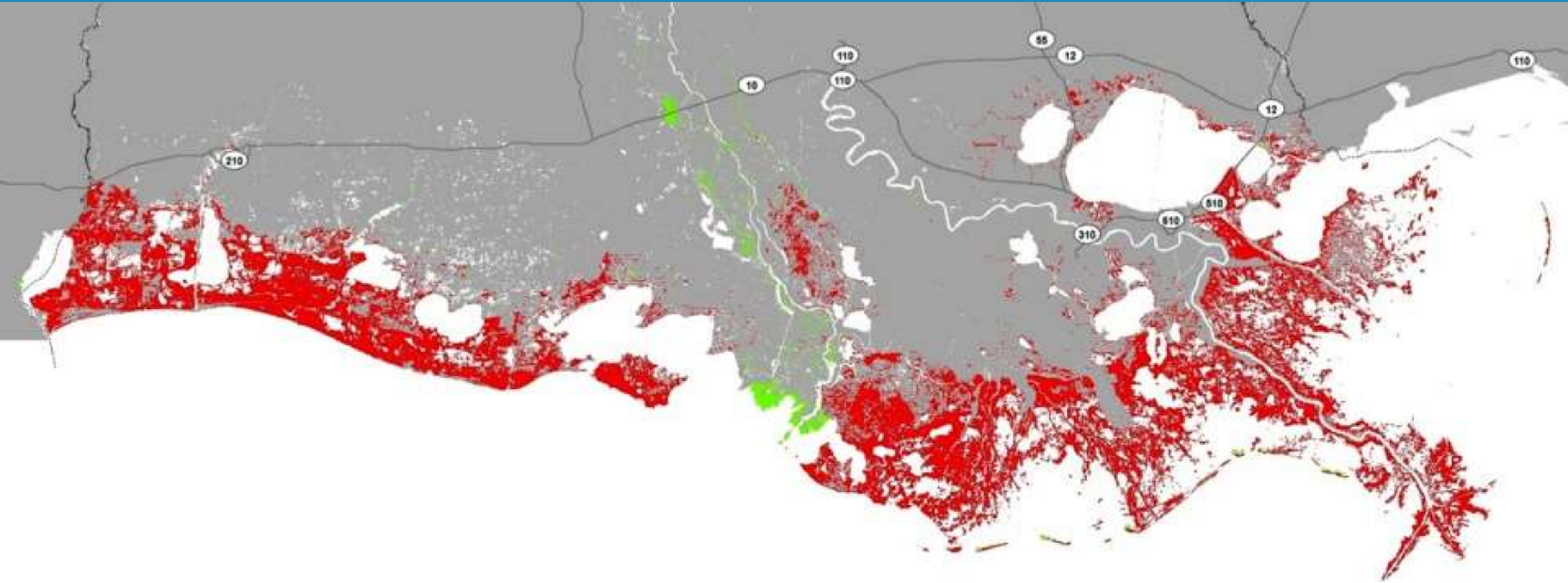
- Sea Level Rise
  - Plausible range: 0.14 to 0.83 m over 50 years
- Subsidence
  - Plausible range: spatially variable; same as 2012 regions and values
- Precipitation
  - Plausible range: -5% to +14% of 50-year observed cumulative
- Evapotranspiration
  - Plausible range: -30% to historic 50-year cumulative

2017 Future Scenarios

Scenario	Precipitation	ET	ESLR (m/50yr)	Subsidence
01	High	Low	0.43	20% of range
02	High	High	0.63	50% of range
03	Medium	High	0.83	50% of range

Not varying among scenarios for 2017

- River discharge – 1964-2014 historical record
- River sediment – current sediment-rating curves
- River nutrients – used historical long-term monthly concentrations
- Marsh collapse threshold – calibrated values based on USGS analysis
- Tropical cyclone intensity and frequency – reflect historical
  - 23 hurricanes; 11 major. *Varies only in Risk Analyses in CLARA*



Questions?

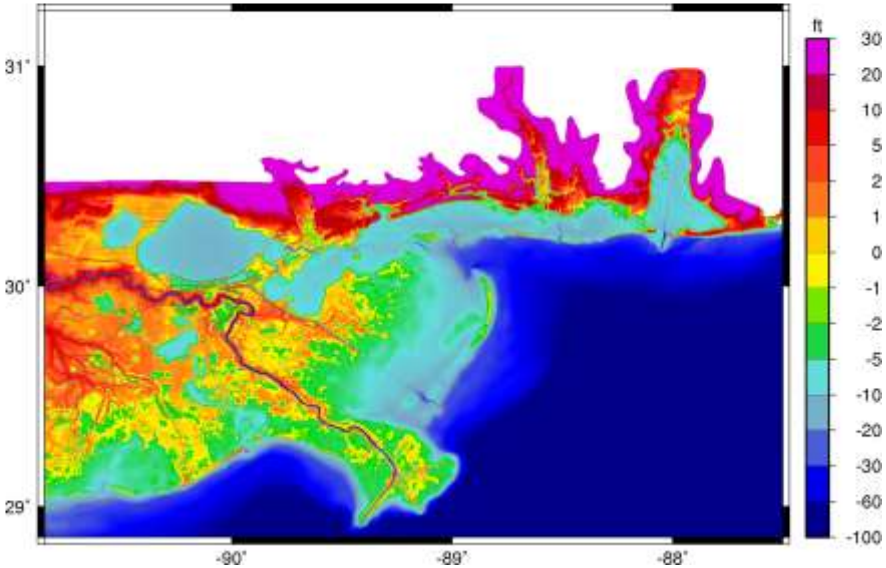
Storm Surge & Wave Modeling

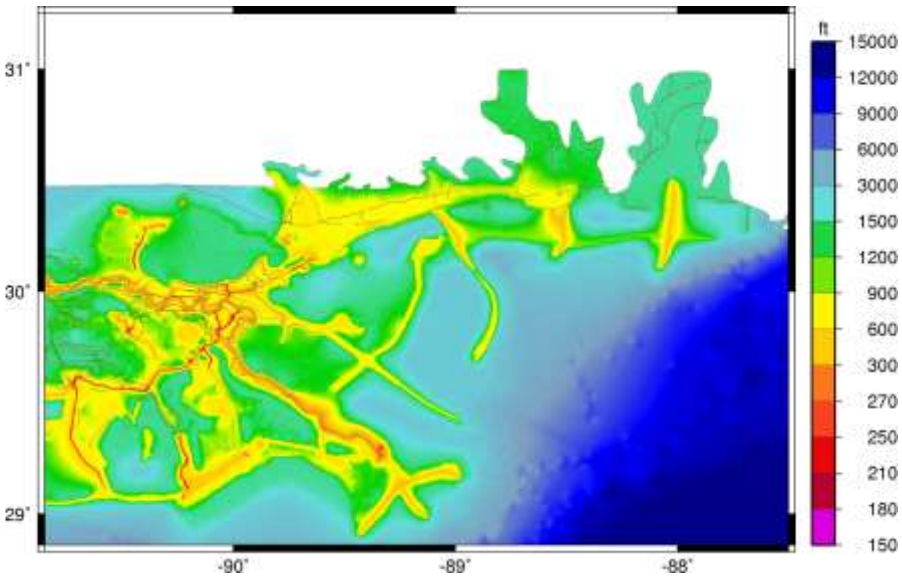
Hugh Roberts

Team Members

- Hugh Roberts
- Zach Cobell
- John Atkinson
- Haihong Zhao

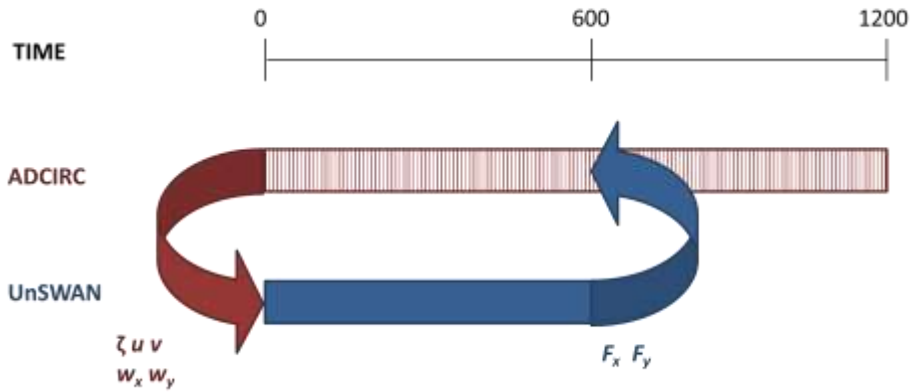
Computing Surge and Waves

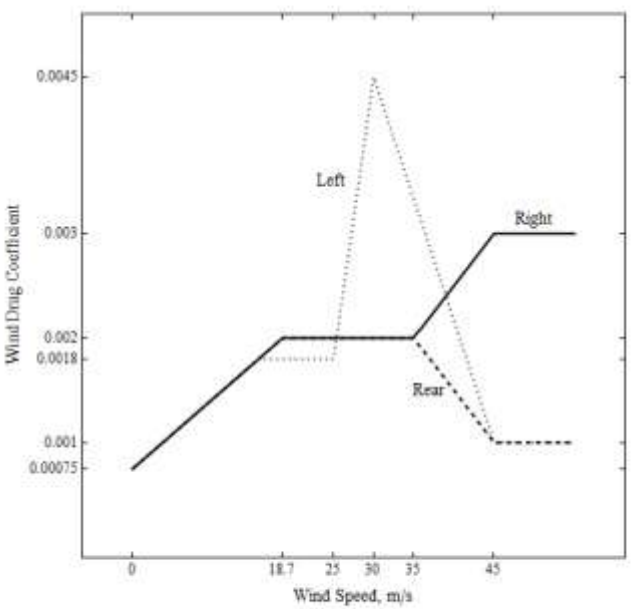




Computing Surge and Waves

- ADCIRC
  - Computes wind and tide driven circulation
  - Unstructured mesh allows for flexibility to capture natural features
  - Highly efficient parallel model framework
- SWAN
  - Computes wind and circulation driven waves
  - Nonstationary waves
  - Uses same mesh as ADCIRC

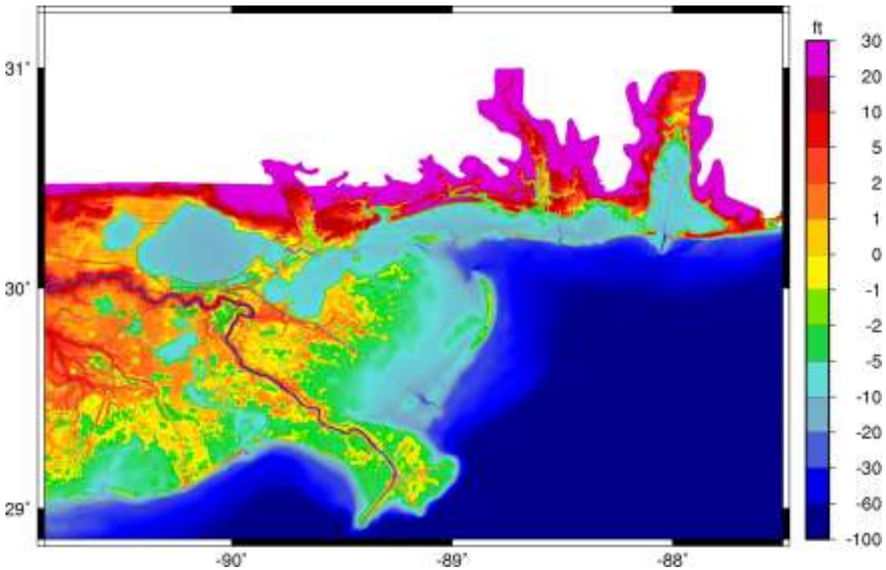


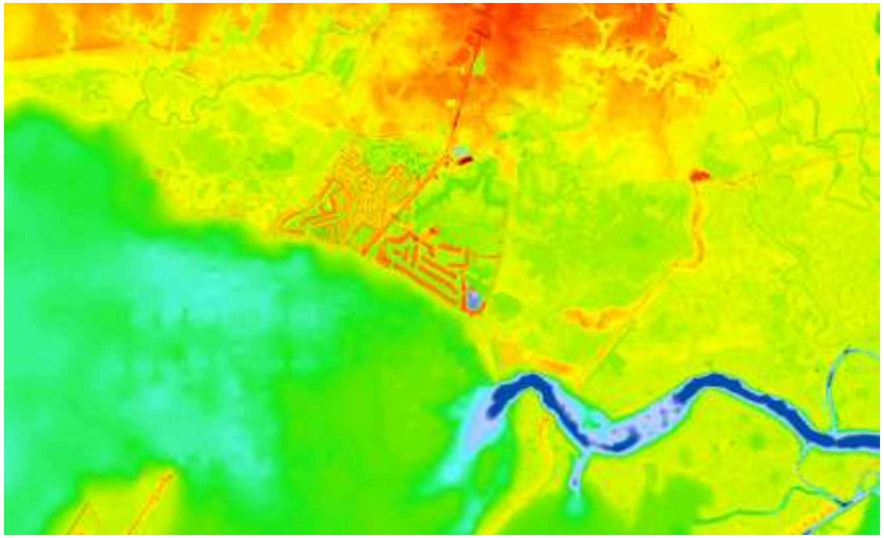


Computing Surge and Waves

- Tightly Coupled
  - Models run together, exchanging information in real time
- Updated Wind Algorithms
  - Hurricane Hunter dropsonde data used to develop sector based wind drag (Powell, 2006)
  - Improves model response to historic storms

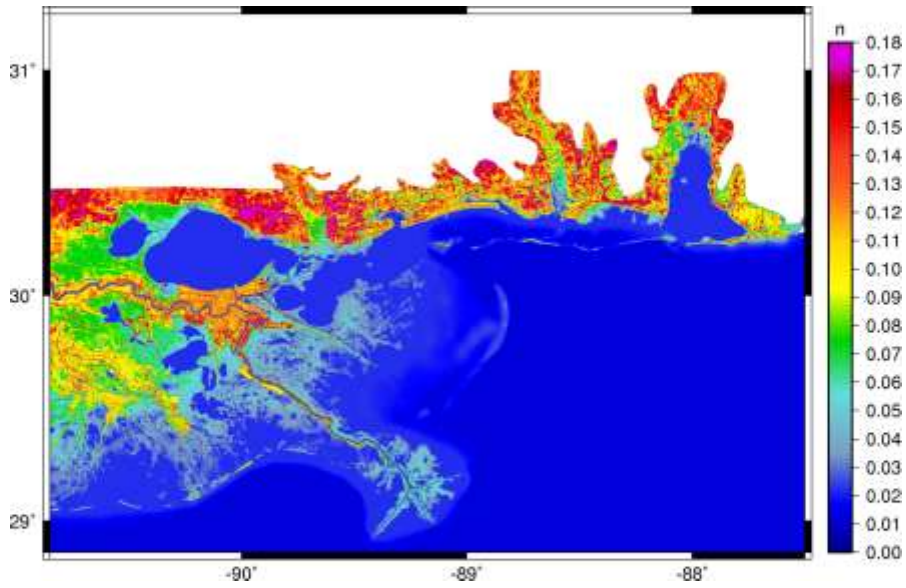
Model Inputs





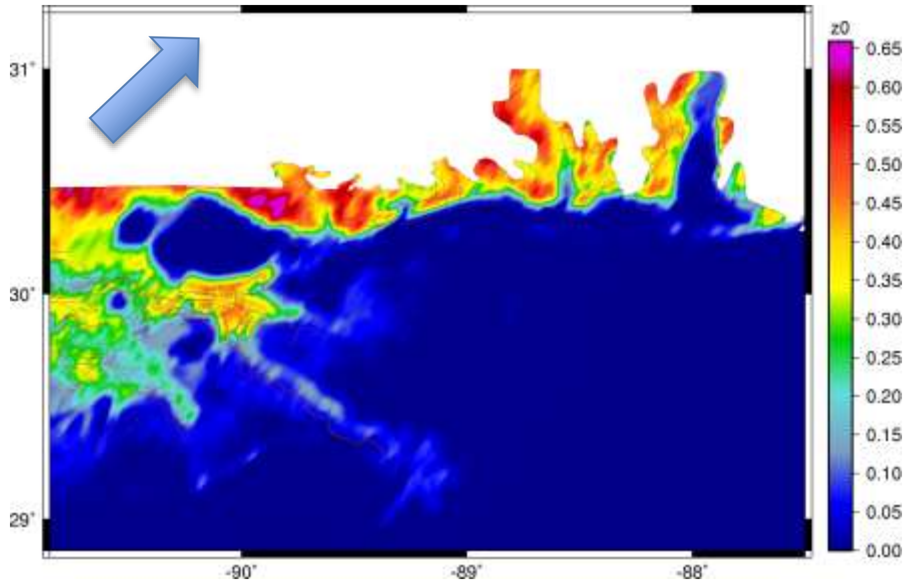
Model Inputs

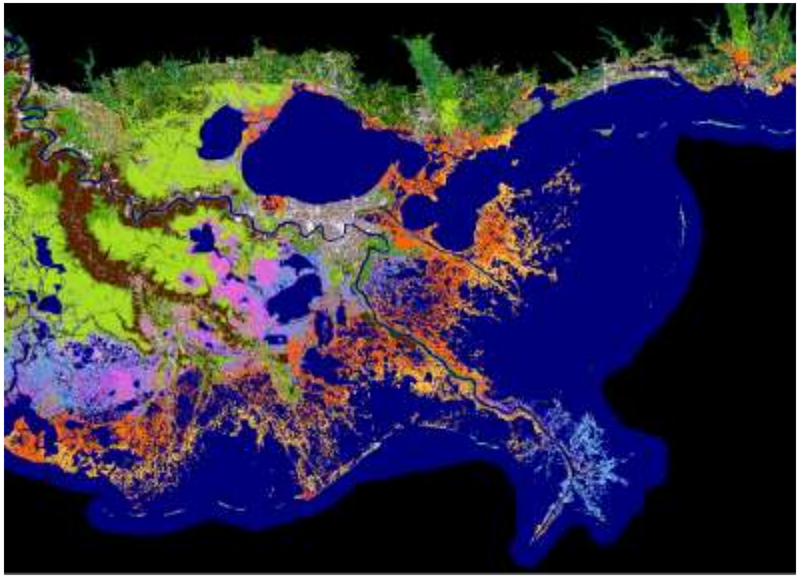
- LIDAR and Bathymetric Sounding
  - Interpolated to model
  - Checked for consistency with satellite imagery
  - Special care taken for raised features



Model Inputs

- Land Use Data
  - Determines Manning's roughness coefficient
  - Directional based wind reduction coefficients

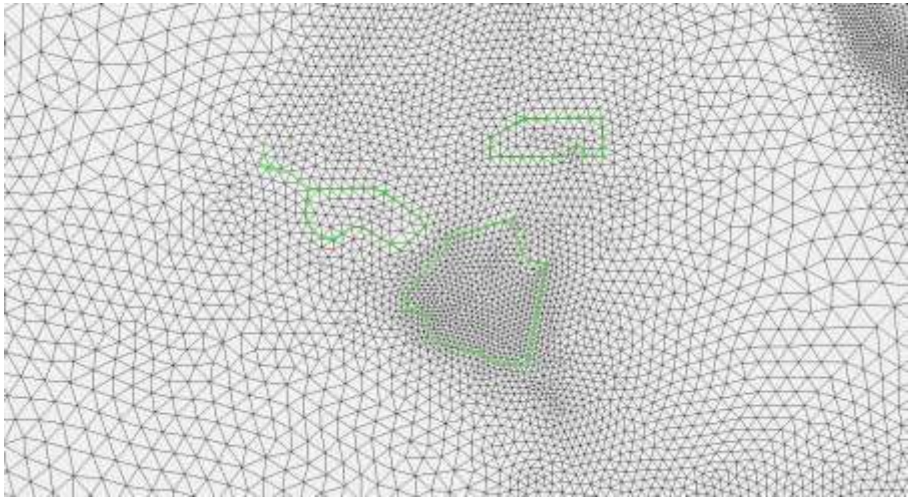




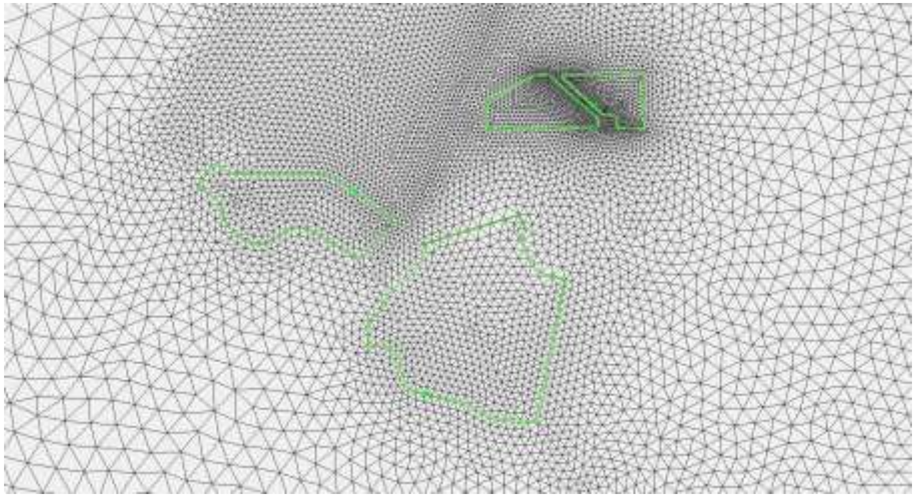
Model Inputs

Slidell, LA

2012



2017

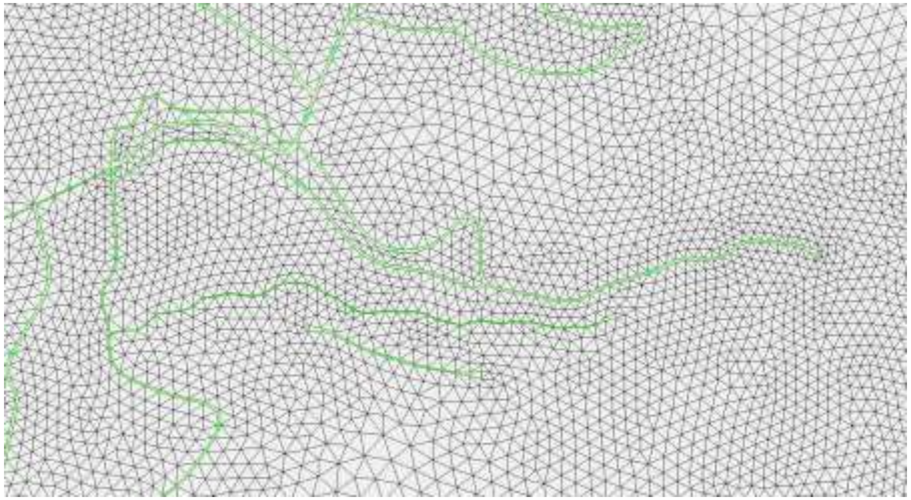


- Levee Survey
  - Updated per Louisiana Sea Grant survey
  - Features added since 2012 Coastal Master Plan

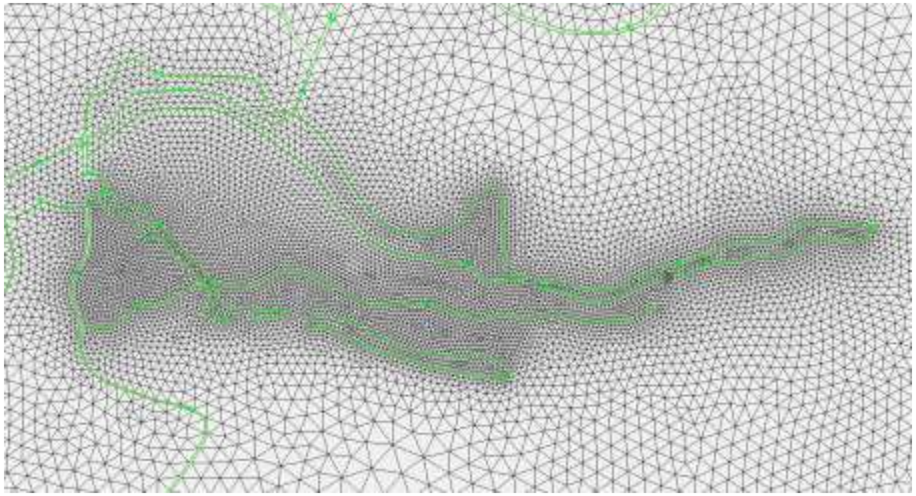
Model Inputs

Kraemer, LA

2012



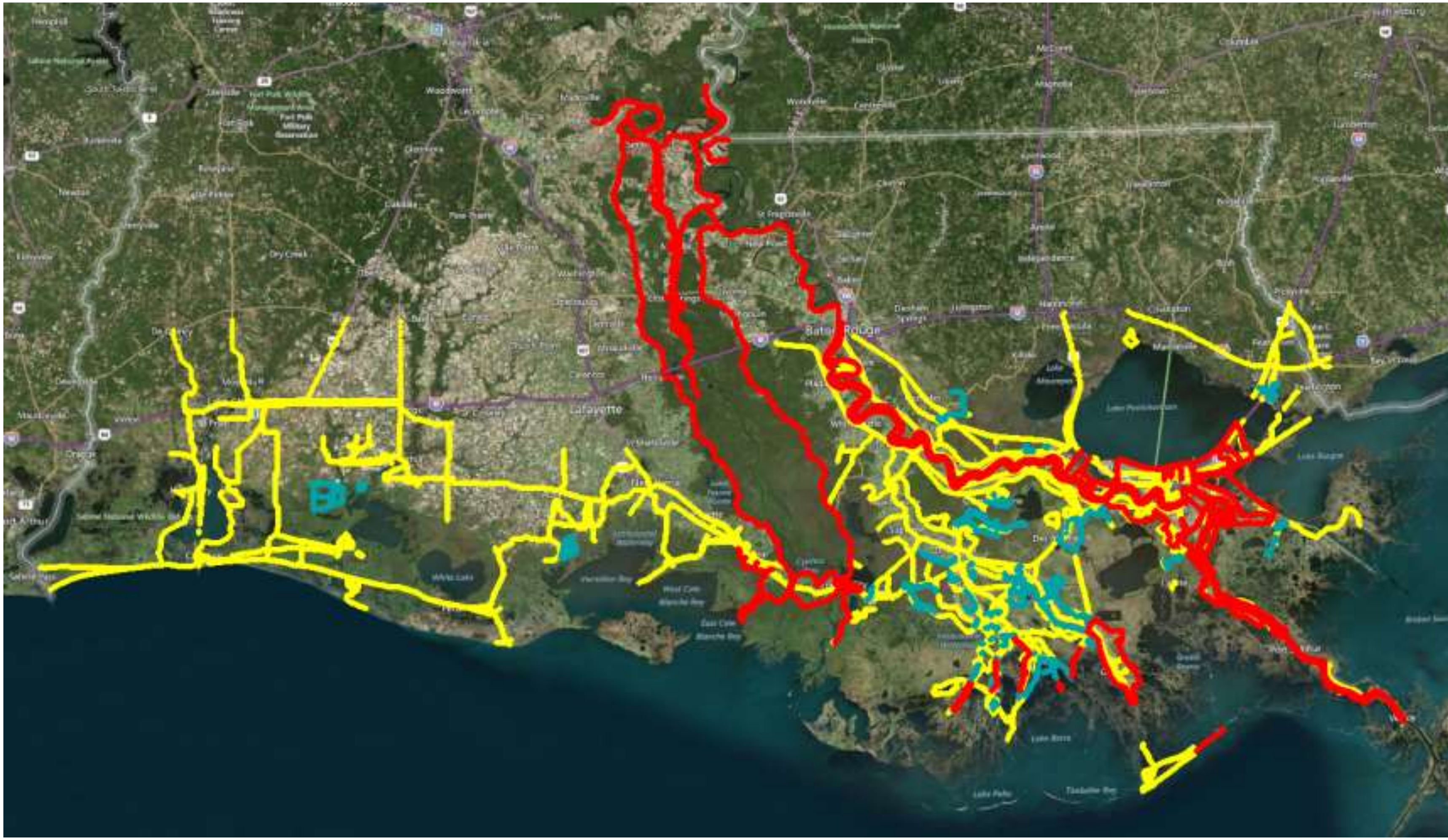
2017



- Levee Survey
  - Updated per Louisiana Sea Grant survey
  - Features added since 2012 Coastal Master Plan

USACE
Sea Grant
USGS CoNEDS

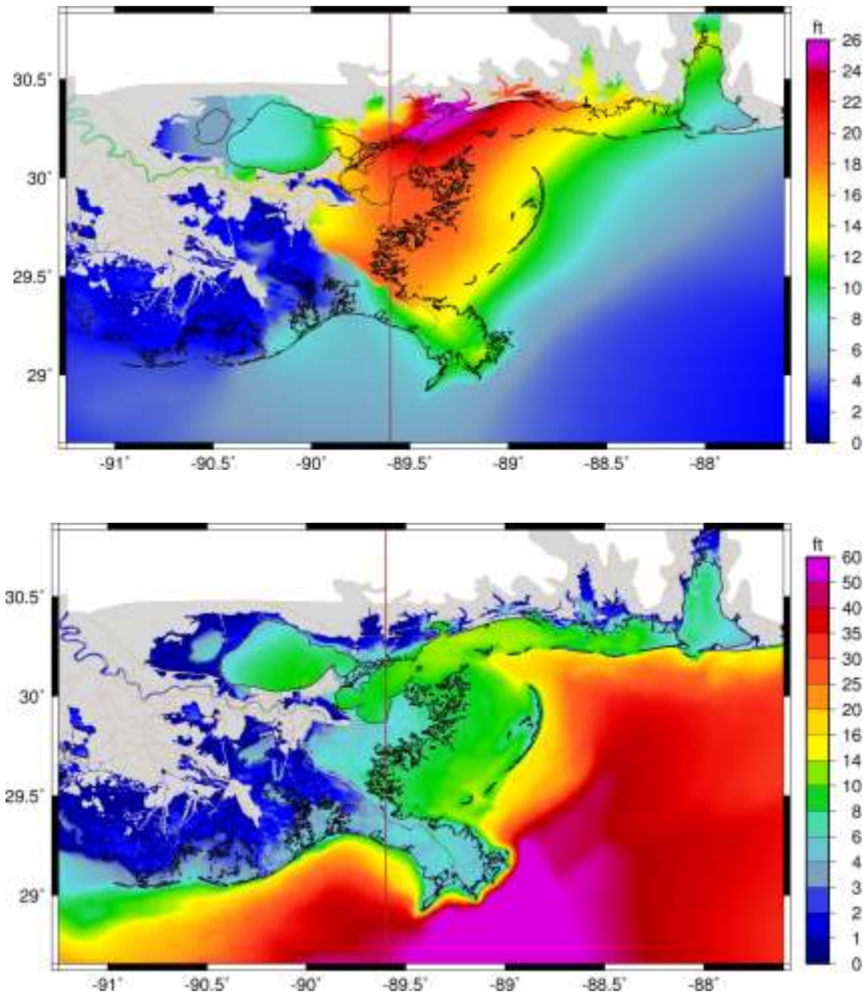
Raised Feature Sources

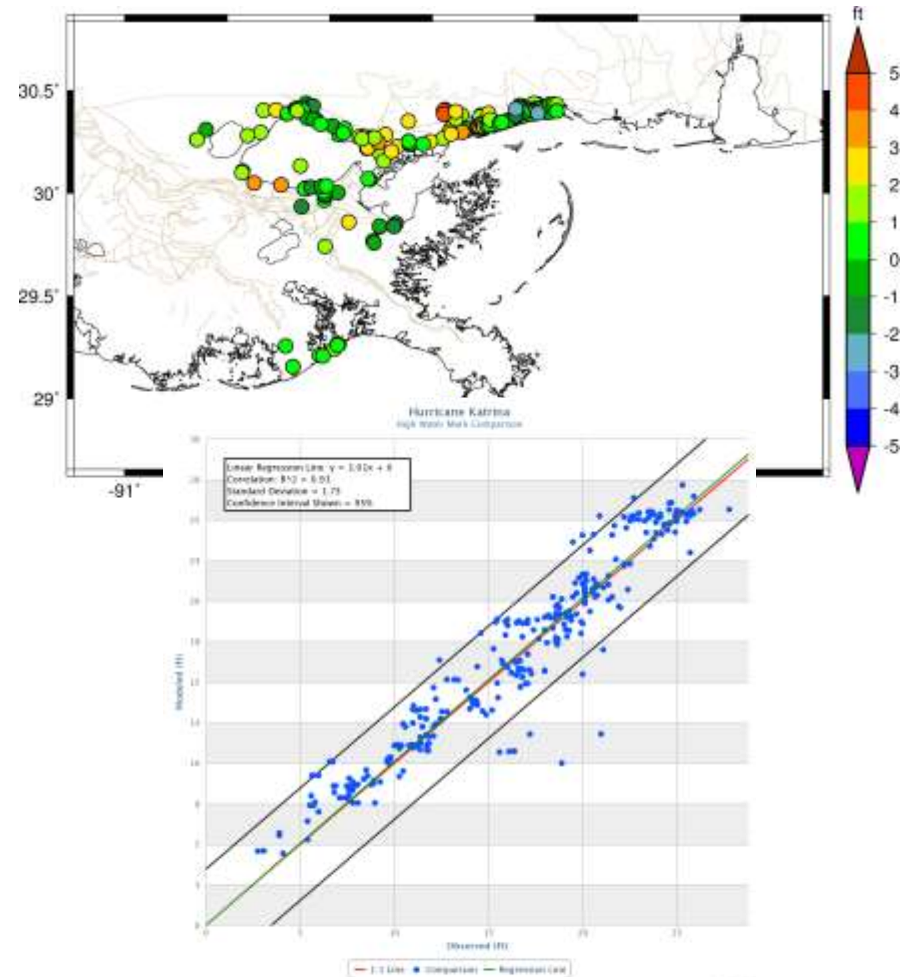


Model Validation

Regression Line: y=1.01
R^2=0.91
StdDev=1.73

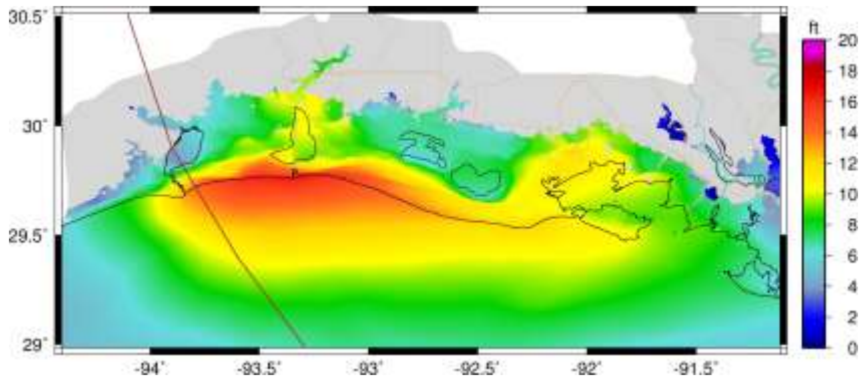
Katrina

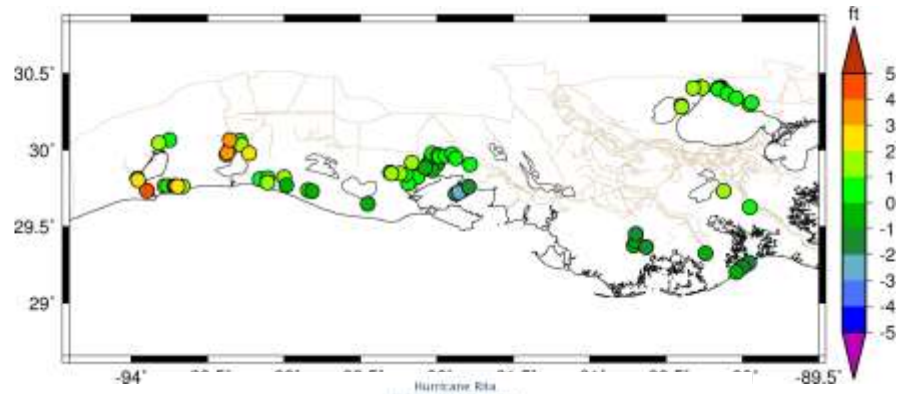


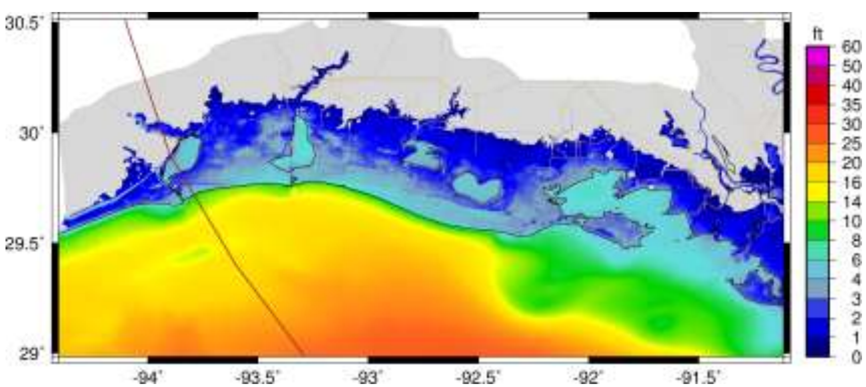


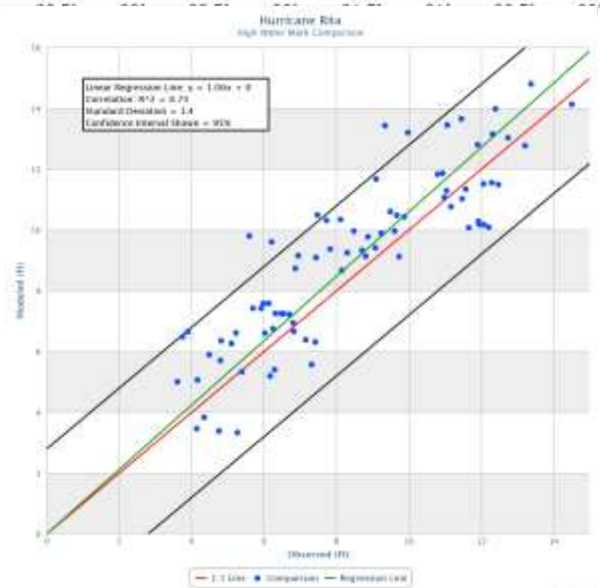
Regression Line: y=1.06
R^2=0.73
StdDev=1.4

Rita



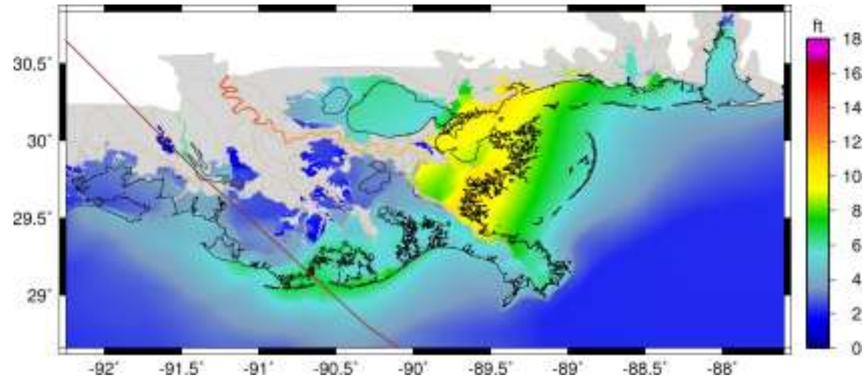


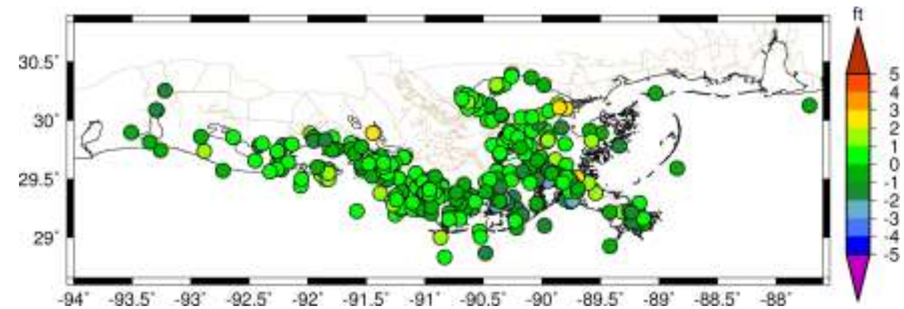


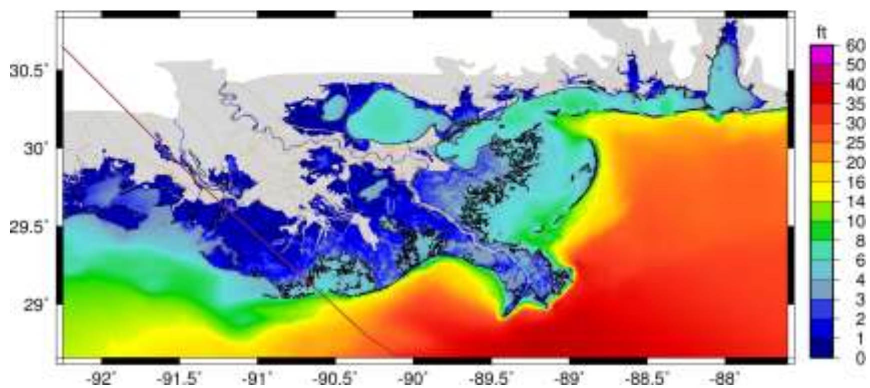


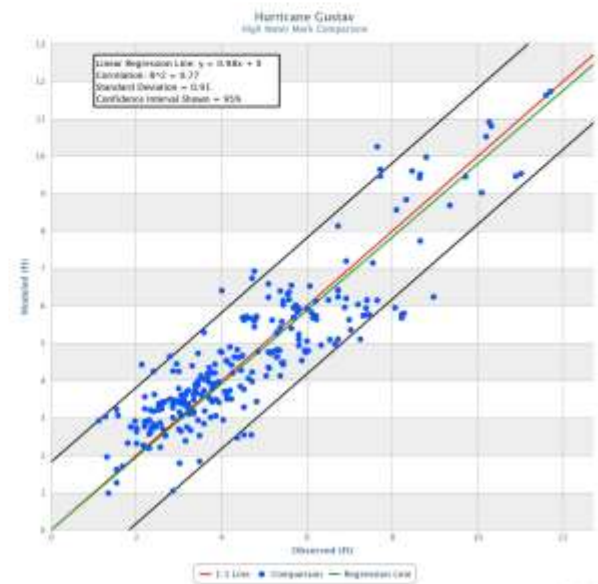
Regression Line: y=0.98
R^2=0.73
StdDev=0.91

Gustav



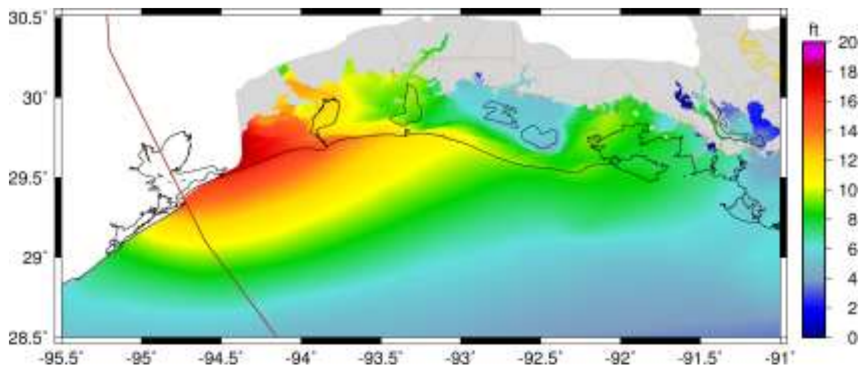


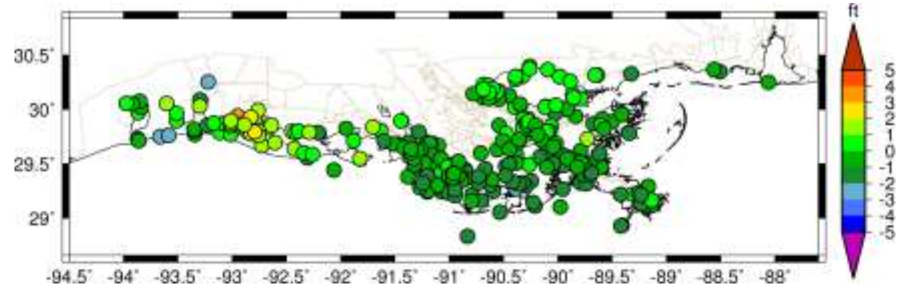


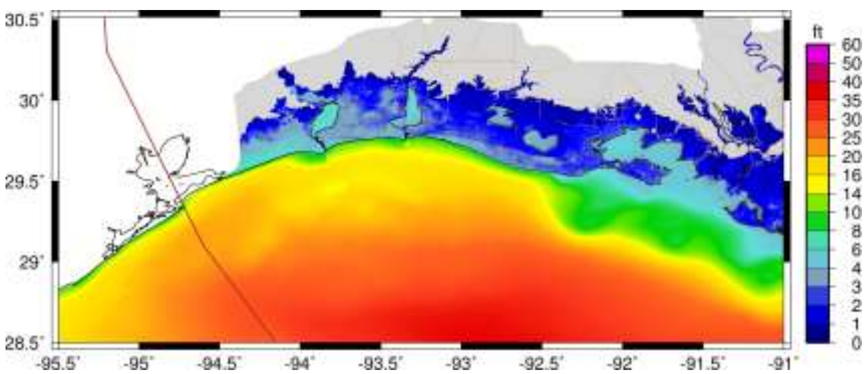


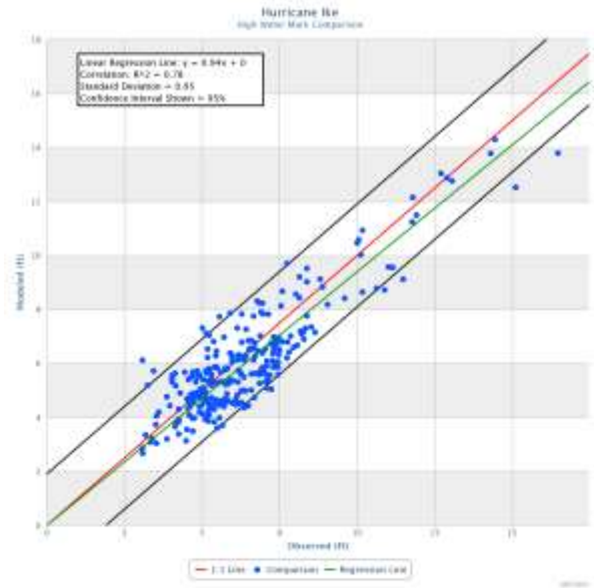
Regression Line: y=0.94
R^2=0.78
StdDev=0.95

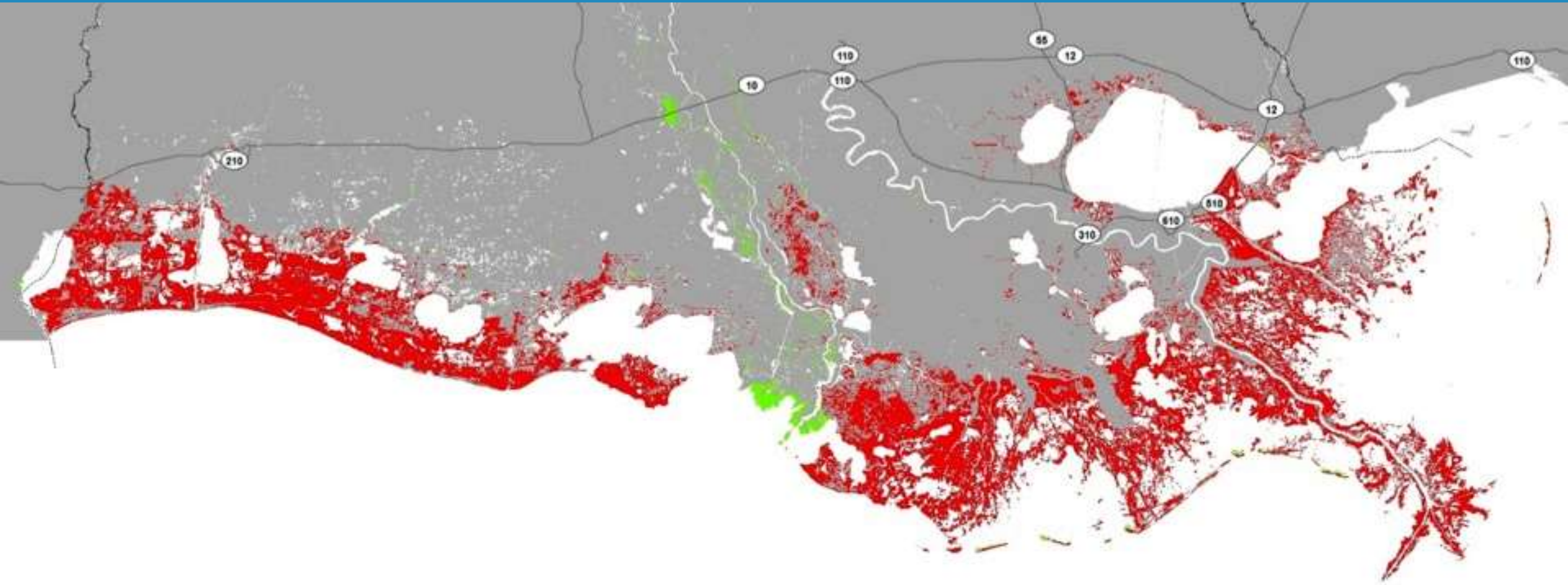
Ike











Questions?

Coastal Louisiana Risk Assessment

Jordan Fischbach

Team Members

- Jordan Fischbach
- David Johnson
- Kenneth Kuhn
- Chuck Stelzner
- James Syme

Overview of the Coastal Louisiana Risk Assessment (CLARA) Model

CLARA Model Estimates Direct Economic Damage from Coastal Flooding

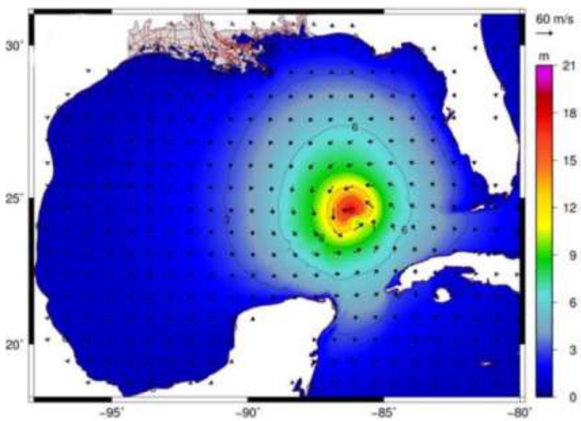
- Builds on post-Katrina flood modeling in coastal Louisiana
- Provides balanced resolution for future risk estimates
  - Estimates damage reduction from structural and nonstructural projects
  - Considers many future scenarios

Estimates flood depths across the coast

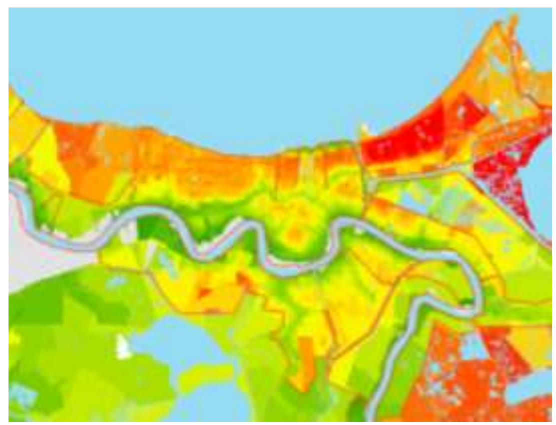
Determines direct economic damage

CLARA Consists of Three Primary Modules

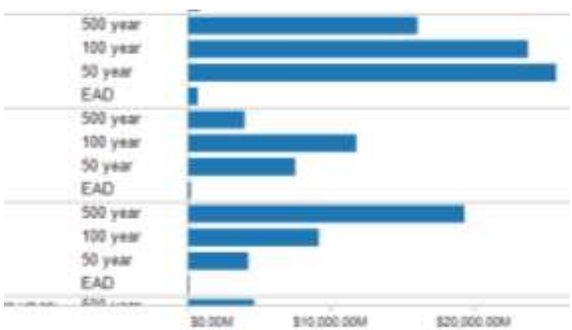
1. Statistical Pre-Processing Module



2. Flood Depth Module



3. Economic Damage Module

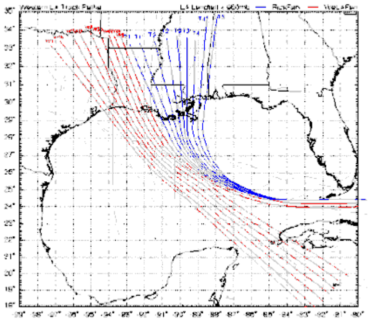


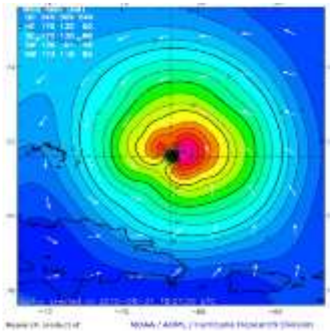
Flood Recurrence Estimated Using Modified Joint Probability Method with Optimal Sampling (JPM-OS)

- Response surface model
  - Predicts surge and wave response as a function of storm parameters
  - Fit using ADCIRC/UnSWAN hydrodynamic inputs

Response Surface Model Predicts Surge and Wave Response as a Function of Storm Parameters

Storms are parameterized by a set of characteristics

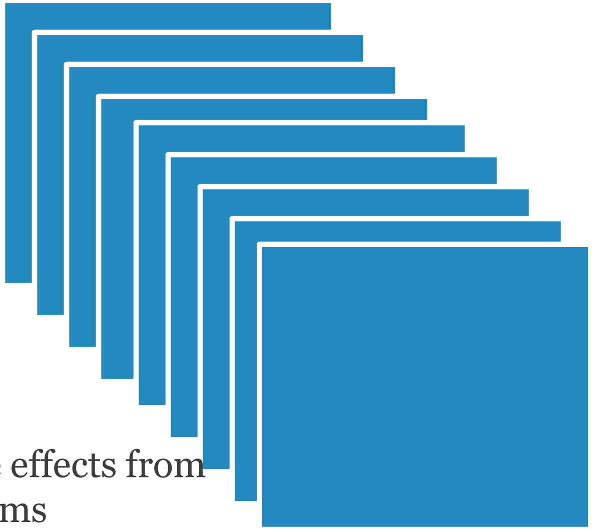




- Central pressure
- Radius
- Track
- Landfall angle
- Forward velocity

Surge and wave effects from training storms (ADCIRC/UnSWAN)

Response surface estimation

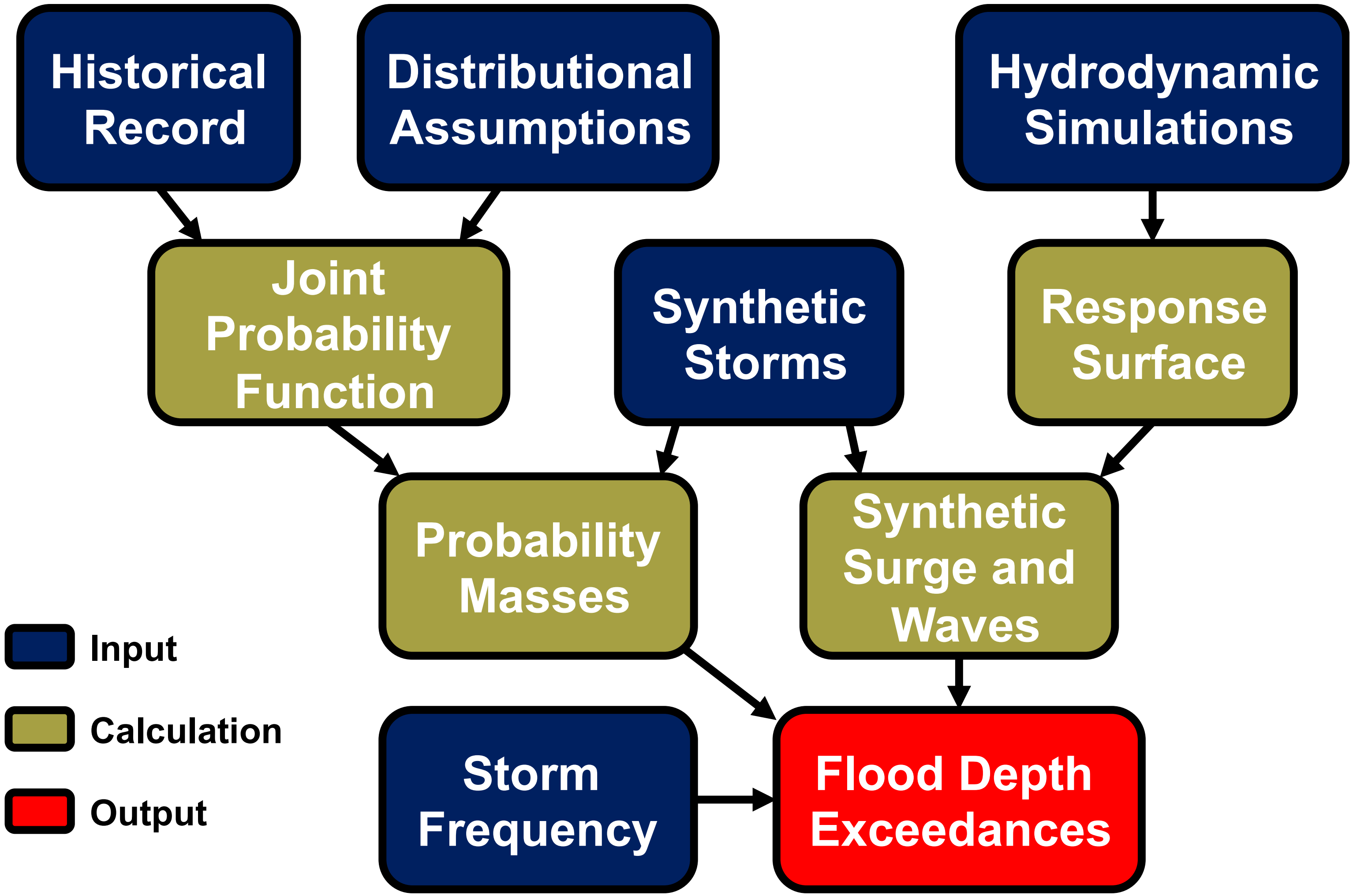


Surge and wave effects from "synthetic" storms

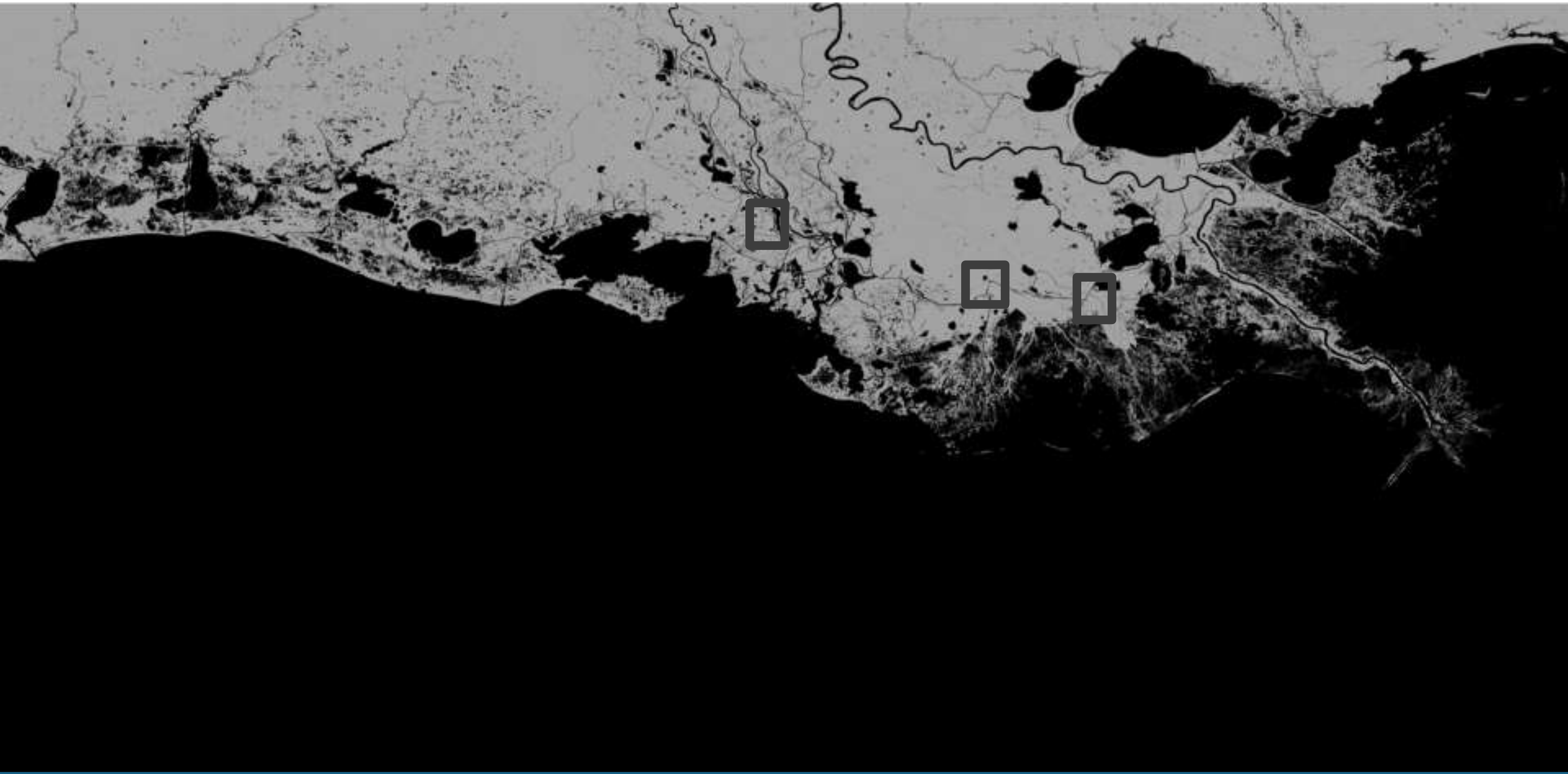
Flood Recurrence Estimated Using Modified Joint Probability Method with Optimal Sampling (JPM-OS)

- Response surface model
  - Predicts surge and wave response as a function of storm parameters
  - Fit using ADCIRC/UnSWAN hydrodynamic inputs
- Joint probability model
  - Assesses the relative likelihood of a set of storms
  - Fit using the limited historical record of observed storms

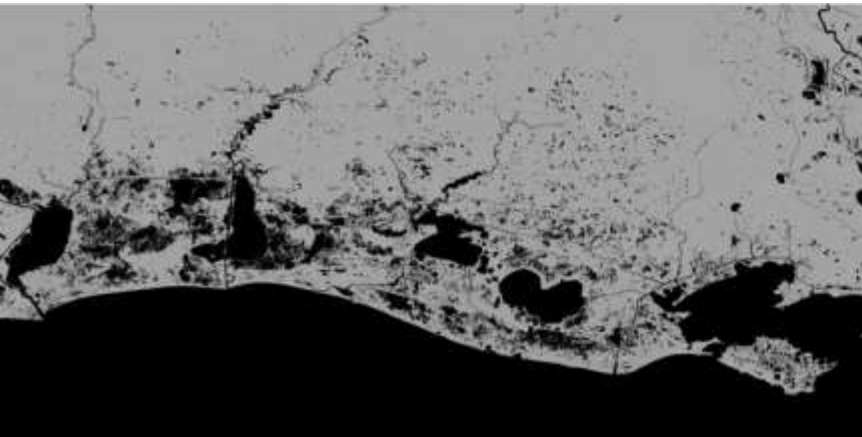
Summary of Modified JPM-OS Process



2. CLARA Estimates Flooding for Unenclosed and Enclosed Areas

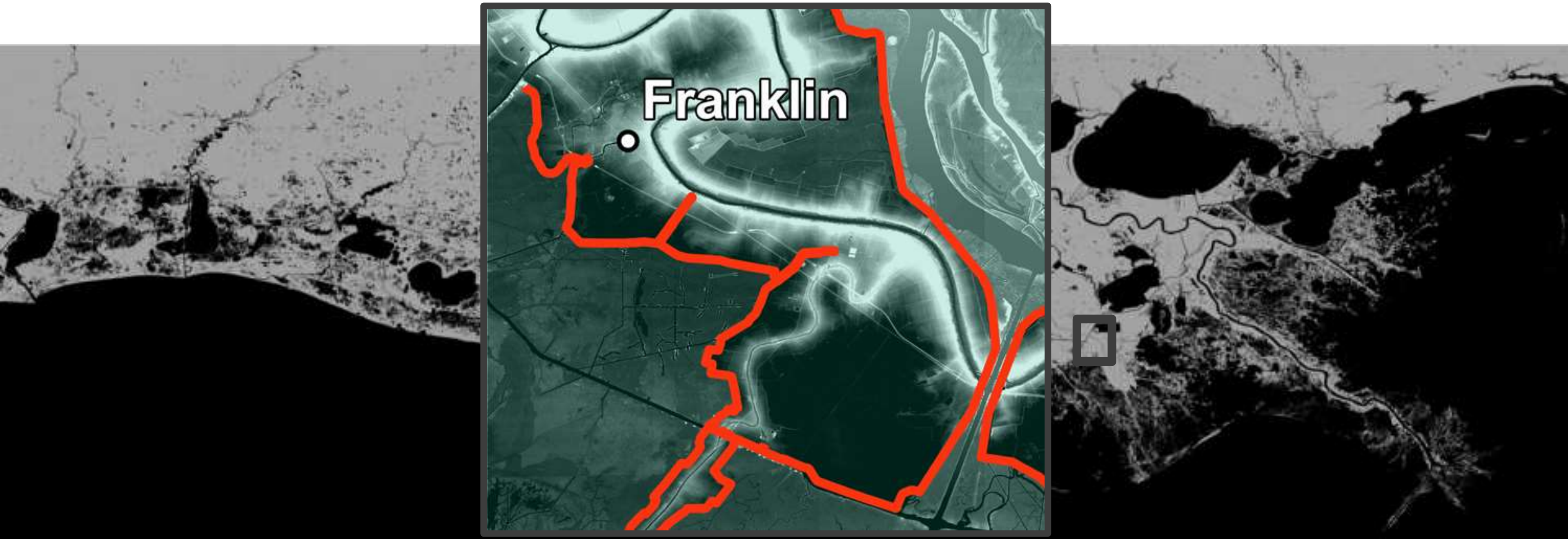


2. CLARA Estimates Flooding for Unenclosed and Enclosed Areas



- No levee protection
  - Storm surge
  - Wave heights

2. CLARA Estimates Flooding for Unenclosed and Enclosed Areas



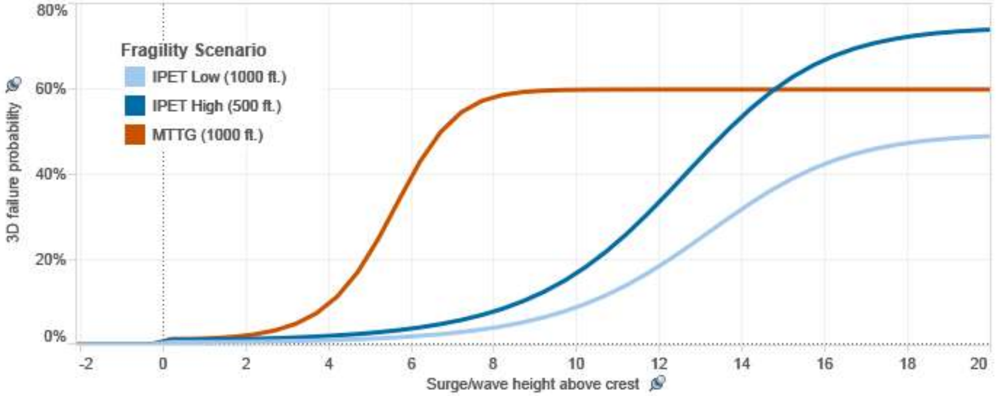
- Unenclosed surge barrier
  - Storm surge overtopping
  - Storm surge "run-around"

2. CLARA Estimates Flooding for Unenclosed and Enclosed Areas

- Enclosed protection system
  - Storm surge overtopping
  - Wave overtopping
  - Rainfall
  - Protection system breach

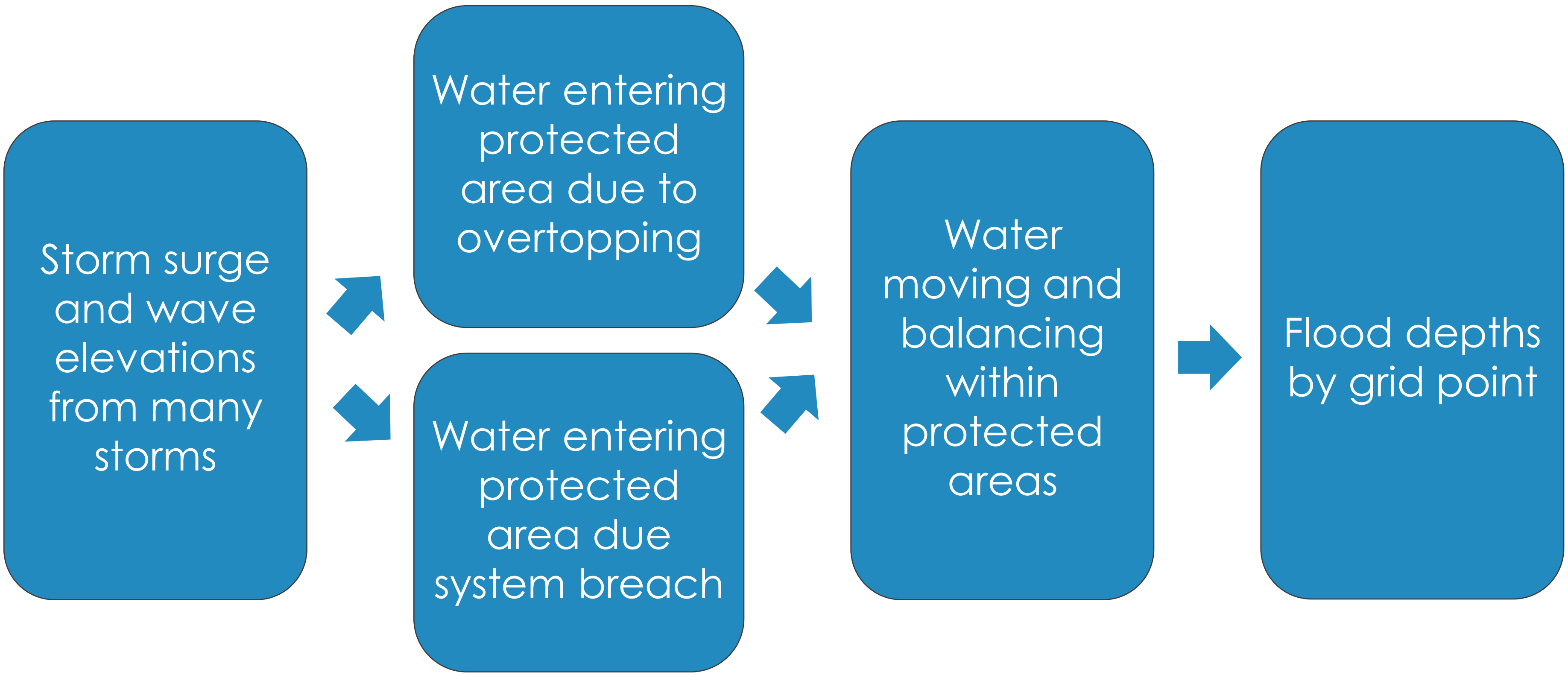
CLARA Fragility Module Considers the Possibility That Enclosed Protection Systems Might Fail

- Uses peak surge height and overtopping rates to estimate failure probability by location
  - Underseepage
  - Erosion (overtopping)
- Applies Monte Carlo simulation to probabilistically estimate failure rate
- Estimates breach flow volumes in the event of a failure



Example Fragility Curve

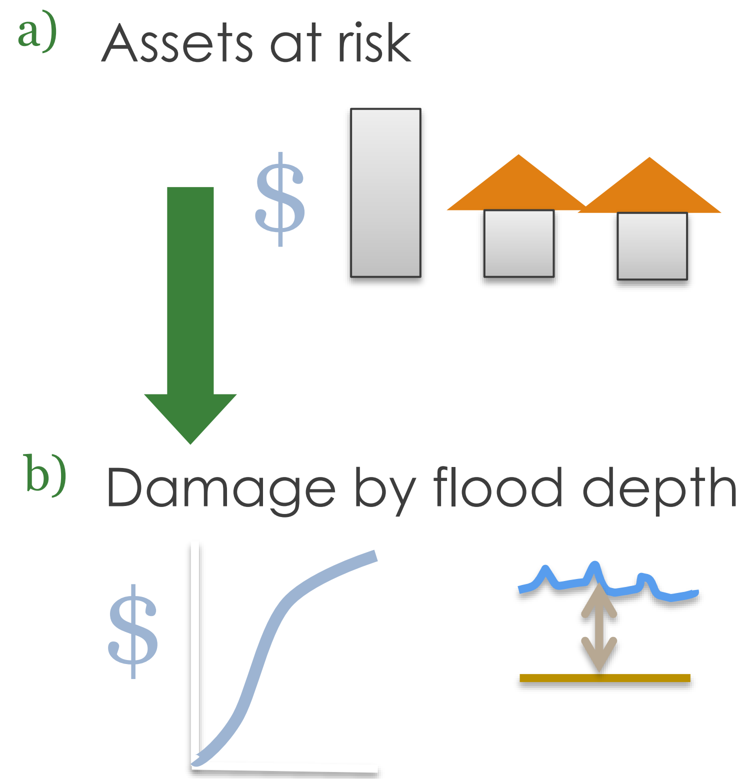
CLARA Then Estimates Final Flood Depths in Enclosed Areas

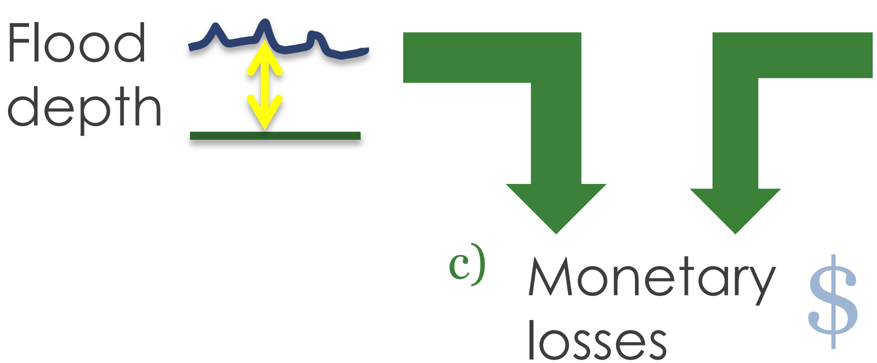


3. CLARA Determines Direct Economic Damage to Physical Assets

- Approach based on FEMA HAZUS
- Project assets at risk
- Estimate monetary damage from floods of a given depth
- Calculate damage using modeled flood depth

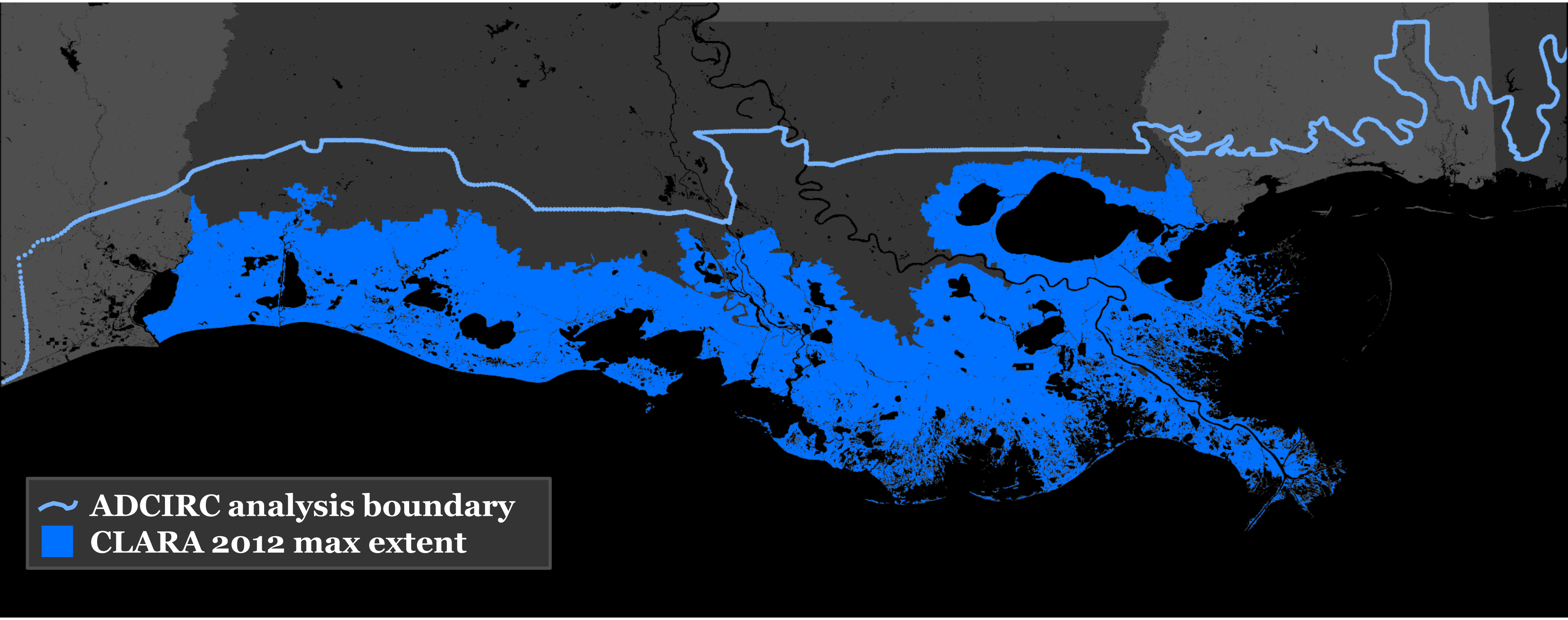
Calculations performed for each grid point



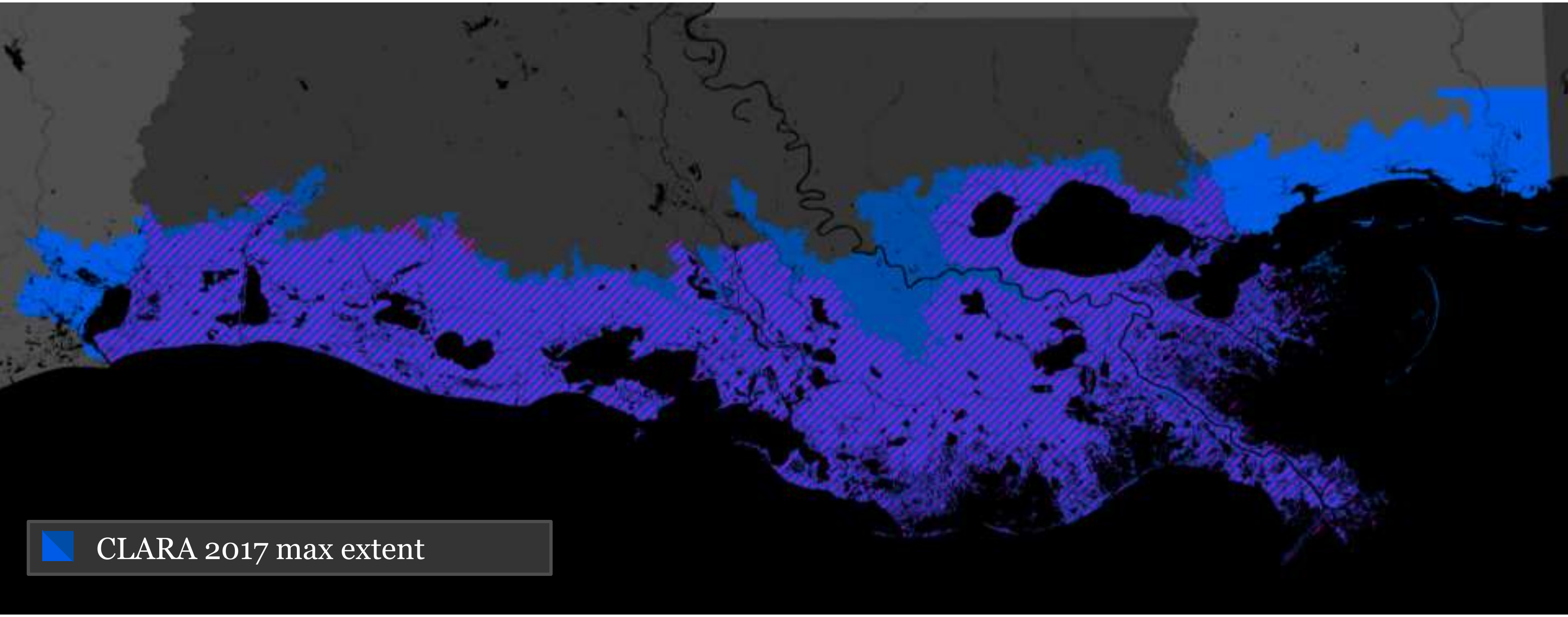


Improvements for the 2017 Coastal Master Plan Analysis

Model Domain Expanded to Account for a Growing Floodplain and Support New Analysis



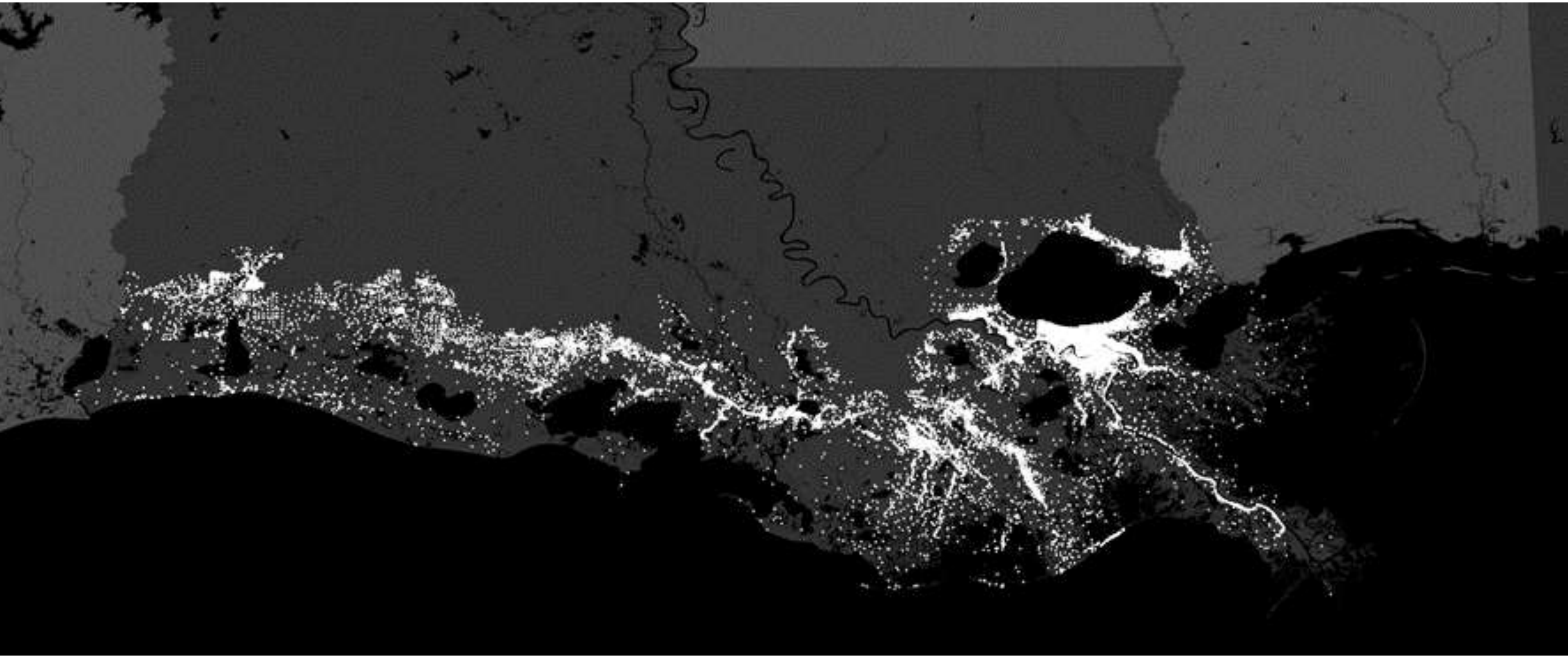
Model Domain Expanded to Account for a Growing Floodplain and Support New Analysis



Developed a New Spatial Grid to Support Higher Resolution Analysis for Coastal Communities

- New grid provides at least 1 km resolution
  - 1 km grid for low-population areas, or
  - 2010 census block centroids for more dense areas
- LandScan population distribution data (~100 m) used to convert from census block populations to grid
  - Nighttime population ~ residential assets
  - Daytime population ~ commercial and industrial assets
- Key assumption: Assets at risk proportional to Landscan population within census blocks

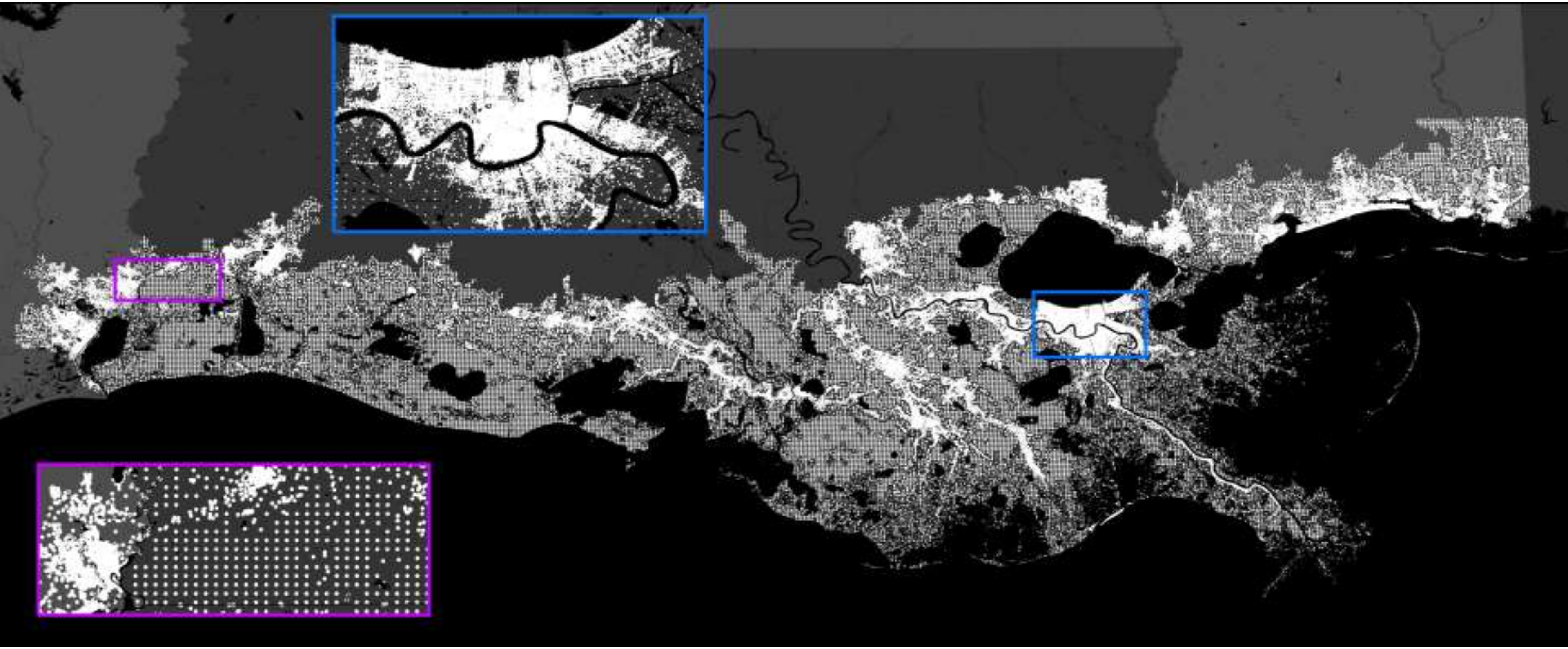
Developed a New Spatial Grid to Support Higher Resolution Analysis for Coastal Communities



- 2000 US Census block

2012 version included approx. 35,000 census block centroids

Developed a New Spatial Grid to Support Higher Resolution Analysis for Coastal Communities

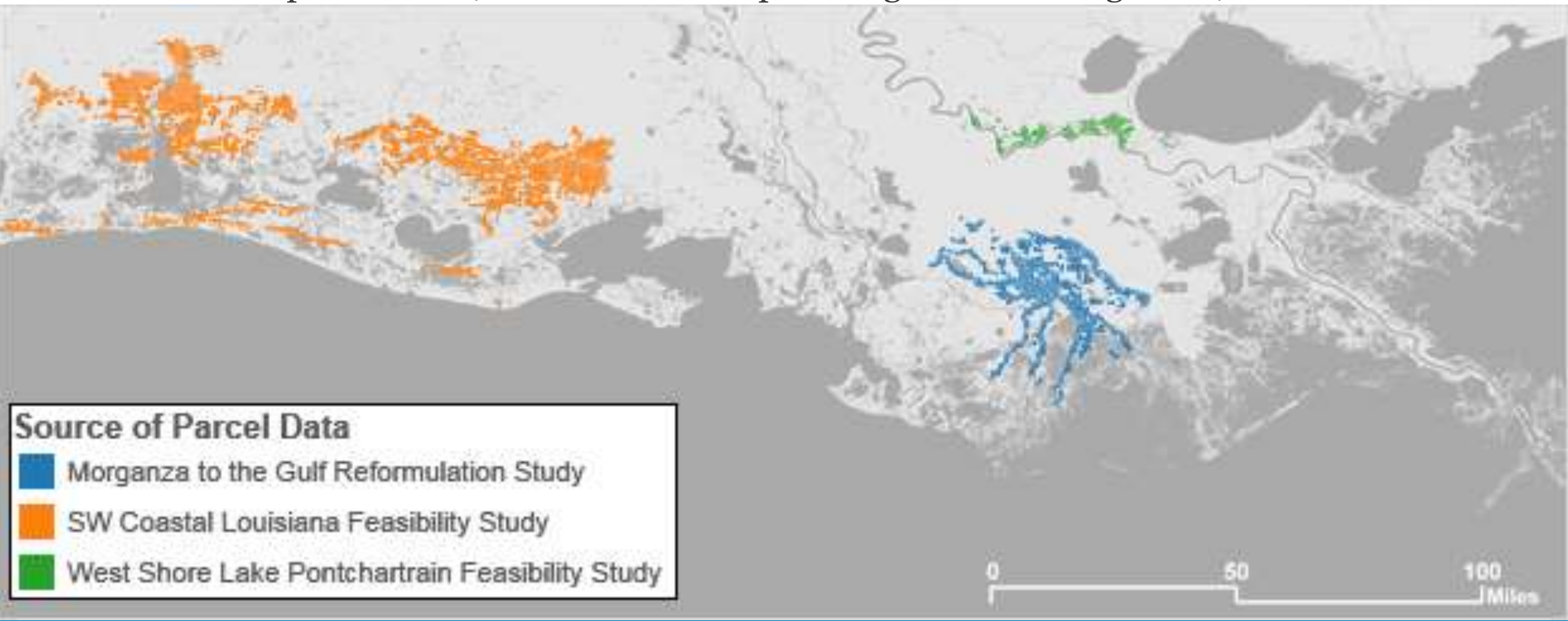


- **CLARA 2017 grid points**

2017 model includes approx. 114,000 grid points (90,000 in Louisiana)

Updated and Improved Database of Assets at Risk

- Added new critical infrastructure classes
- Replaced or augmented existing assets with new information
  - 2010 Census
  - Tax parcel data (source: recent Corps of Engineers investigations)



Incorporated Parametric Uncertainty into Flood Depth Estimates Using Several Methods

Monte Carlo Simulation

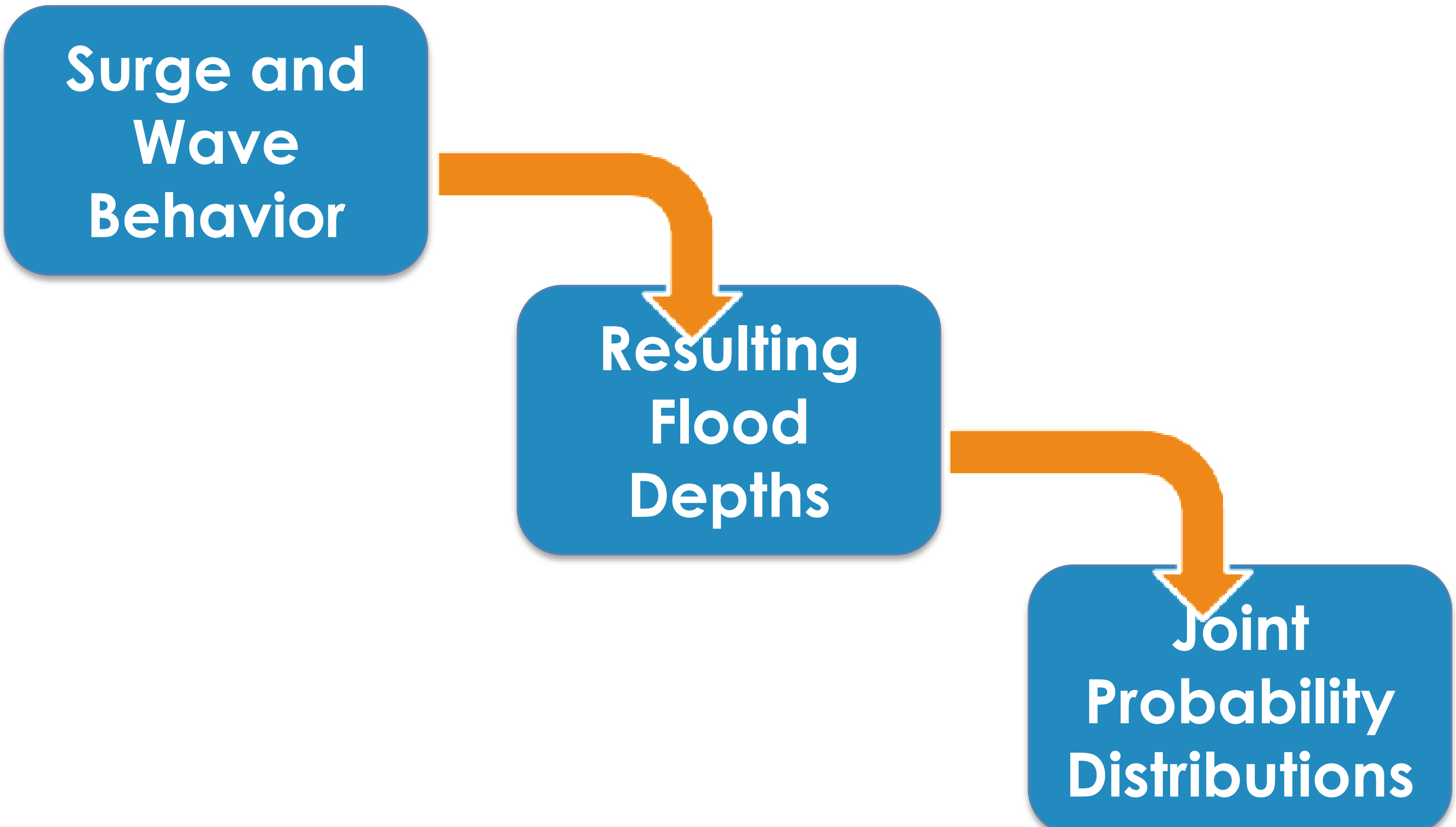
- Flood depths in unenclosed areas
  - Random error in ADCIRC/UnSWAN
  - Uncertainty in the response surface fits
  - Random error in ground elevation estimates
- Flood depths in enclosed areas
  - Uncertainty in the response surface fits on the boundary of the protection system
  - Surge and wave overtopping rates (van der Meer)

Bootstrap Resampling

- Uncertainty in the relative probabilities of each synthetic storm

Uncertainty Propagates Through Each Model Step

Individual Storms   Aggregate Statistics



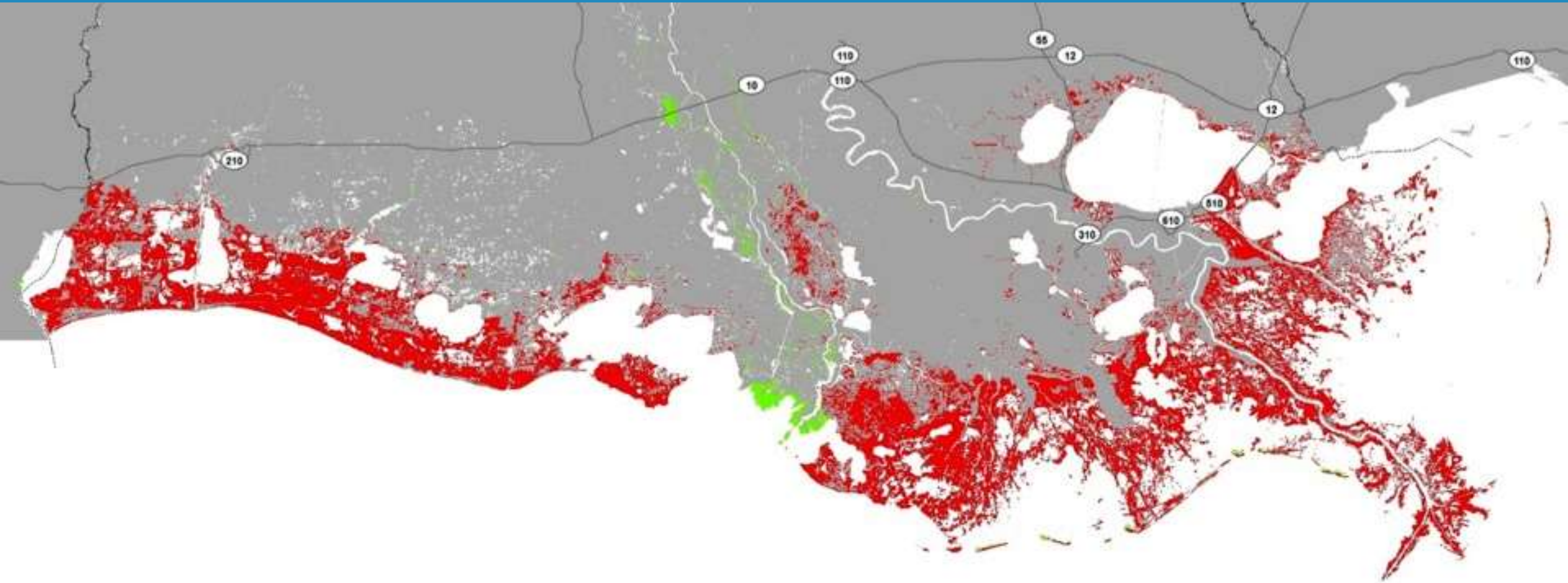
Scenario Uncertainty Approach and Methods Updated for 2017

Levee erosion and failure

- 2012: Used Interagency Performance Evaluation Taskforce (IPET) approach
- 2017: Incorporated multiple Corps of Engineers methods for estimating erosion failure as scenarios

Future 50-year population and asset growth

- 2012: Simple coast wide population growth and urban/rural distribution assumptions
- 2017: Revised approach that considers physical changes over time (flood depth, land loss)



Questions?

Hydrology and Water Quality

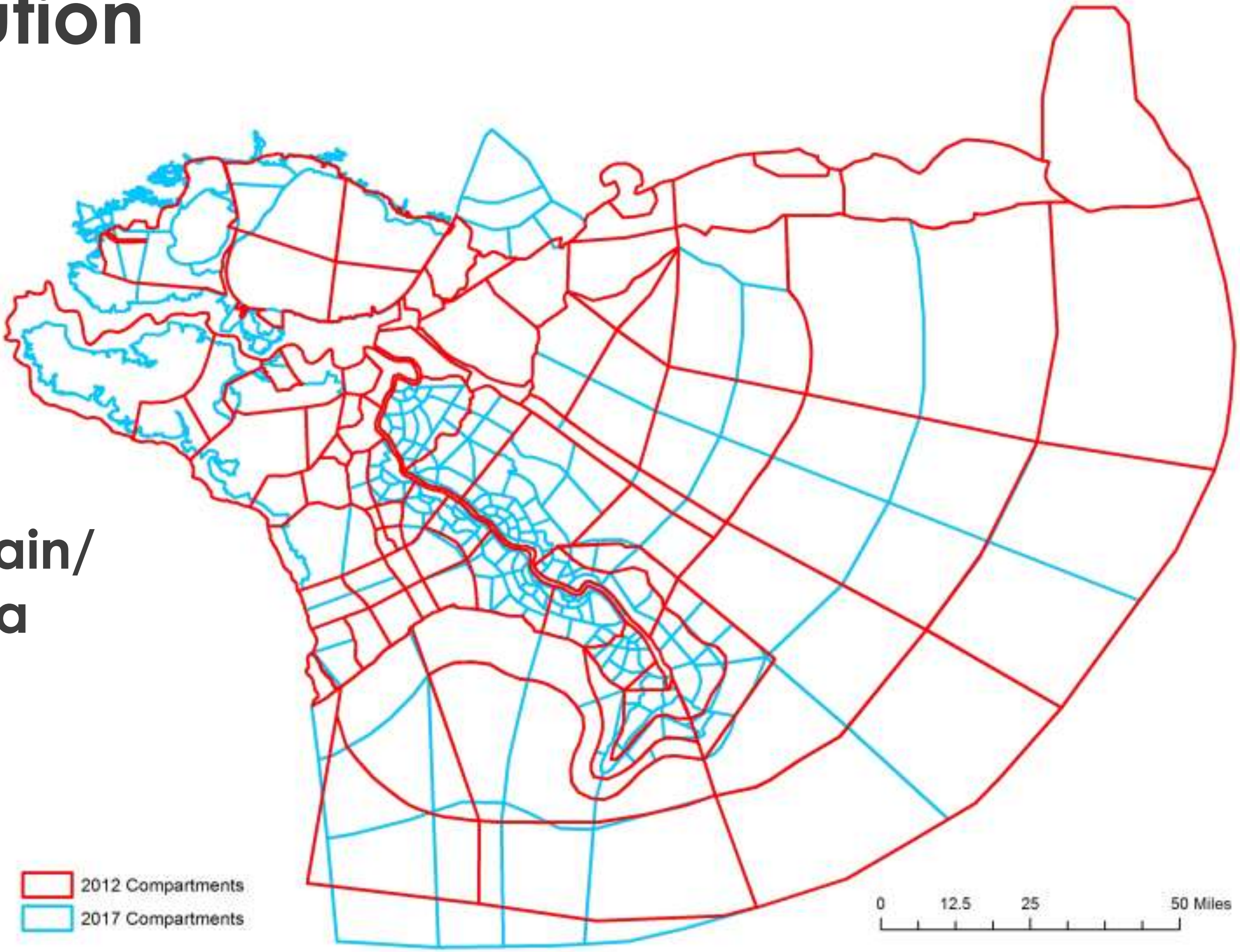
Eric White

Team Members

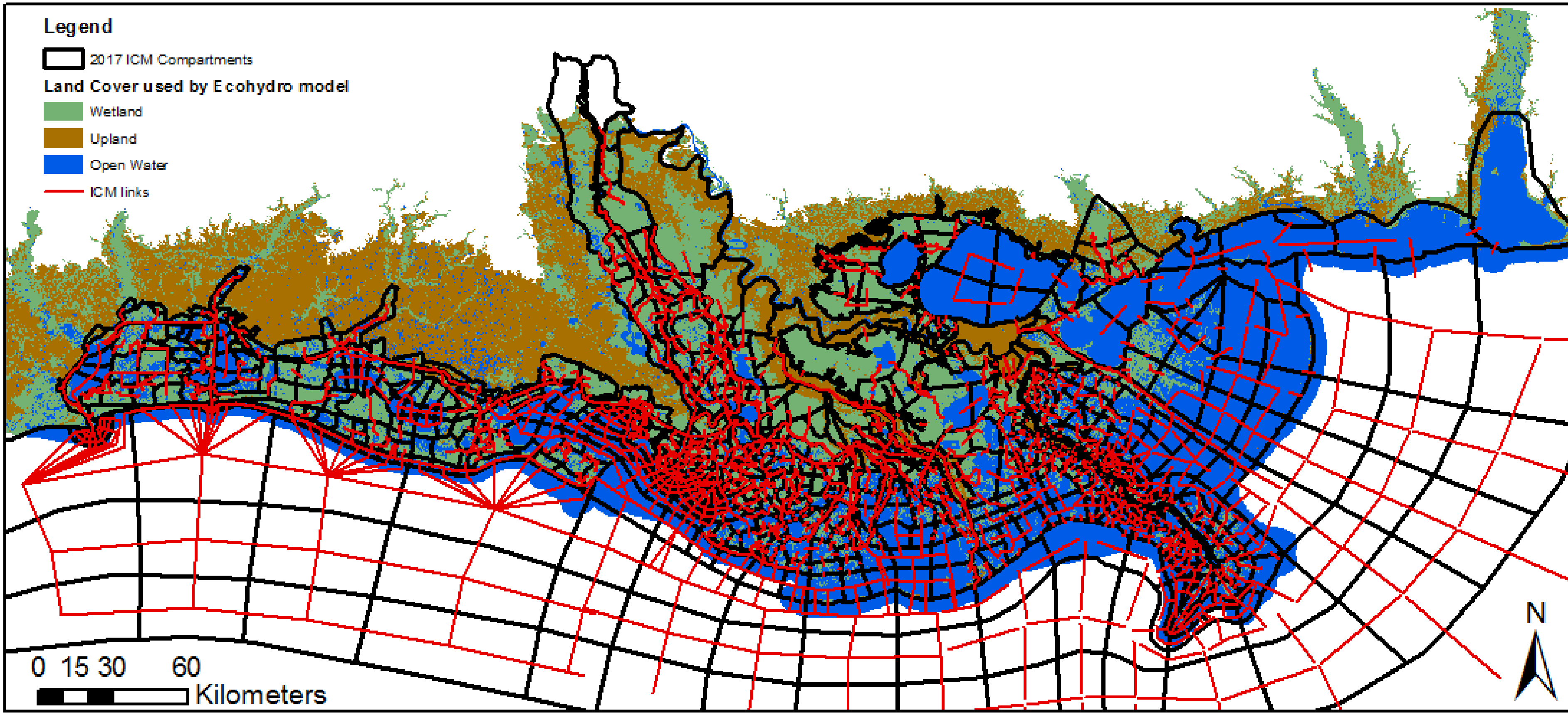
- Eric White
- Alex McCorquodale
- Ehab Meselhe
- Ben Roth
- Jeff Shelden
- Mark Dortch
- Stokka Brown
- Zhanxian Wang
- Mallory Rodrigue
- Jenni Schindler
- Yushi Wang

Improved Hydrology Compartment Resolution

Pontchartrain/ Barataria



ICM Model Hydraulic Link Network

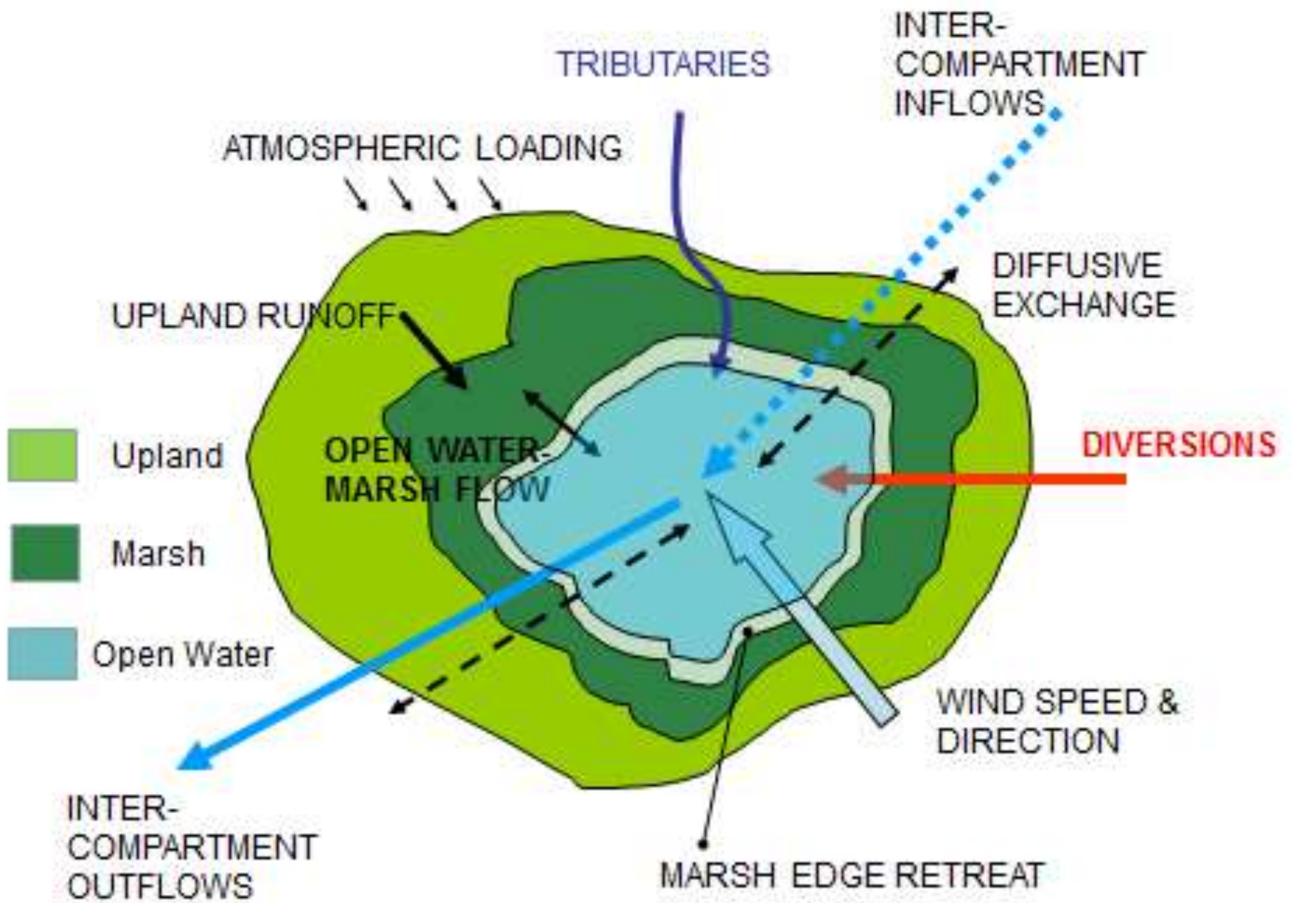


Contains 946 ICM compartments

Hydraulic link types

- Rectangular open channel
- Rectangular open channel with control logic
  - Downstream salinity
  - Differential stage
  - Downstream stage
  - Time of day
  - Observed open/close record
  - Both downstream stage and salinity
- Bridge/culverts
- Weirs
- Tide gates/orifices
- Pumps (pump rate assigned based on upstream drainage area/rainfall rate)
- Overland flow links
  - Marsh flow connection
  - Ridge/levee barriers

Hydrologic Compartment Layout



Sediment Distribution

- Mass balance on each hydro compartment on:
  - Mass in
    - Flows
    - Marsh edge erosion sediment load
  - Mass out
    - Flows
    - Marsh surface deposition
  - Resuspension of bed material
    - Critical shear stresses calculated from flow & wave velocities
    - Separate routines for cohesive (silt & clay) and sand particles
  - Deposition of bed material
    - Settling velocities calculated for particle class
    - Flocculation of clay
- Non-uniform deposition in marsh; particles with higher fall-velocities deposit in near-edge zone (30 m)
- Procedure for sediment deposition and resuspension, also applied during storm events

Model Calibration and Validation

- Calibration Period: 2010-2013
- Validation Period: 2006-2009

Hydrology

- Mean water level (daily & monthly comparisons): ~200 CRMS and USGS stations
- Mean flowrate: Limited USGS data
- Mean salinity (daily & monthly comparisons): ~180 CRMS and USGS stations

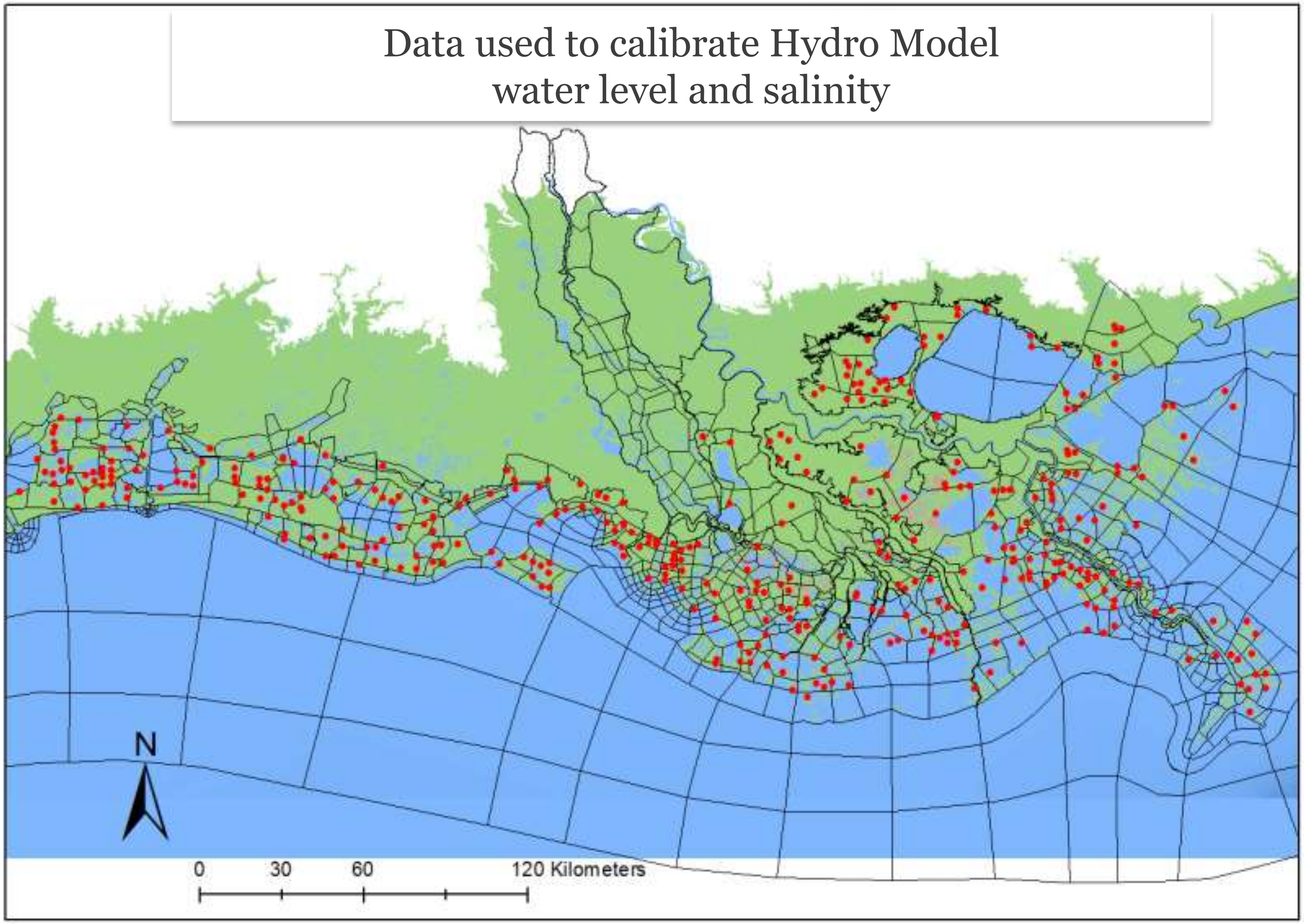
Water Quality

- Mean water quality concentrations: ~200 LDEQ stations used
  - Salinity, water temperature, nitrate+nitrite, ammonium nitrogen, total inorganic phosphorus, dissolved organic phosphorus, dissolved organic nitrogen, blue-green algae, and detritus.
  - Limited input data available as timeseries
    - Long term monthly mean values are used to define input concentrations
    - Model-wise monthly averages are used when no data is available

Suspended Sediment

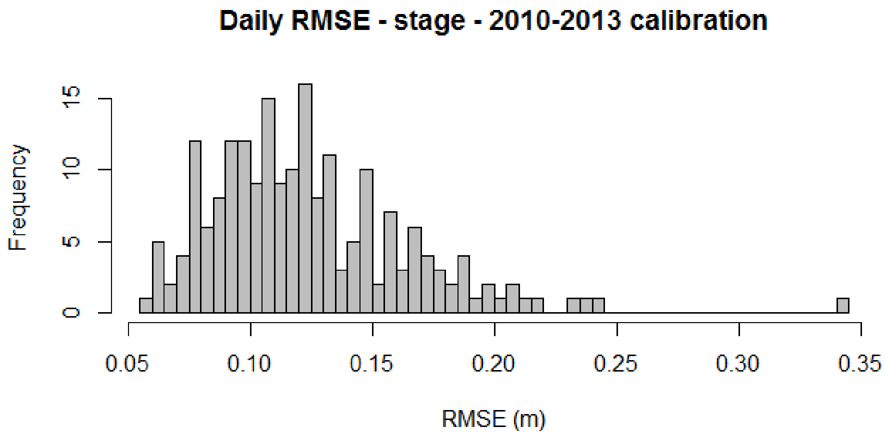
- Mean annual total suspended sediment concentration: 166 observation stations
  - Limited data available (all discrete samples); Morphology model's accretion patterns used to fine-tune sediment distribution deposition and resuspension parameters

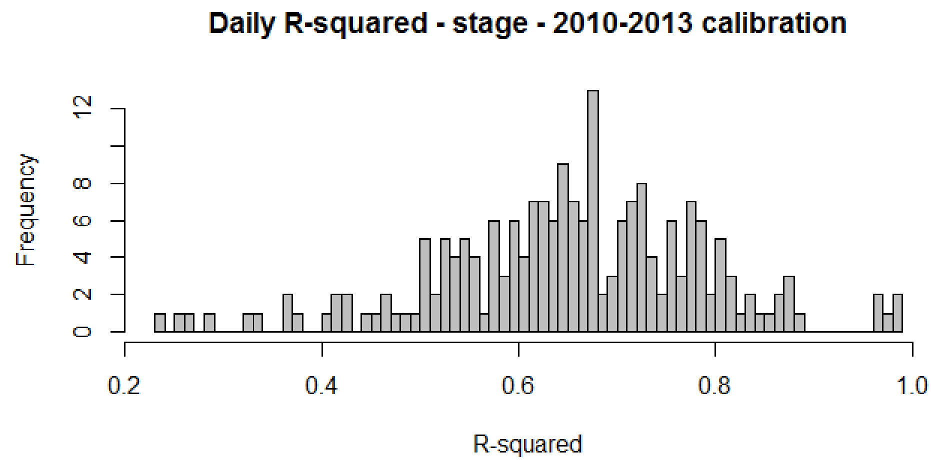
2017 Coastal Master Plan Integrated Compartment Model Coastwide Reference Monitoring System (CRMS)

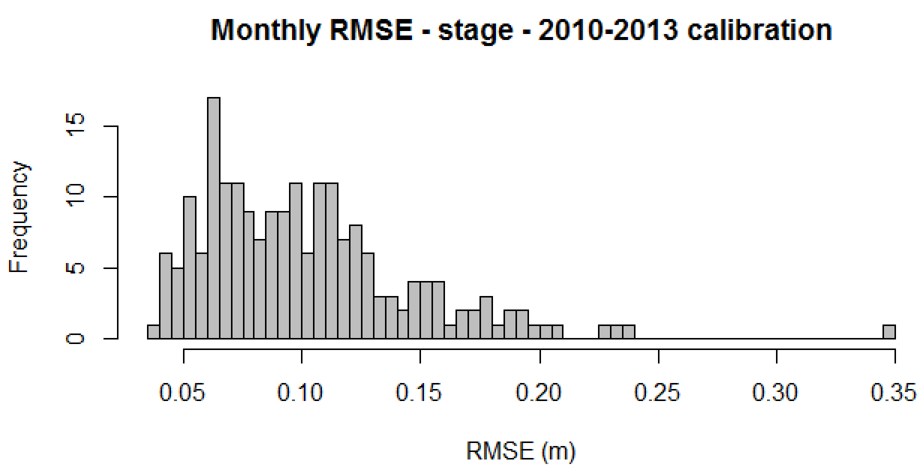


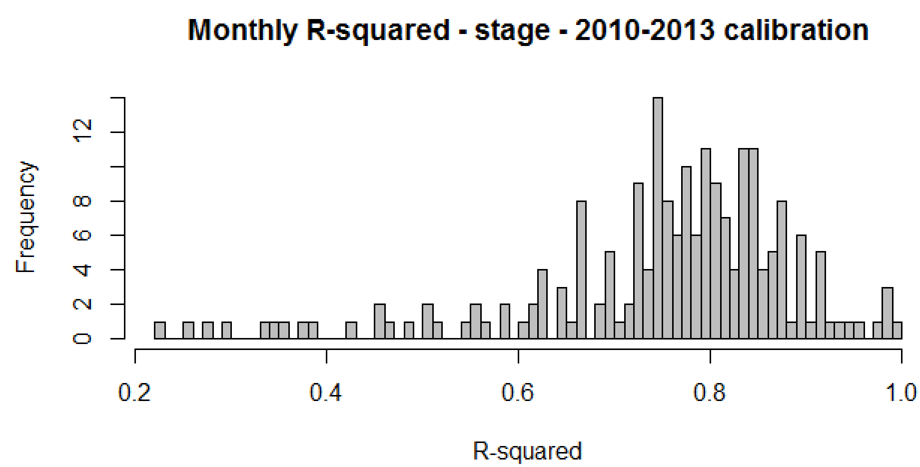
Stage Calibration – 201 sites

	Bias (m)	Monthly RMSE (m)	Monthly R^2	Daily RMSE (m)	Daily R^2
mean	0.00	0.10	0.75	0.12	0.65
stdev	0.08	0.05	0.14	0.04	0.14
min	-0.31	0.04	0.23	0.06	0.24
max	0.22	0.35	0.99	0.34	0.99

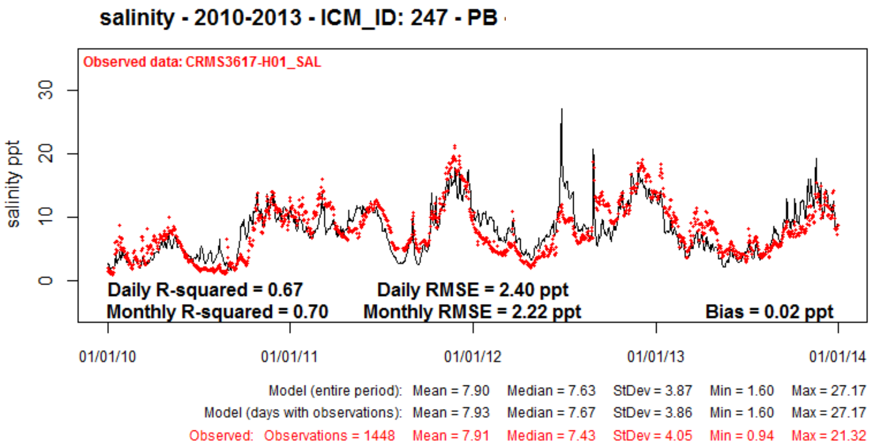


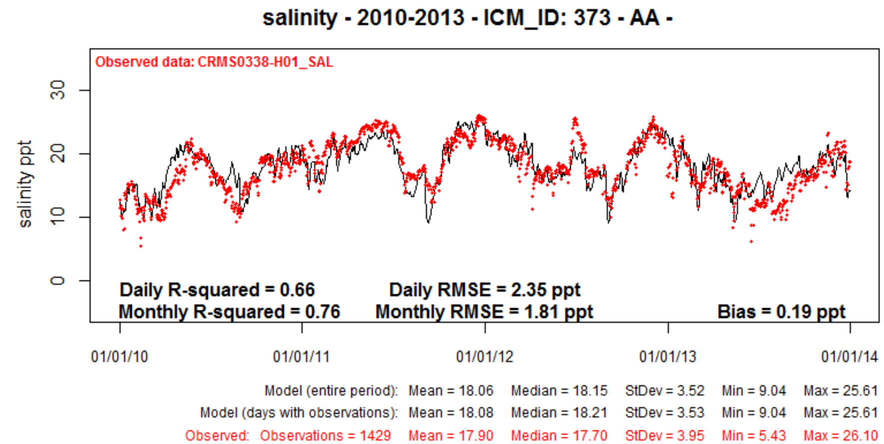


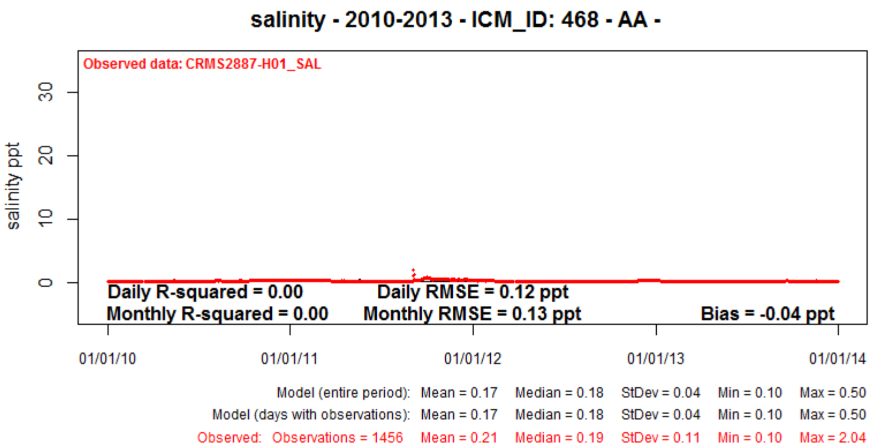


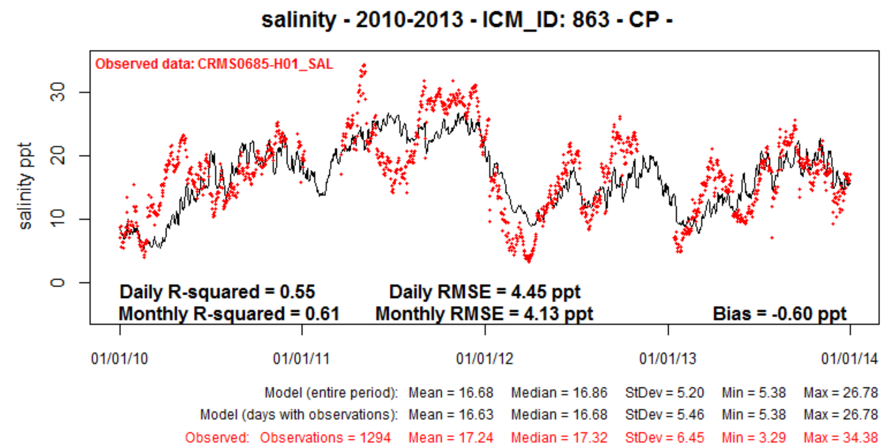


Salinity Calibration Example

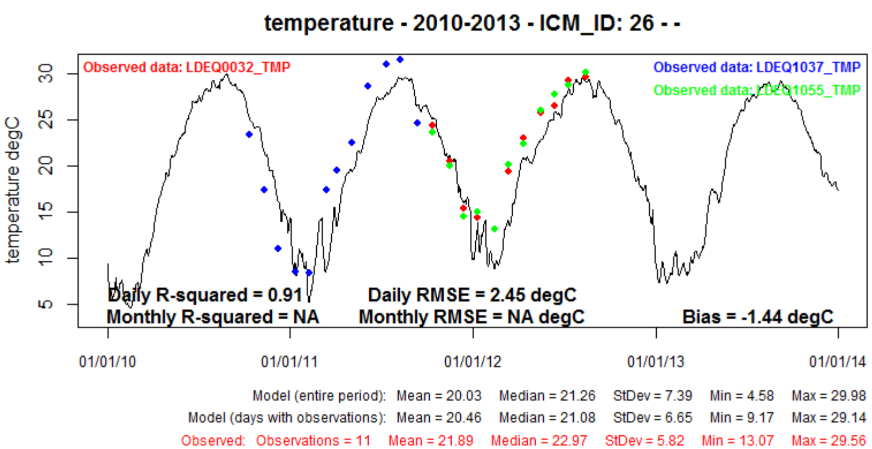


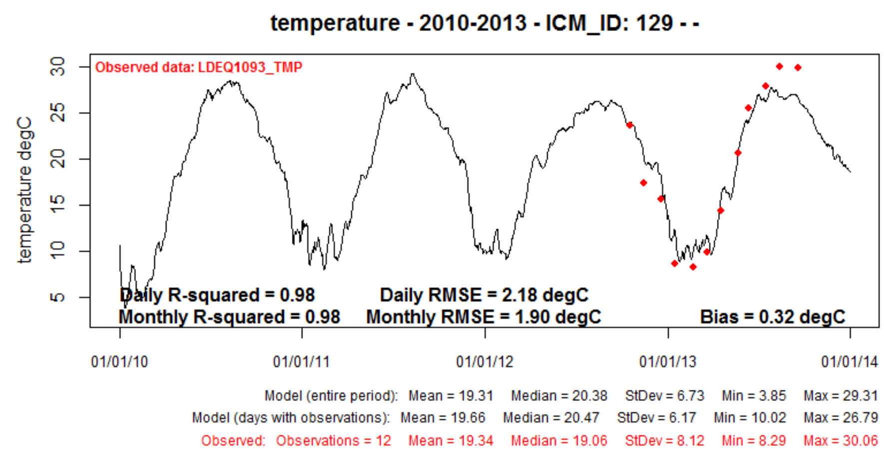


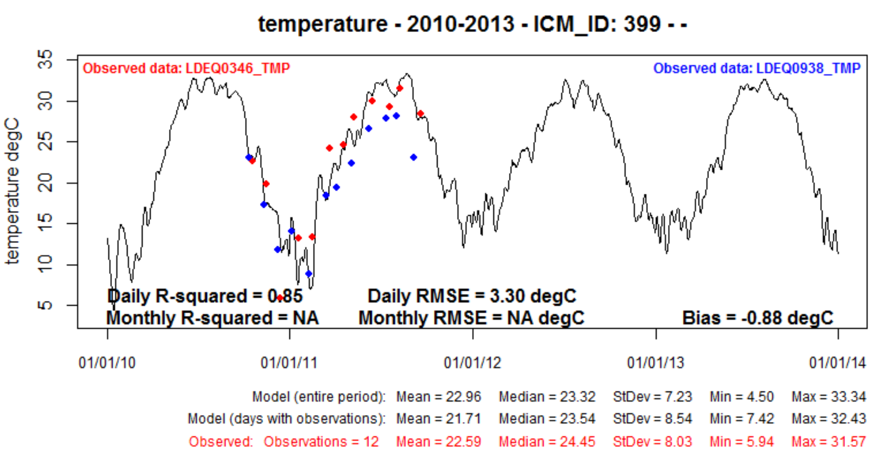


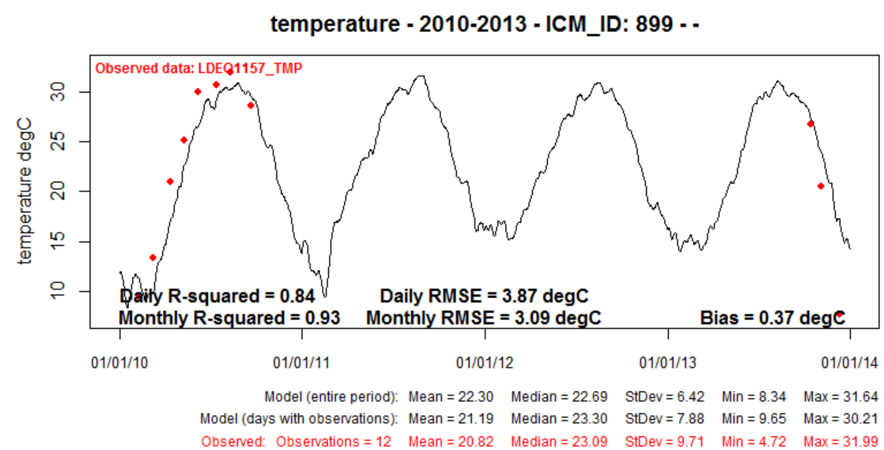


Temperature Calibration Example

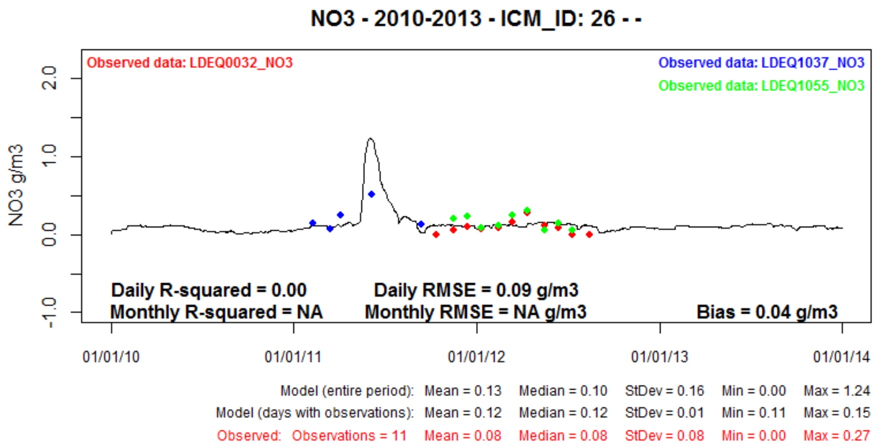


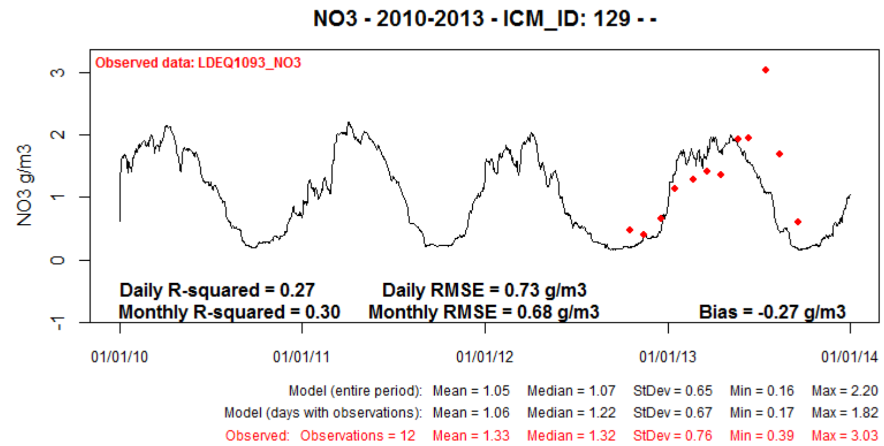


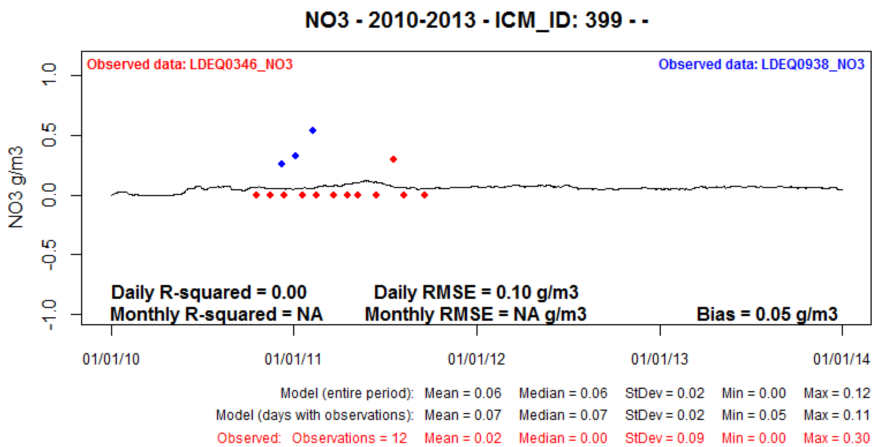


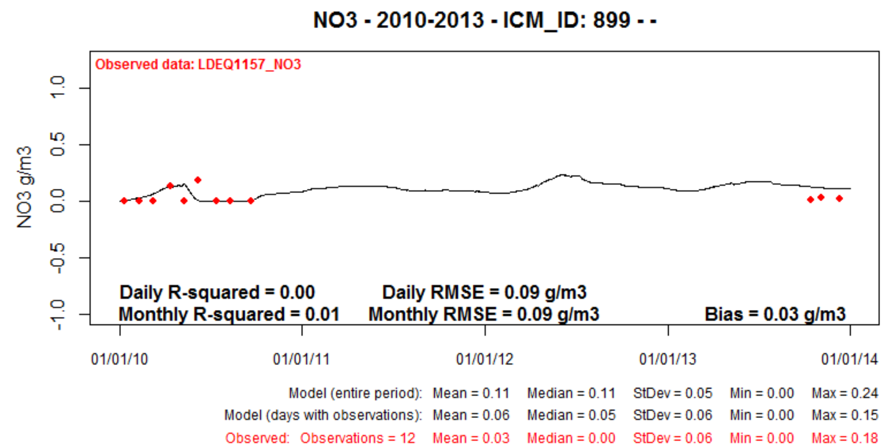


Nitrate+Nitrite Calibration Example

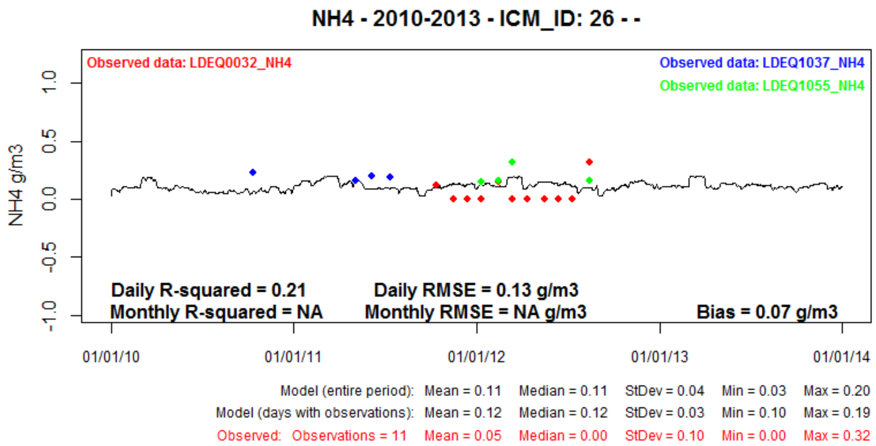


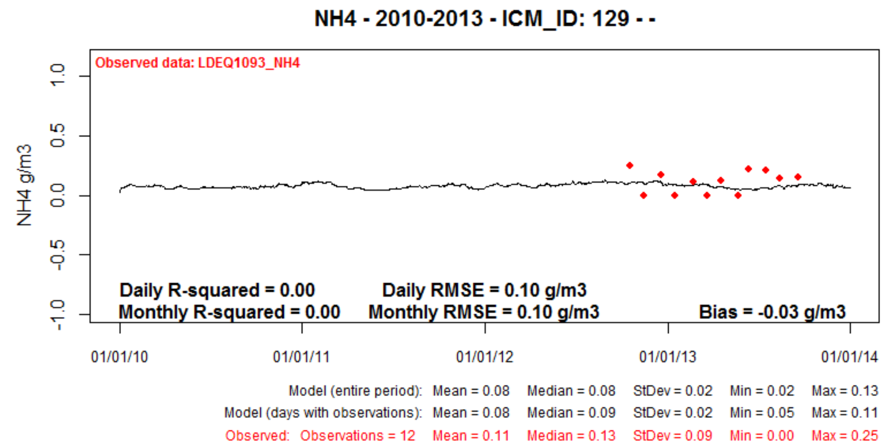


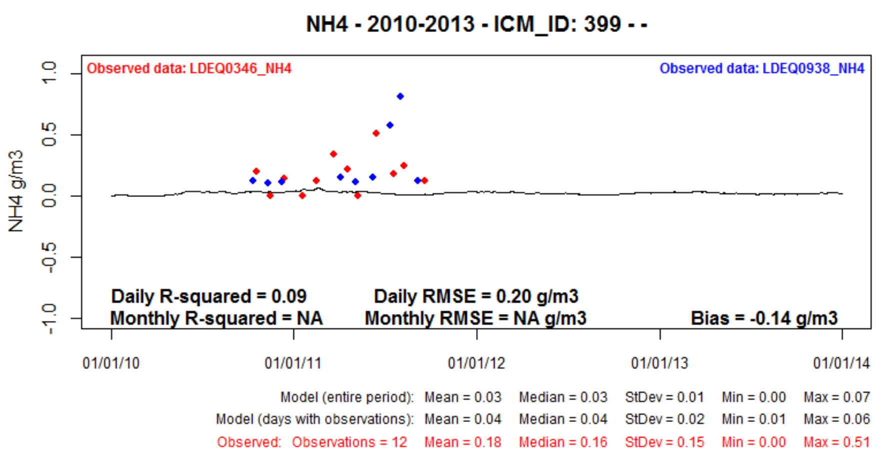


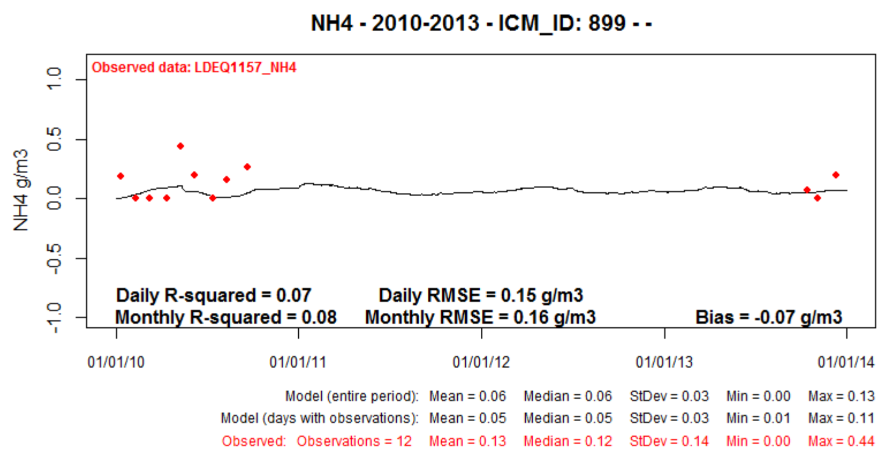


Ammonium Calibration Example

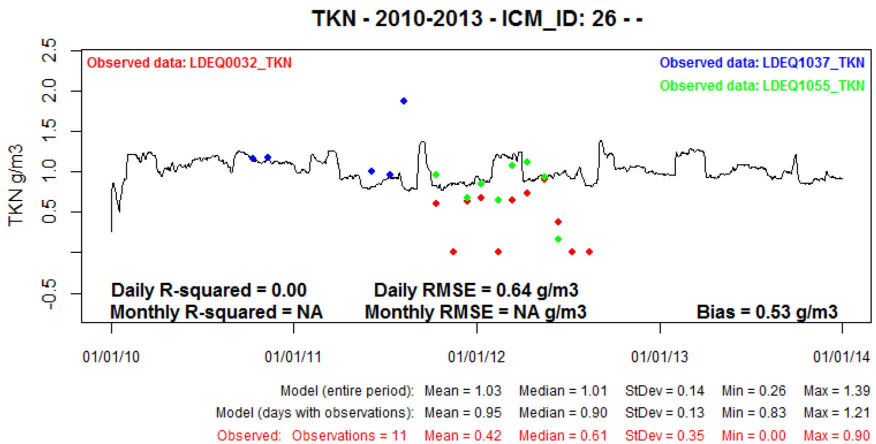


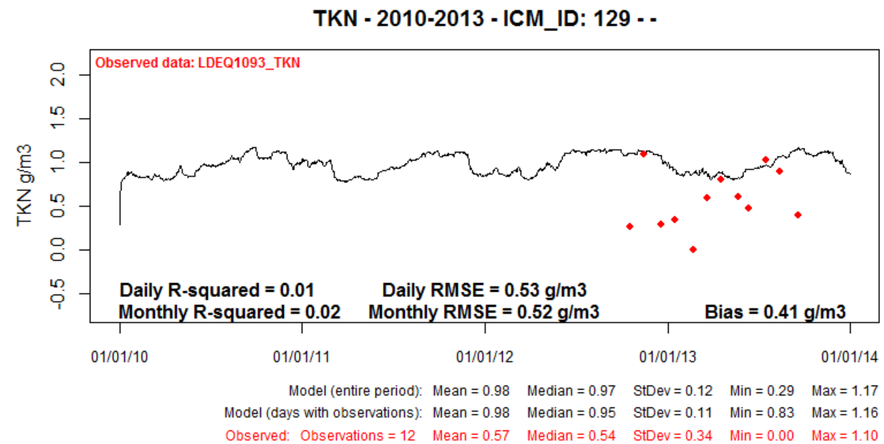


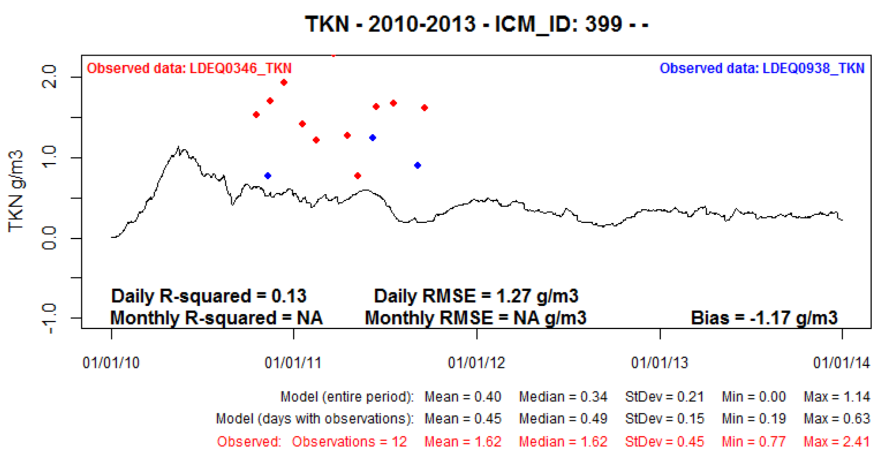


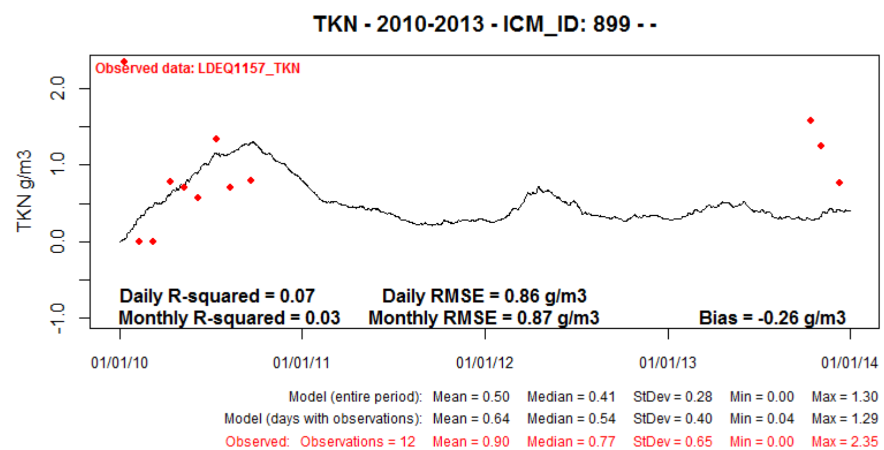


Total Kjeldahl Nitrogen Calibration Example

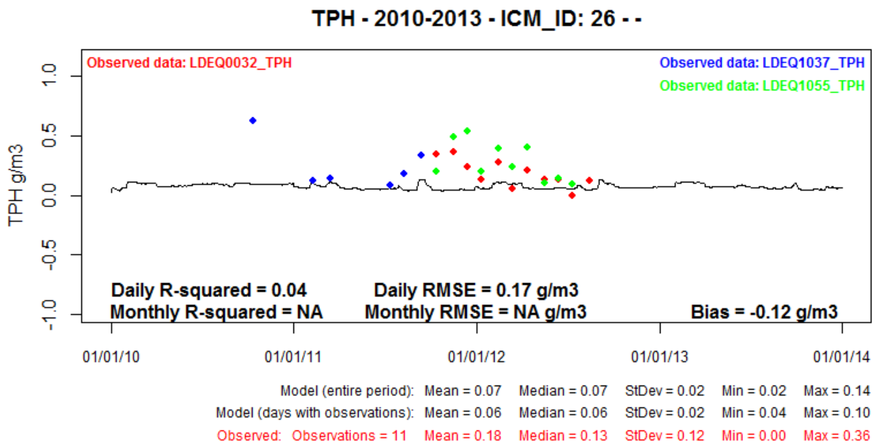


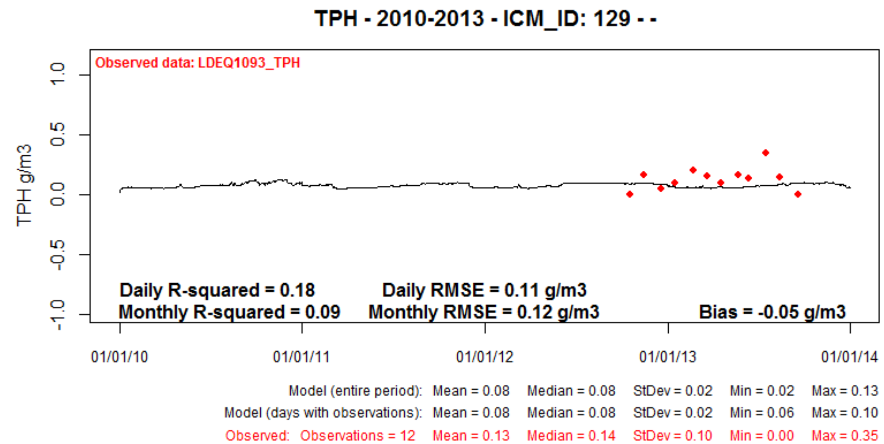


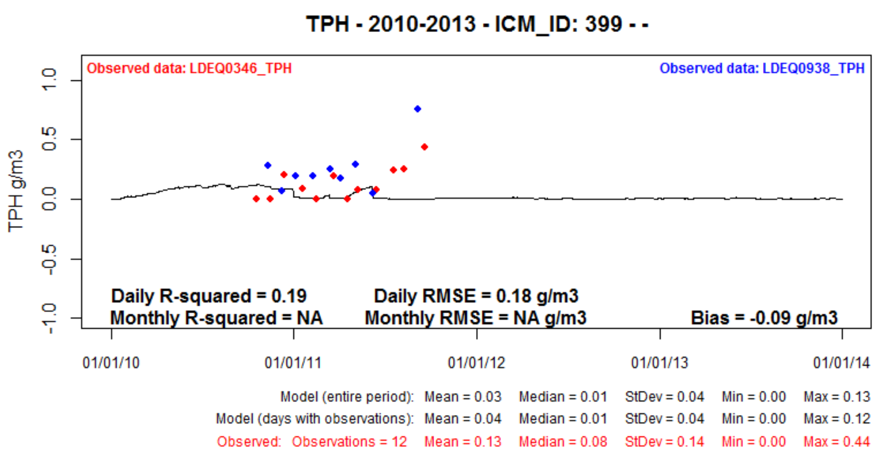


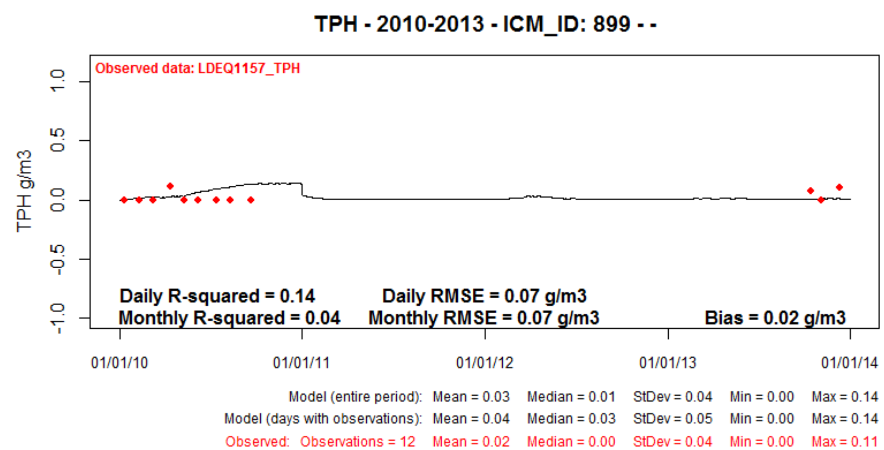


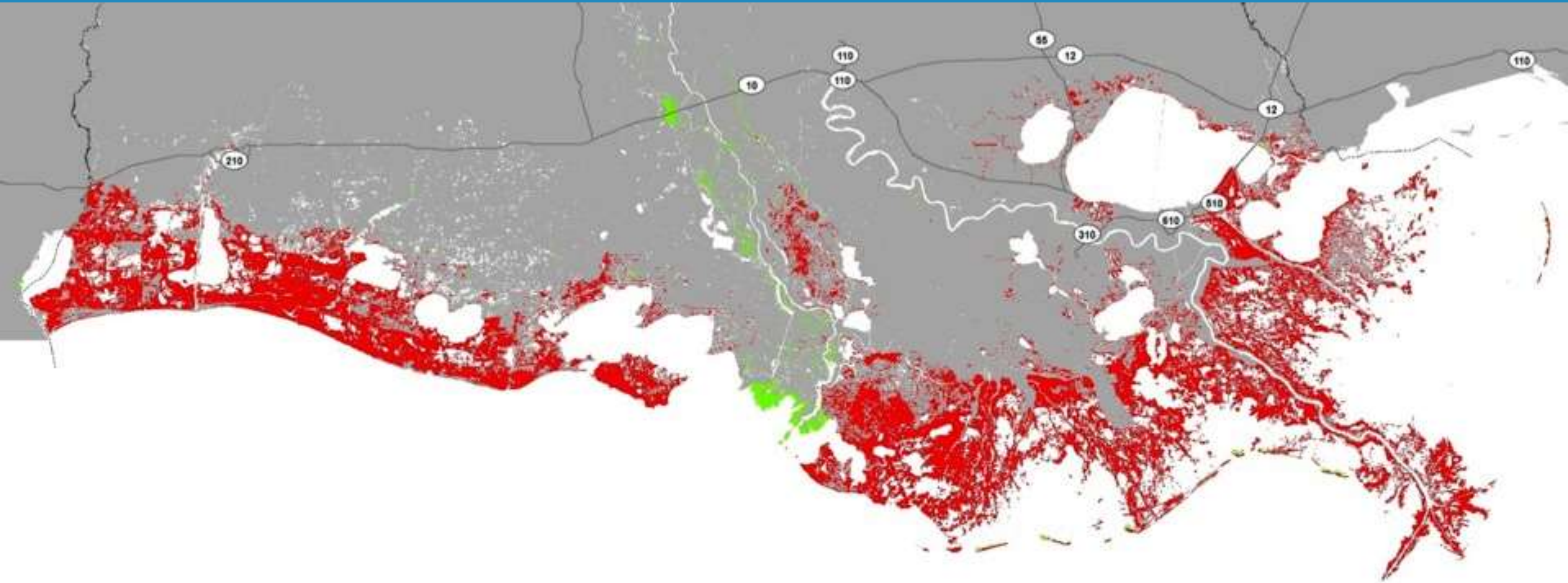
Total Phosphorus Calibration Example











Questions?

Wetland Morphology

Brady Couvillion

Team Members

- Brady Couvillion
- Gregg Snedden
- Hongqing Wang
- Holly Beck
- Bill Sleavin

Model Overview

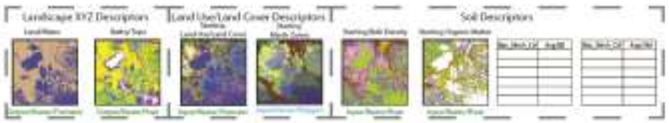
- The wetland morphology model tracks relative elevation change as a result of subsidence, sea level rise (SLR) and accretion, along with salinities from the eco-hydrology model to assess changes in wetland area.
- Therefore, the fate of a particular area is partly determined by its ability to maintain or build to an elevation (relative to water level) suitable for wetland establishment or persistence in the face of subsidence and Eustatic Sea Level Rise (ESLR).

$$E_{t2} = E_{t1} + H - S, \qquad (3)$$

where E_{t2} is the adjusted surface elevation (m NAVD88); E_{t1} is the starting surface elevation (m NAVD88); H is the vertical accretion, as defined in Equation 1 (converted to m and summed over the $t_1 - t_2$ time period); and S is subsidence (m).

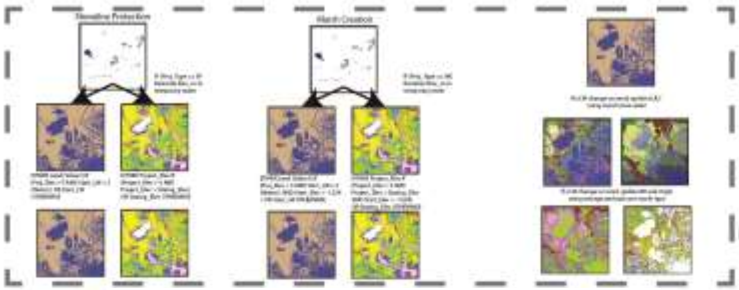
Wetland Morphology Model Conceptual Diagram

Primary Intitialization Inputs



Input from Hydrology Subroutine

Incorporate Projects



Accretion Calculations

t1 Elevation | Starting Bulk Density | Starting Organic Matter | Subsidence

$$H = \frac{Q_{sed} + Q_{org}}{10,000 \times BD}, \qquad (1)$$

where H is the rate of vertical accretion (cm/y), Q_{sed} is mineral sediment accumulation rates (g/m²/y) forecasted by the ecohydrology model (Meselhe *et al.*, 2013), Q_{org} is organic matter accumulation rates (g/m²/y), the constant 10,000 is a conversion factor from cm² to m², and BD is soil bulk density (g/cm³).

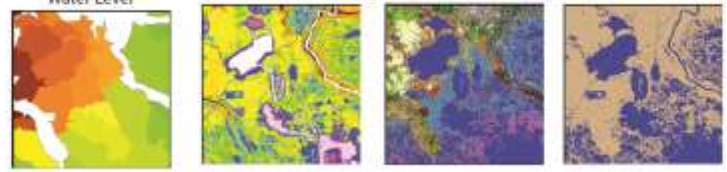
Relative Elevation Model - Elevation Change subroutine

$$E_{t2} = E_{t1} + H - S, \qquad (3)$$

where E_{t2} is the adjusted surface elevation (m NAVD88); E_{t1} is the starting surface elevation (m NAVD88); H is the vertical accretion, as defined in Equation 1 (converted to m and summed over the $t_1 - t_2$ time period); and S is subsidence (m).

Relative Elevation Model - Elevation Change subroutine (cont.)

t2 Mean Water Level | t2 temp Relative Elevation | t2 temp Land Cover | t2 temp Land_Water

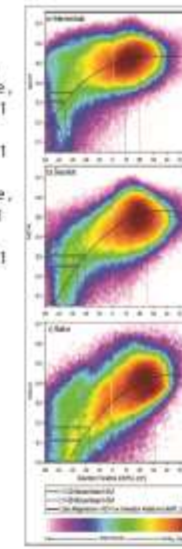


CONDITIONAL ((IF starting_lw == 0) No Change ,
(IF t+1 Land/Water == 1 AND Starting_mean_water_level_meters == 0) No Change ,
(IF t+1 Land/Water == 2 AND Relative Elevation t+1 <= MWL t+1) No Change ,
(IF t+1 Land/Water == 2 AND Starting_mean_water_level_meters == 0) No Change ,

Marsh Collapse - Salinity Stress
(IF t+1 Land/Water == 1 AND LULC Recode == 1 AND Salinity t+1 <= 5.5) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 1 AND Salinity t+1 > 5.5 AND MWL t+1 < Relative Elevation t+1) No Change,
(IF t+1 Land/Water == 1 AND LULC Recode == 1 AND Salinity t+1 > 5.5 AND MWL t+1 >= Relative Elevation t+1) Change to Water ,
(IF t+1 Land/Water == 1 AND LULC Recode == 2 AND Salinity t+1 <= 7.0) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 2 AND Salinity t+1 > 7.0 AND MWL t+1 < Relative Elevation t+1) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 2 AND Salinity t+1 > 7.0 AND MWL t+1 >= Relative Elevation t+1) Change to Water ,

Marsh Collapse - Inundation Stress
(IF t+1 Land/Water == 1 AND LULC Recode == 3 AND (MWL t+1-0.3436) <= Relative Elevation t+1) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 3 AND (MWL t+1-0.3436) > Relative Elevation t+1) Change to Water ,
(IF t+1 Land/Water == 1 AND LULC Recode == 4 AND (MWL t+1-0.2278) <= Relative Elevation t+1) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 4 AND (MWL t+1-0.2278) > Relative Elevation t+1) Change to Water ,
(IF t+1 Land/Water == 1 AND LULC Recode == 5 AND (MWL t+1-0.2050) <= Relative Elevation t+1) No Change ,
(IF t+1 Land/Water == 1 AND LULC Recode == 5 AND (MWL t+1-0.2050) > Relative Elevation t+1) Change to Water ,

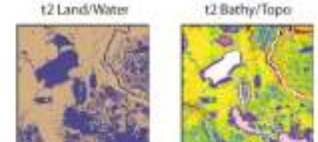
Land Building
(IF t+1 Land/Water == 2 AND Relative Elevation t+1 > (MWL t+1 + 0.2)) Change to Land



Marsh Edge Erosion

Output t2 Landscape XYZ Descriptors

t2 Land/Water | t2 Bathy/Topo



Datasets

- The baseline datasets upon which the model is calibrated, validated, and initialized were updated.
  - The 2012 models were initialized with datasets from a circa 2010 base period.
  - The coastal landscape has changed from 2010 due to ongoing coastal process such as wetland loss, gain and coastal restoration and protection efforts.
  - Several input datasets were updated to reflect a 2014 starting period.
    - Land/Water
    - Bathymetry/Topography
    - Land Cover

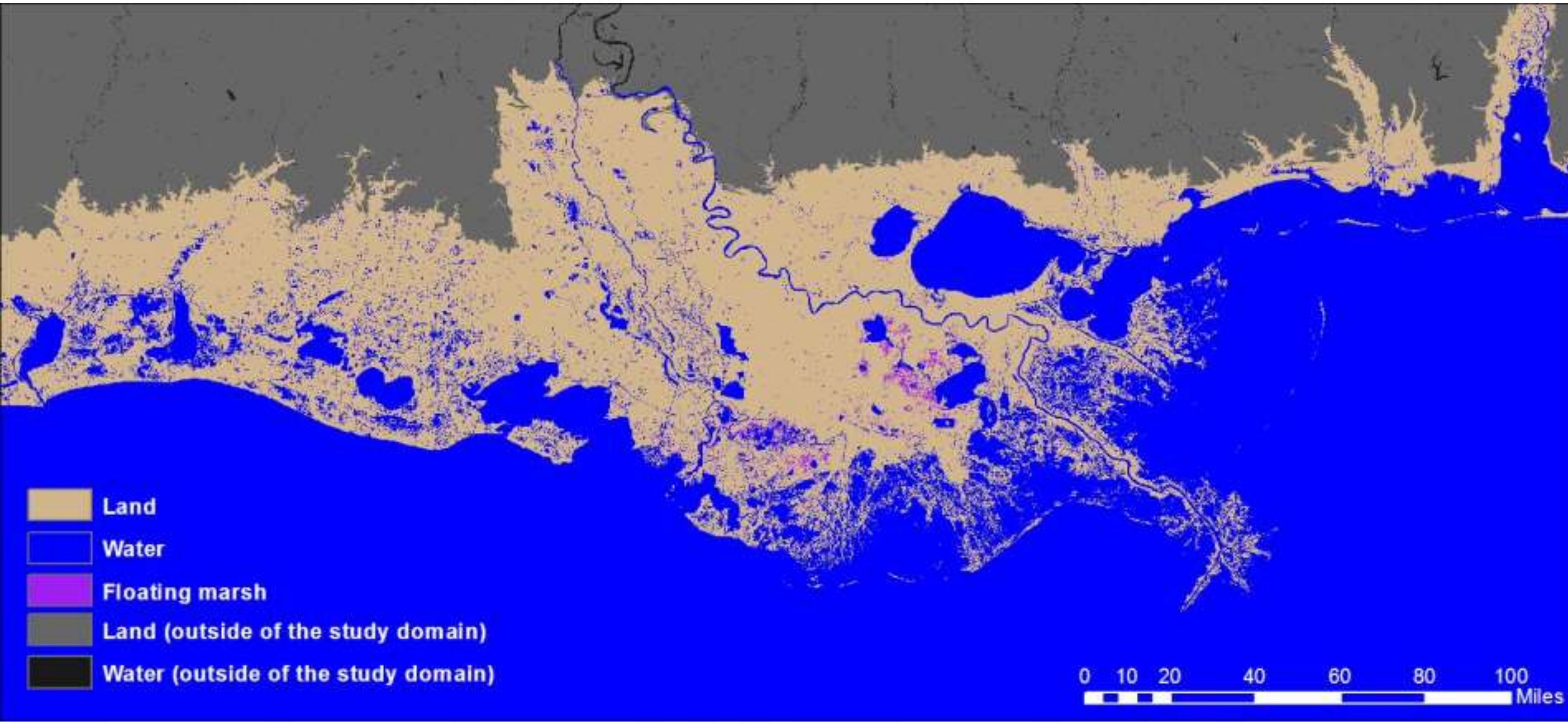
Sediment Distribution

- In 2012, a single sediment accumulation value was calculated for each compartment.
  - Sediment was distributed within a compartment based on a sediment distribution probability surface.
  - Based upon weighting factors such as distance from sediment source, frequency of inundation and distance from edge.
- For 2017, sediment accumulation will be calculated in three distinct zones; marsh edge, interior marsh, and open water.

Marsh Edge Erosion

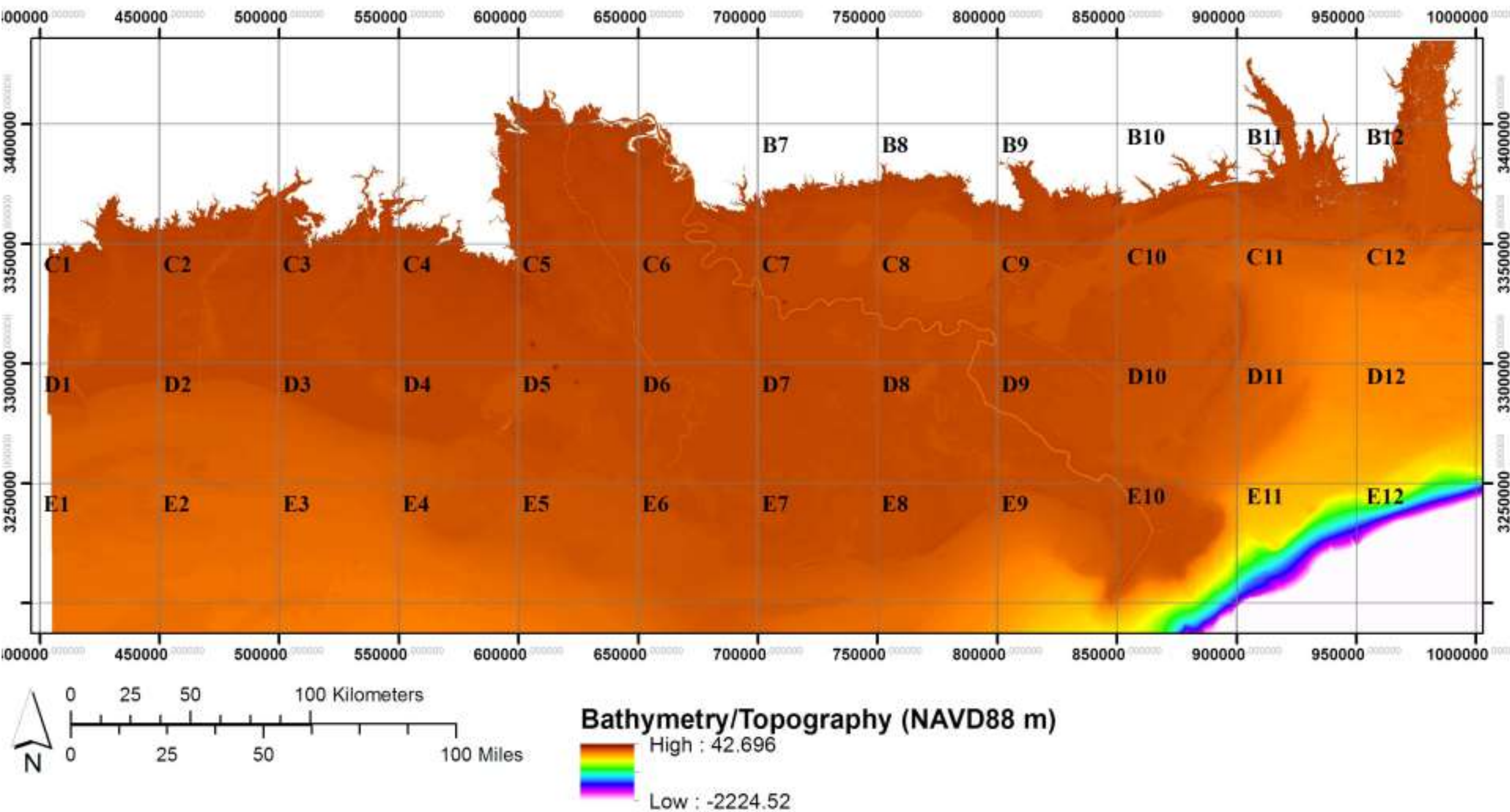
- In 2012, marsh edge erosion was not directly calculated.
  - It was rather incorporated through the use of historical land change rates.
  - Losses due to marsh edge erosion were forced upon the landscape through the use of an erosion probability surface and a background land change incorporation sub-model.
- For the 2017 effort, spatially variable marsh edge erosion rates were calculated during a 2004-2012 observation period.
- Model code calculates the number of pixels of shoreline eroded for any given modeling period based upon these historical rates.

Key Input Datasets

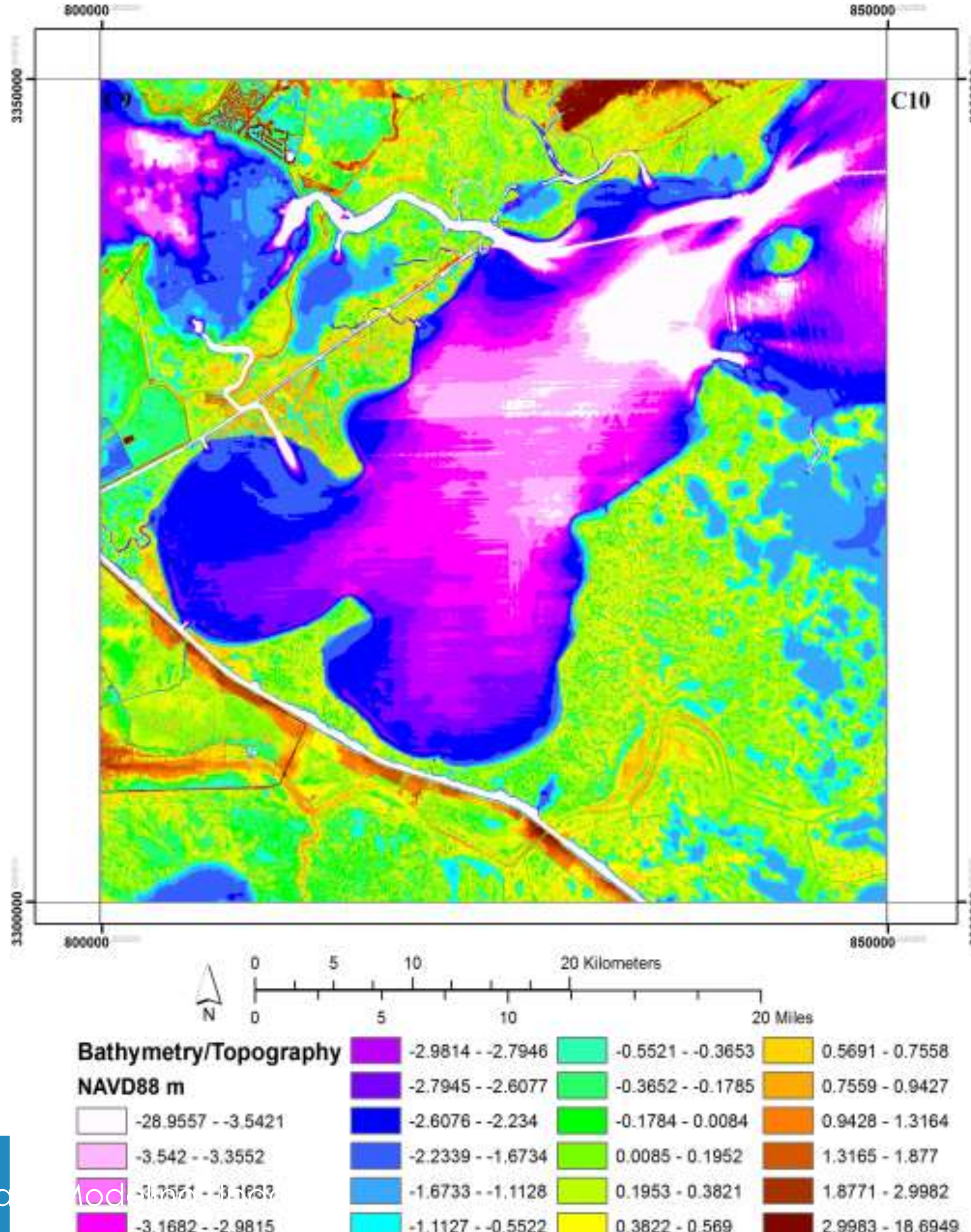


Key Input Datasets

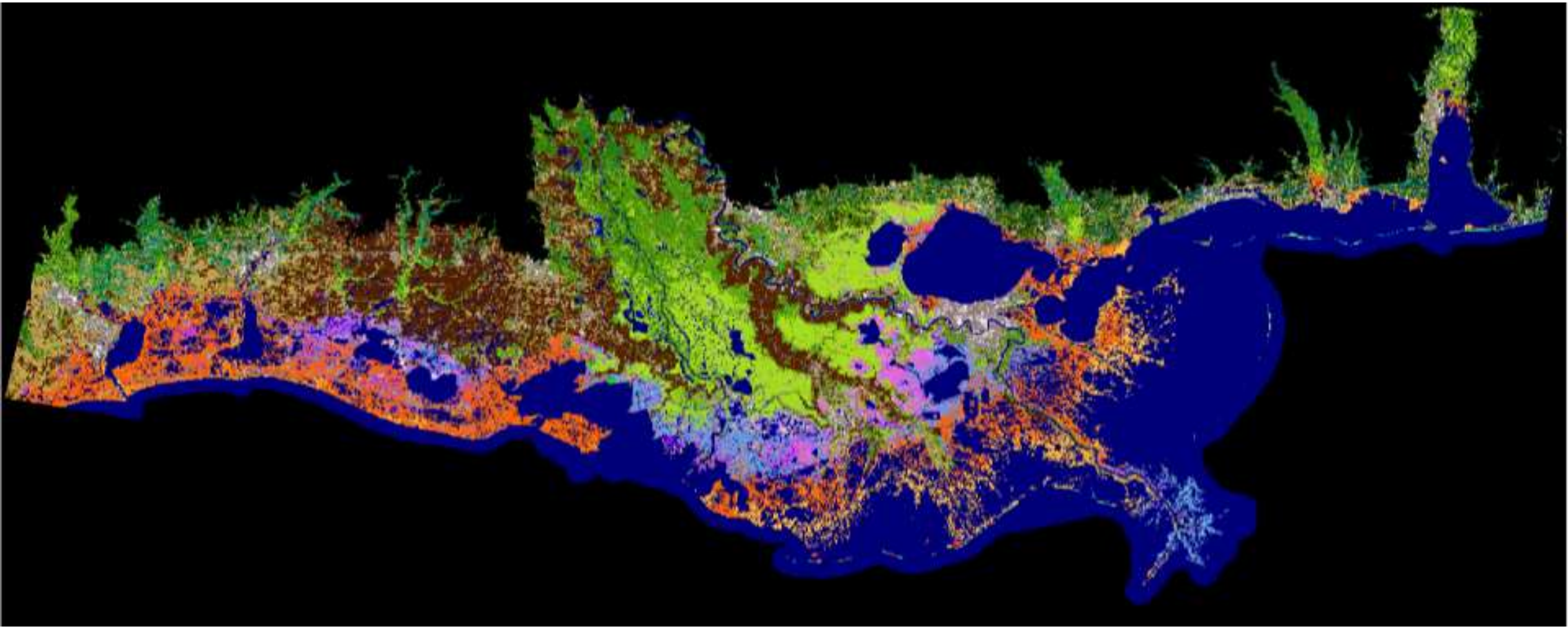
2017 Master Plan: Integrated Bathymetry/Topography Base Condition



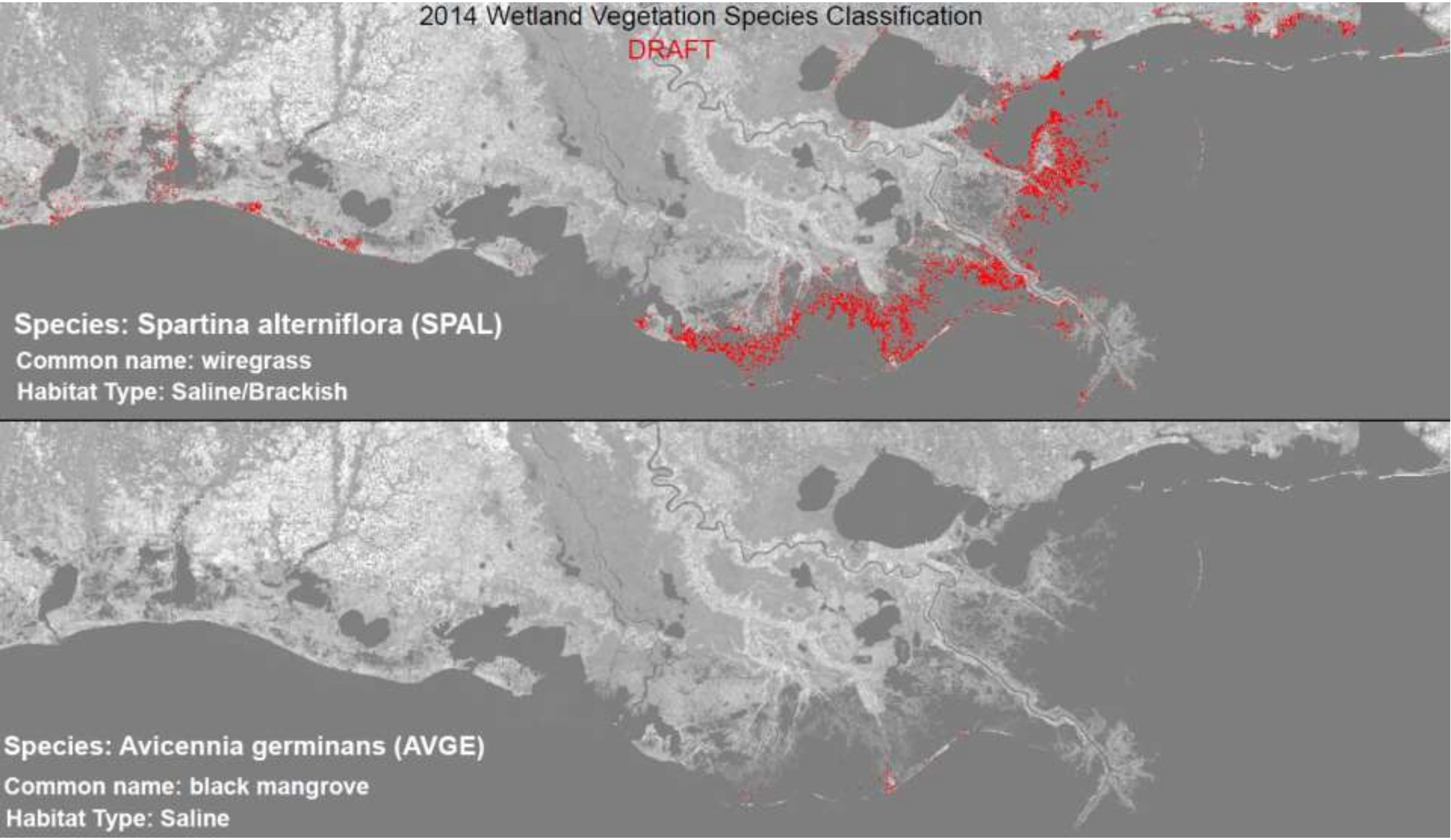
Key Input Datasets



Key Input Datasets



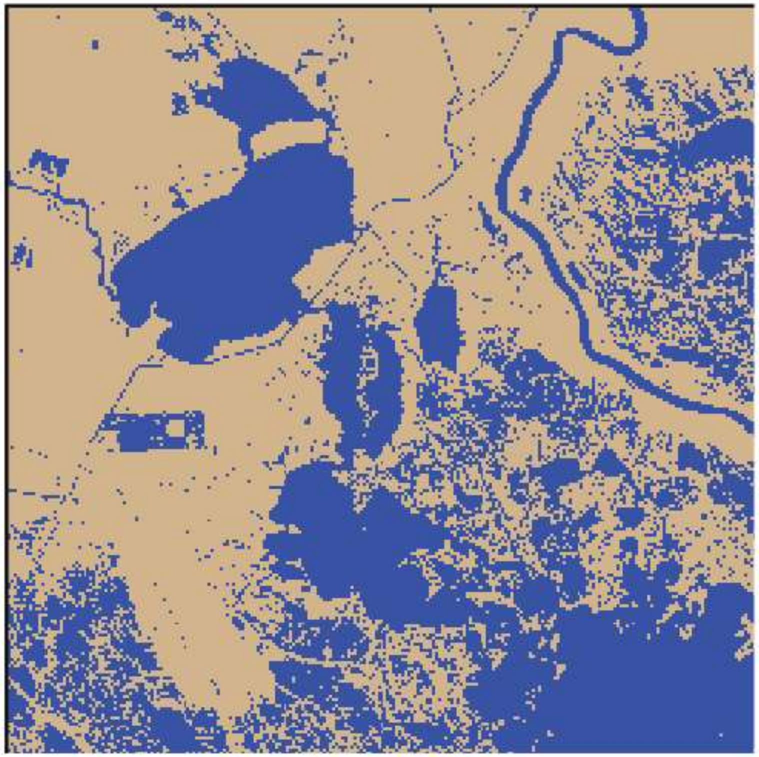
Key Input Datasets



Key Output Datasets

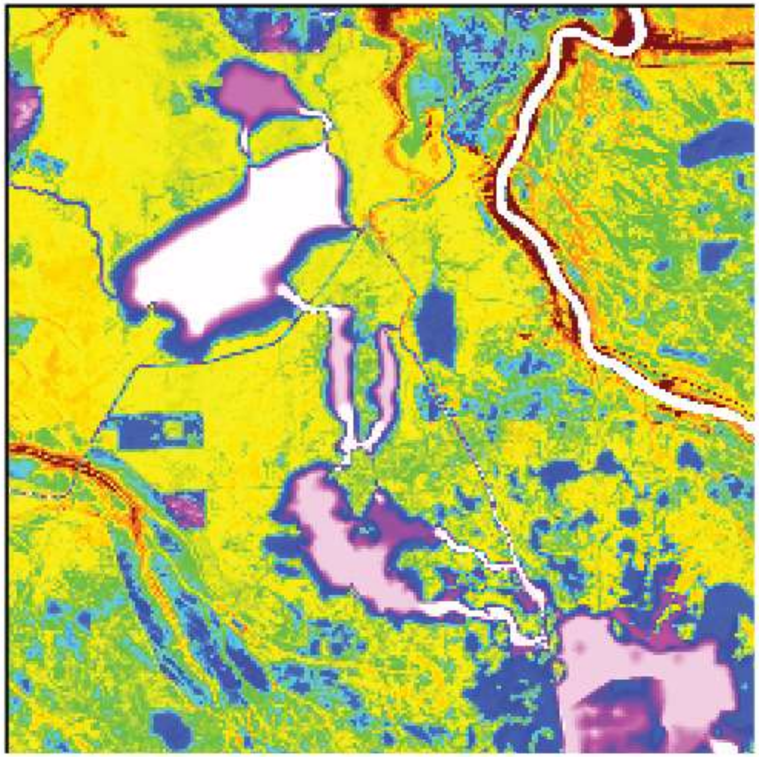
Landscape XYZ Descriptors

Land/Water



Output/Raster/Thematic

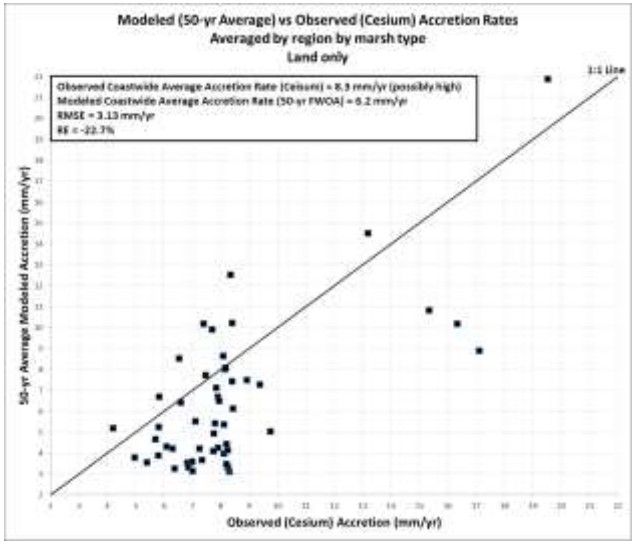
Bathy/Topo



Output/Raster/Float

Calibration/Verification Summary

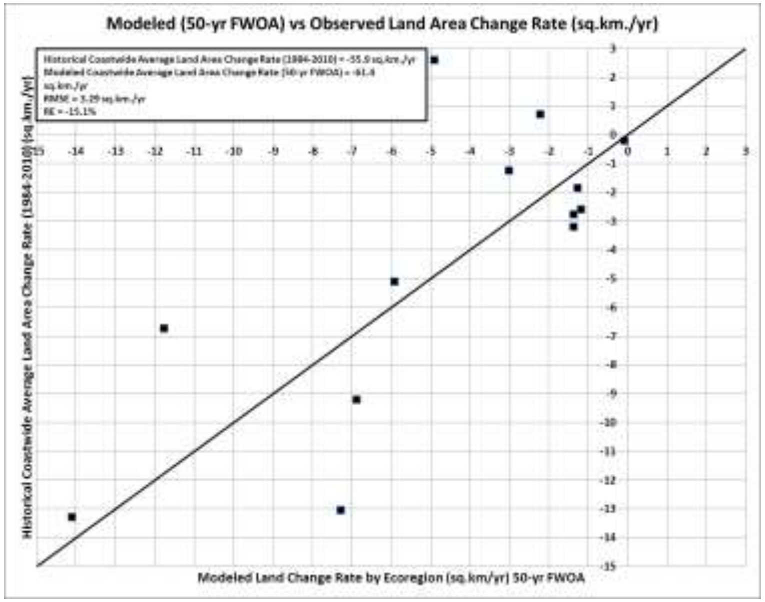
Calibration



- Calibration was performed using 177 Cesium cores, averaged by ecoregion and marsh type
- Bulk density and the organic contribution to accretion were the primary calibration parameters

Verification

- Verification is ongoing and being performed by comparing predicted modeled land area change rates to historical wetland change rates

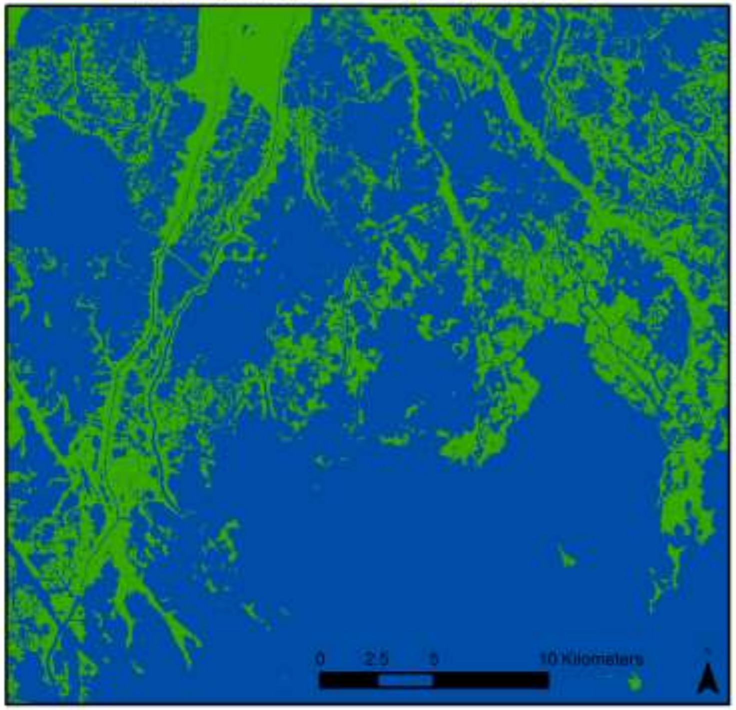


- Scenarios being used for verification are those which most closely resemble historical rates of subsidence, sea-level-rise, and other parameters.

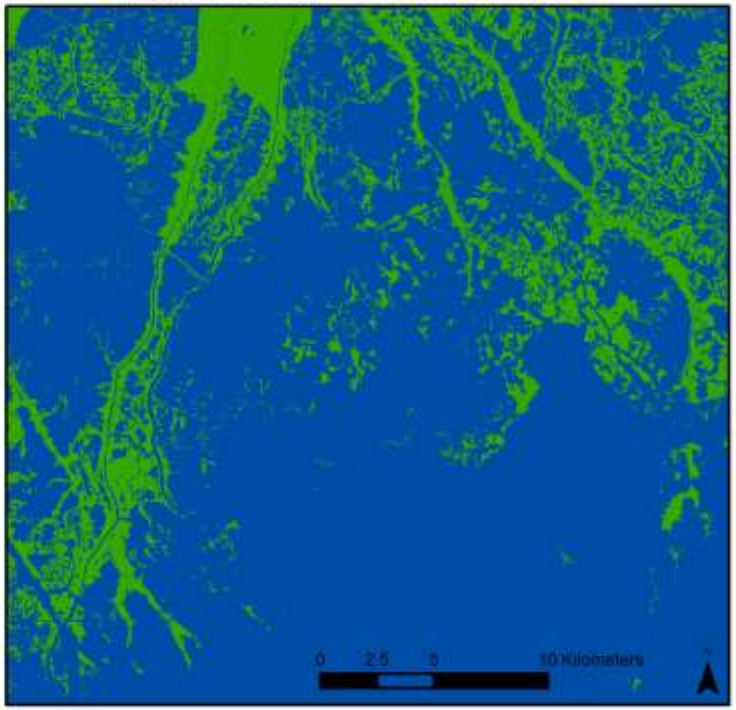
Example outputs

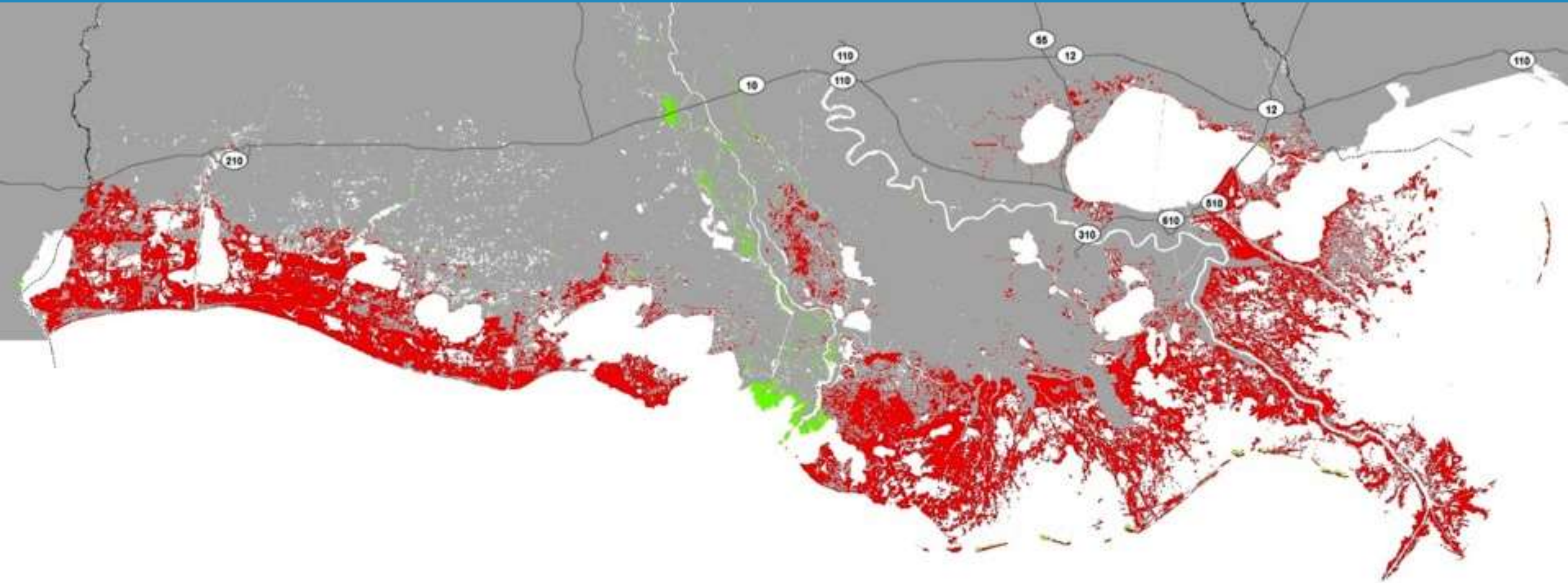
Example of Land/Water Output

Land/Water - End of Year 5



Land/Water - End of Year 25





Questions?

Barrier Island Model (BIMODE)

Gordon Thomson

Team Members

- Gordon Thomson
- Michael Poff
- Mark Kulp
- Ioannis Georgiou
- Dirk-Jan Walstra
- Mark Leadon
- Darin Lee
- Zhifei Dong
- Morjana Signorin
- Vadim Alymov

BIMODE Summary

- Combines storm induced cross-shore changes with longshore changes to determine shoreline location and cross-shore shape

BIMODE Summary

- Longshore Component
  - Hourly WIS data is transformed from offshore to the nearshore (-4m) using the SWAN model
  - The longshore sediment transport rate is approximated by applying the CERC sediment transport equation
  - Longshore sediment transport flux is used to determine shoreline advance or retreat between adjacent profiles; the change in flux is distributed over the active profile height to determine the shoreline advance or retreat
  - The profile seaward of the dune crest is assumed to be constant (one-line model)
  - Shoreline location due to longshore transport is updated monthly

BIMODE Summary

- Cross-shore Component
  - Storm induced changes are performed outside of the ICM using the Storm Induced Beach Change (SBEACH) Model (USACE model)
  - A wide variety of dune widths, dune elevations, berm widths and berm elevations were modeled.
  - The SBEACH model used the synthetic storm events
  - Changes in the SBEACH modeled profile due to a storm event are applied to the profile within the ICM using a look-up table
  - Storm(s) can be applied at a specified month within the 50-year model period

Updates/ Changes from 2012

- Input Wave Data
  - 32 years of WIS data (1980-2012) vs 20 years of data (1989 – 2009)
- Wave Transformation
  - Uses SWAN model to transform the waves from the WIS station to the -4m contour.
- Wave Angle Smoothing
  - The 2017 model smoothes the wave angle over 1500m and uses a "staggered smooth" for profiles within 1500m of the end of a littoral cell. The 2012 model smoothes the wave angle at each time step (annually) when calculating longshore transport based on the island width and shoreline length

Updates/ Changes from 2012

- Cross-Shore Storm Response
  - The 2017 version includes a cross-shore response using SBEACH.
  - SBEACH profiles that most closely resembles the BIMODE profile are selected and changes applied, thus lowering and overwash of the profile due to storms.
- Breaching
  - The 2017 model allows the development of breaches within an island chain based on a number of criteria including island width and width to length ratios, as well as ratios updraft and downdrift length.

Key Input Datasets

- Cross-shore profiles and shoreline locations were based on latest available data including:
  - Post-construction surveys
  - BICM LiDAR data

- Average wave conditions are based on 32-years of WIS data with 18 years repeated to provide a 50-year record.

- The synthetic storm events are used in SBEACH to estimate a cross-shore response

Key Output Datasets

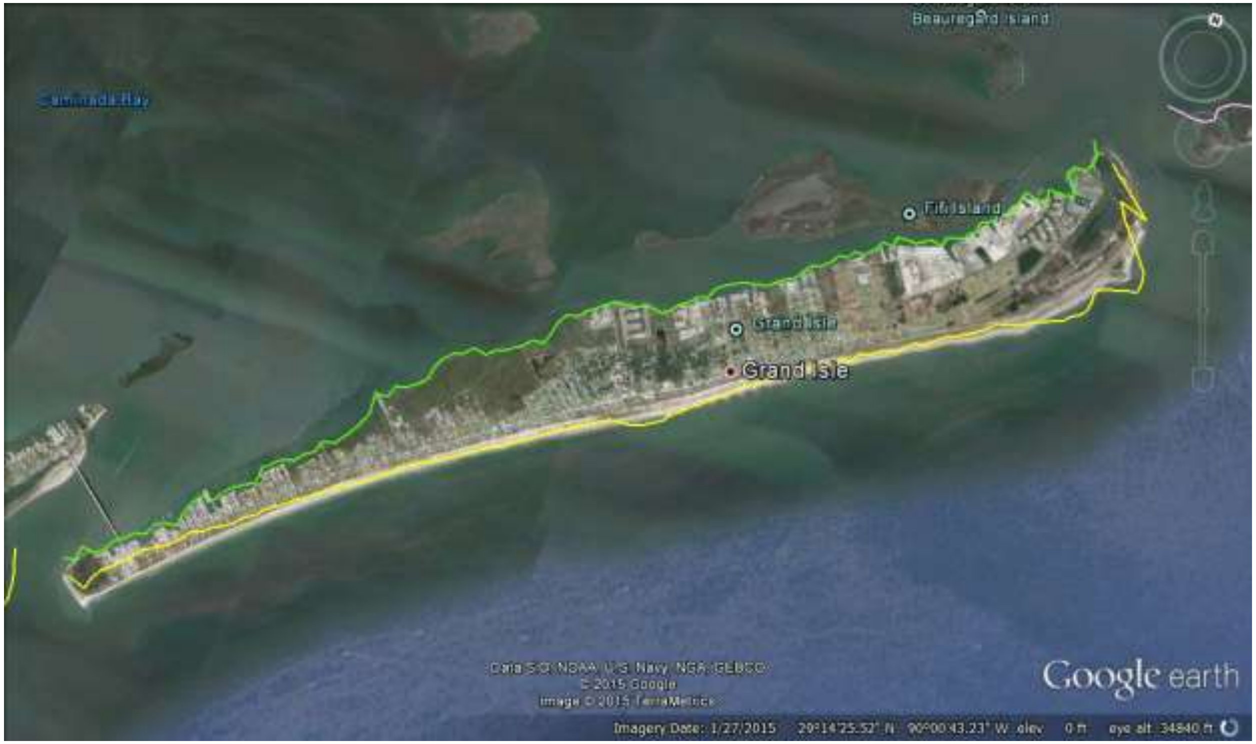
- Output is a cross-section of each profile
  - Profiles are spaced 100m apart
  - Data points along each profile line are spaced 2m apart
- Profile data is converted to an x,y,z file output at the end of each year
- A DEM is created from the x,y,z file

Calibration

- The model calibration period is January 2006 through December 2014, inclusive
- SBEACH is calibrated separately using profile responses measured before and after Hurricane Isaac
- Analysis of the calibration is performed through visual comparison of the model output shoreline exported into Google Earth.
  - The Breton Island region could not be calibrated because it was submerged at the beginning of the calibration period
  - Recovery of the Chandeleur Islands following H. Katrina and construction of the Emergency Berm project limited a true calibration of this area

East Island Calibration

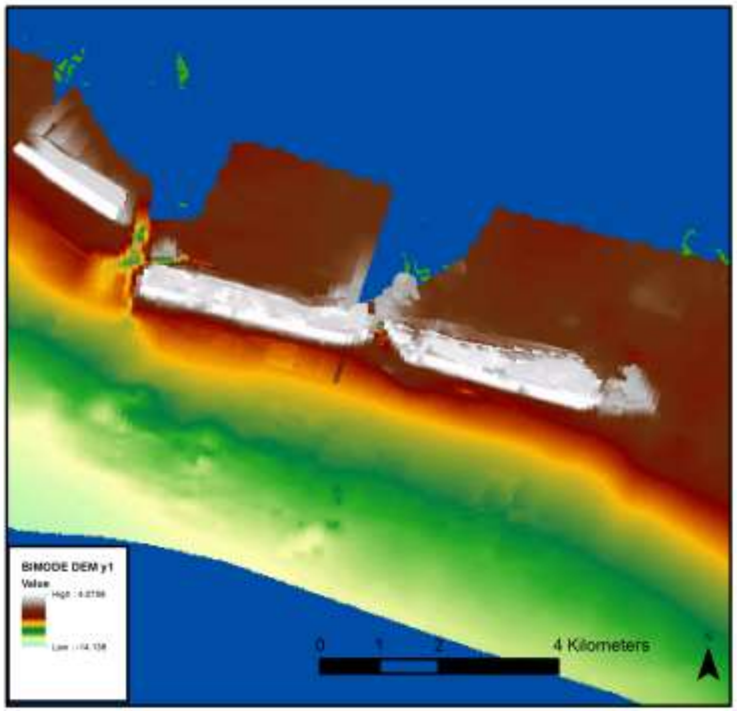
Grand Isle Calibration



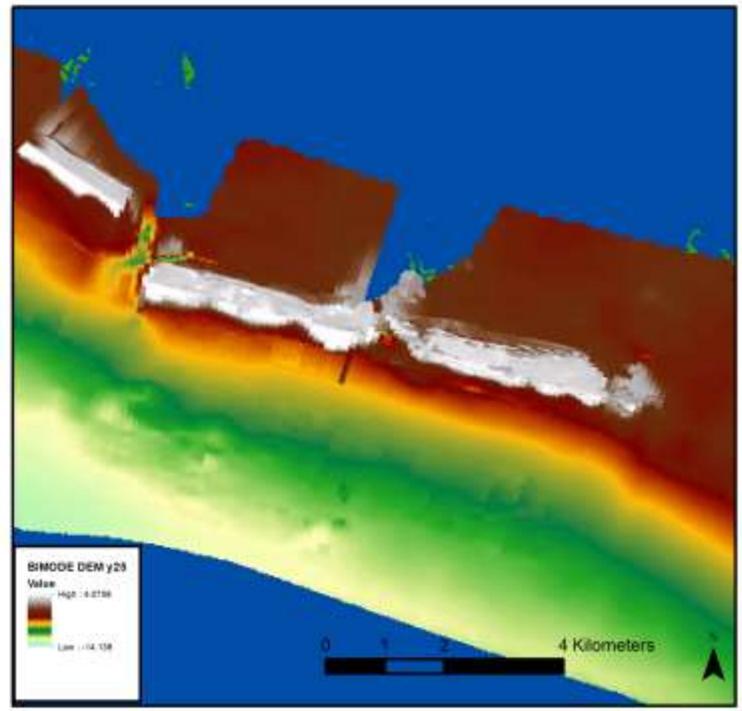
Shell Island East, Pelican Island and Scofield Island Calibration

Example Outputs
Barrier island change over time

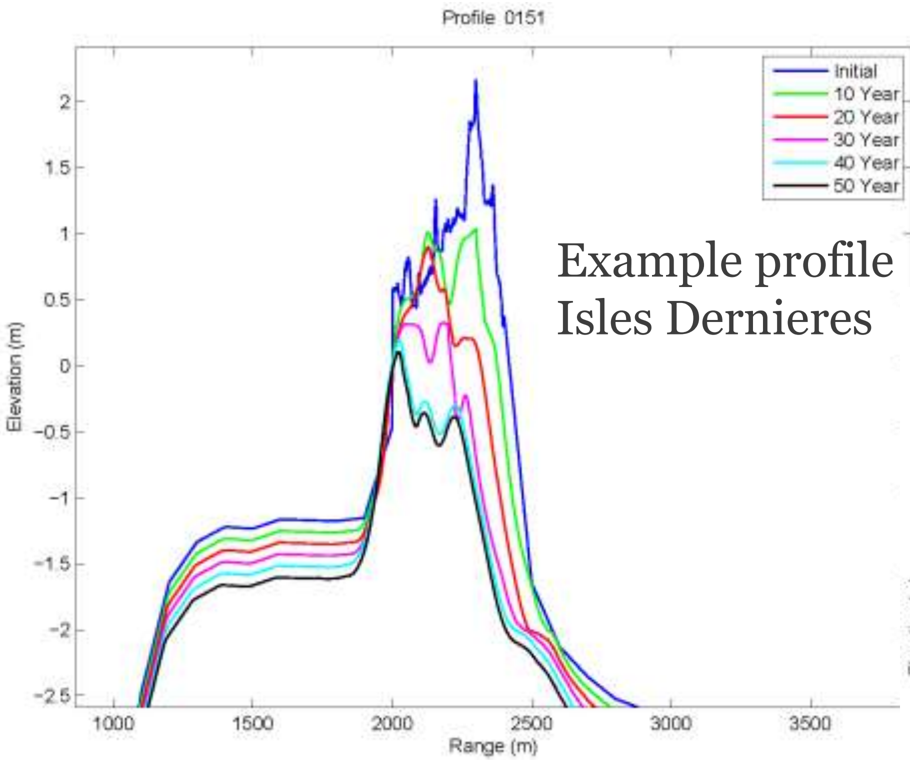
Barrier Island Elevations - End of Year 1



Barrier Island Elevations - End of Year 25

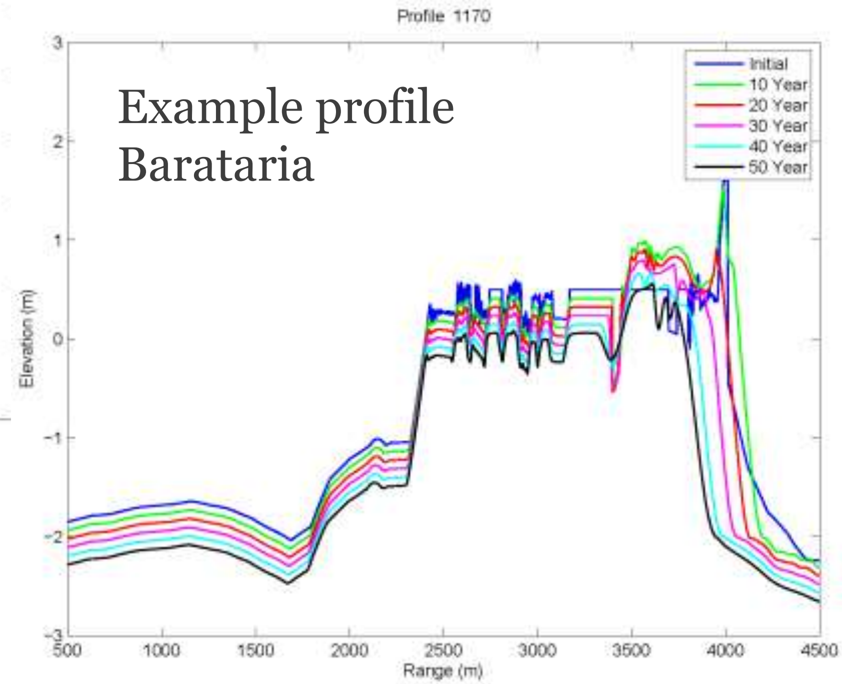


Example Outputs
Barrier island change – cross shore

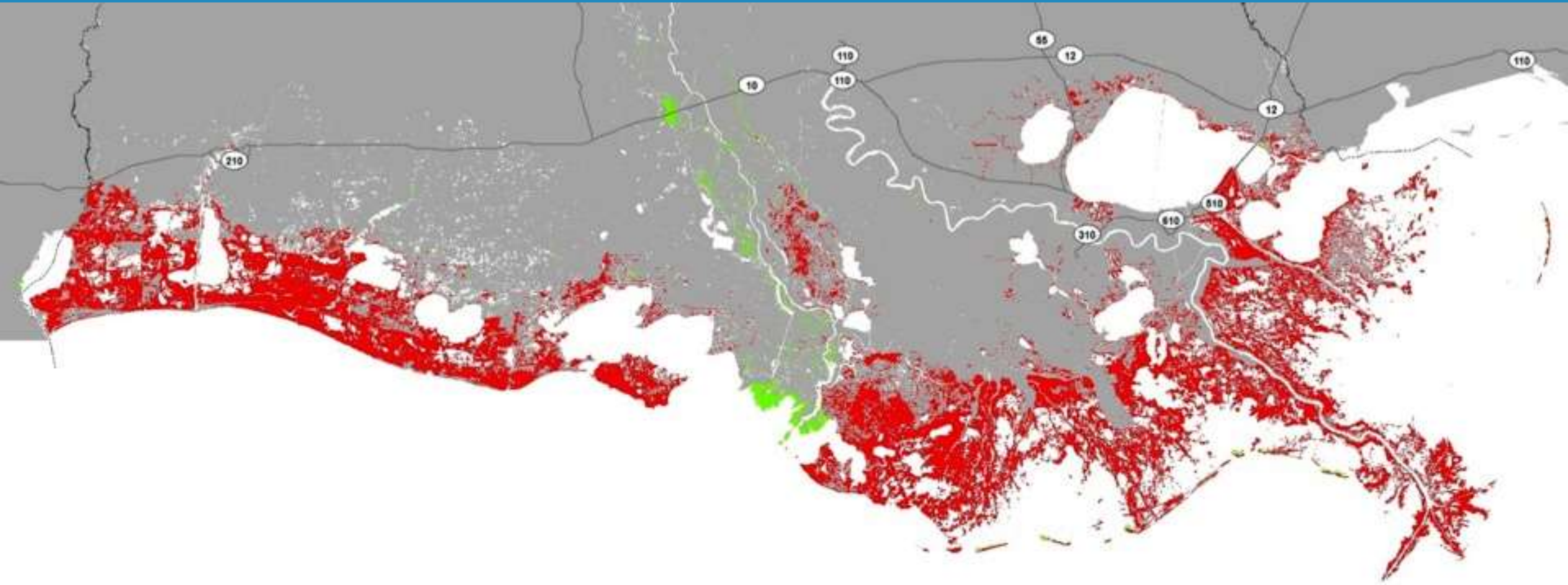


Example profile
Isles Dernieres

Example outputs only – retreat turned off in model.



Example profile
Barataria



Questions?

LaVegMod 2.0: Forecasting vegetation changes in response to restoration and protection features

Jenneke Visser

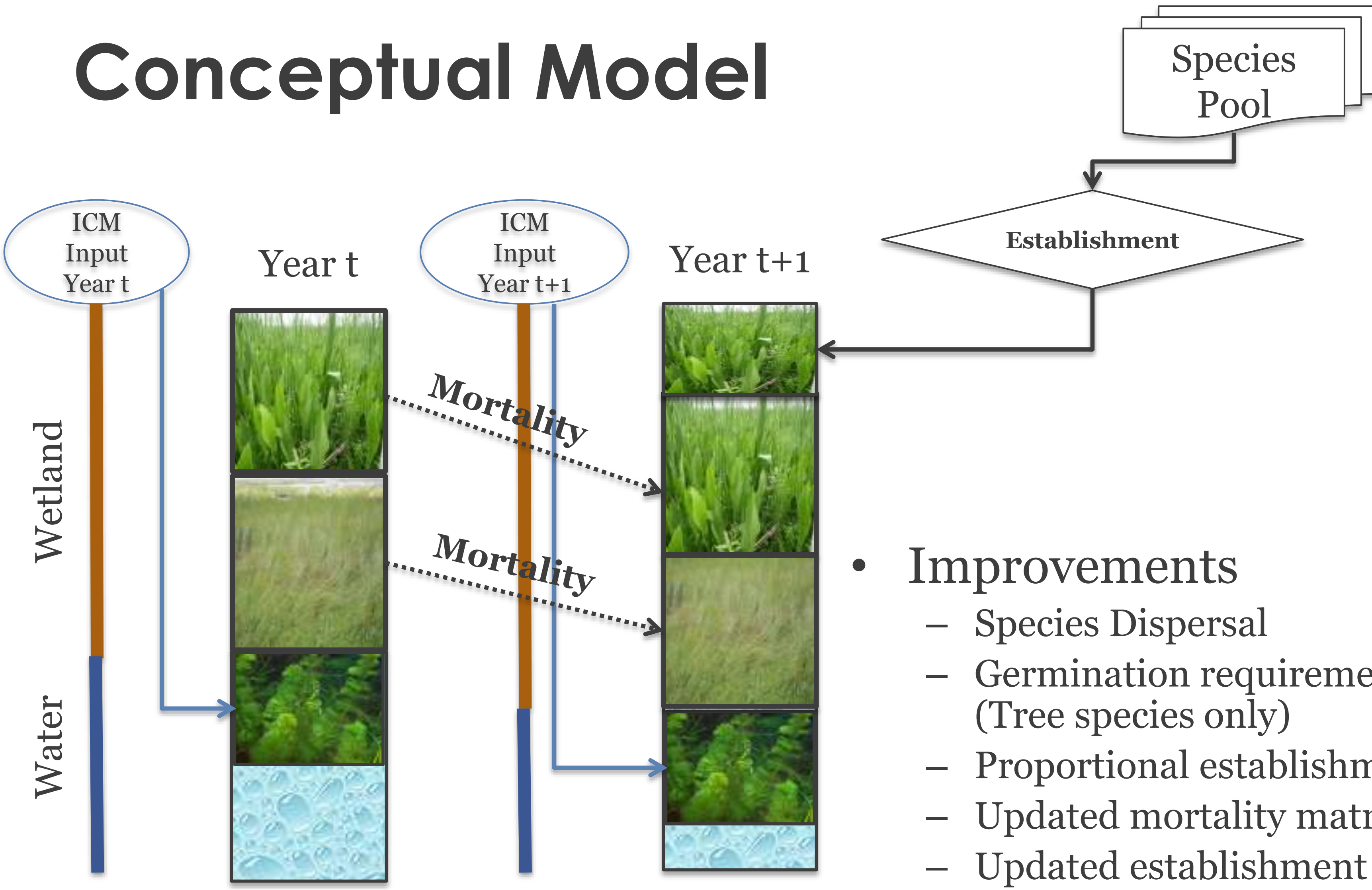
Team Members

- Scott M. Duke-Sylvester
- Mark W. Hester
- Jonathan Willis
- Gary Shaffer
- Brady Couvillion
- Holly Beck
- Whitney Broussard

Habitats and Species

Habitat	Species
Bottomland Hardwood Forest	**Quercus lyrata, Quercus texana, Quercus laurifolia, Ulmus americana, Quercus nigra, Quercus virginiana**
Swamp Forest	**Salix nigra, Taxodium distichum, Nyssa aquatica**
Fresh Floating Marsh	**Panicum hemitomon, Eleocharis baldwinii, Hydrocotyle umbellata**
Fresh Attached Marsh	Morella cerifera, Panicum hemitomon, Sagittaria latifolia, Zizaniopsis miliacea, Cladium mariscus, Typha domingensis
Intermediate Marsh	Sagittaria lancifolia, Phragmites australis, Schoenoplectus californicus, Iva frutescens, Baccharis halimifolia
Brackish Marsh	Spartina patens, Paspalum vaginatum
Saline Marsh	Juncus roemerianus, Distichlis spicata, Spartina alterniflora, Avicennia germinans
Dune	***Uniola paniculata*, *Panicum amarum*, *Sporobolus virginicus***
Swale	***Spartina patens*, *Distichlis spicata*, *Solidago sempervirens*, *Strophostyles helvola*, *Baccharis halimifolia***

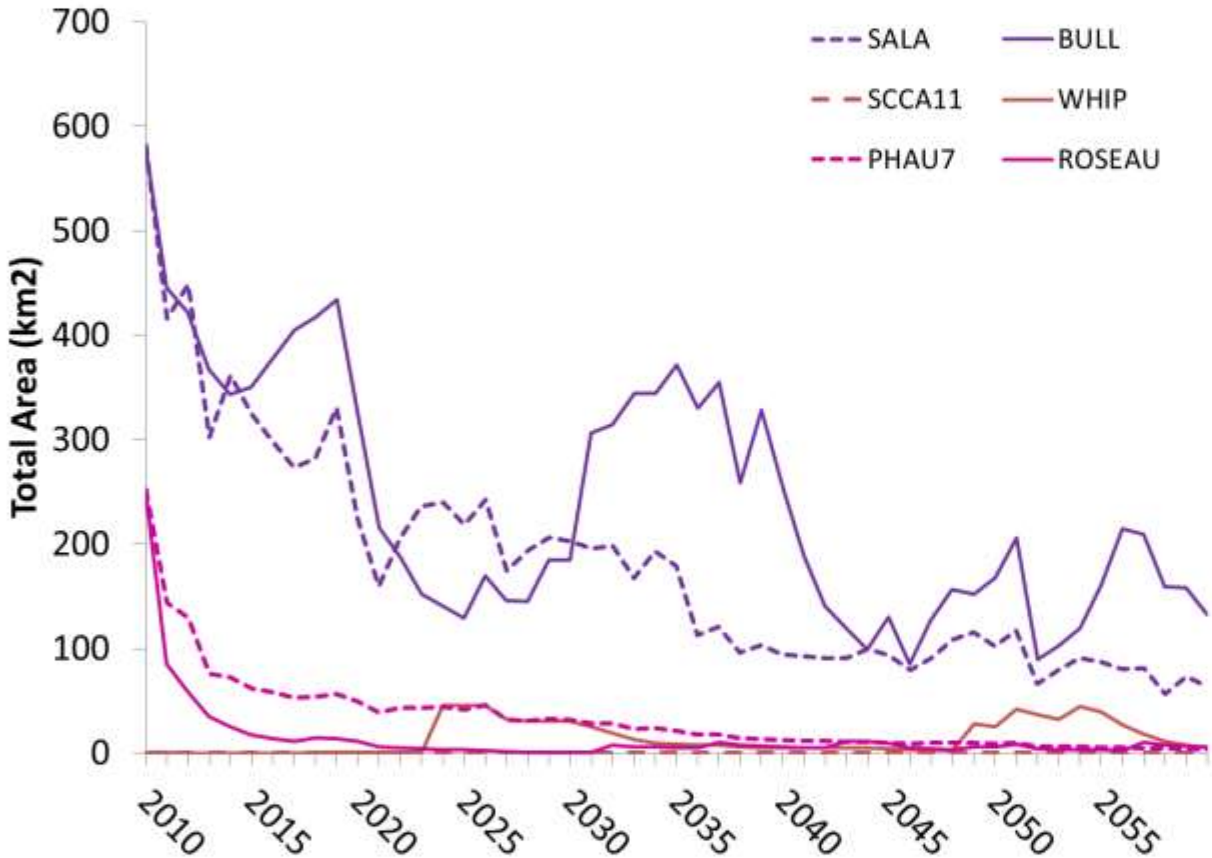
Conceptual Model



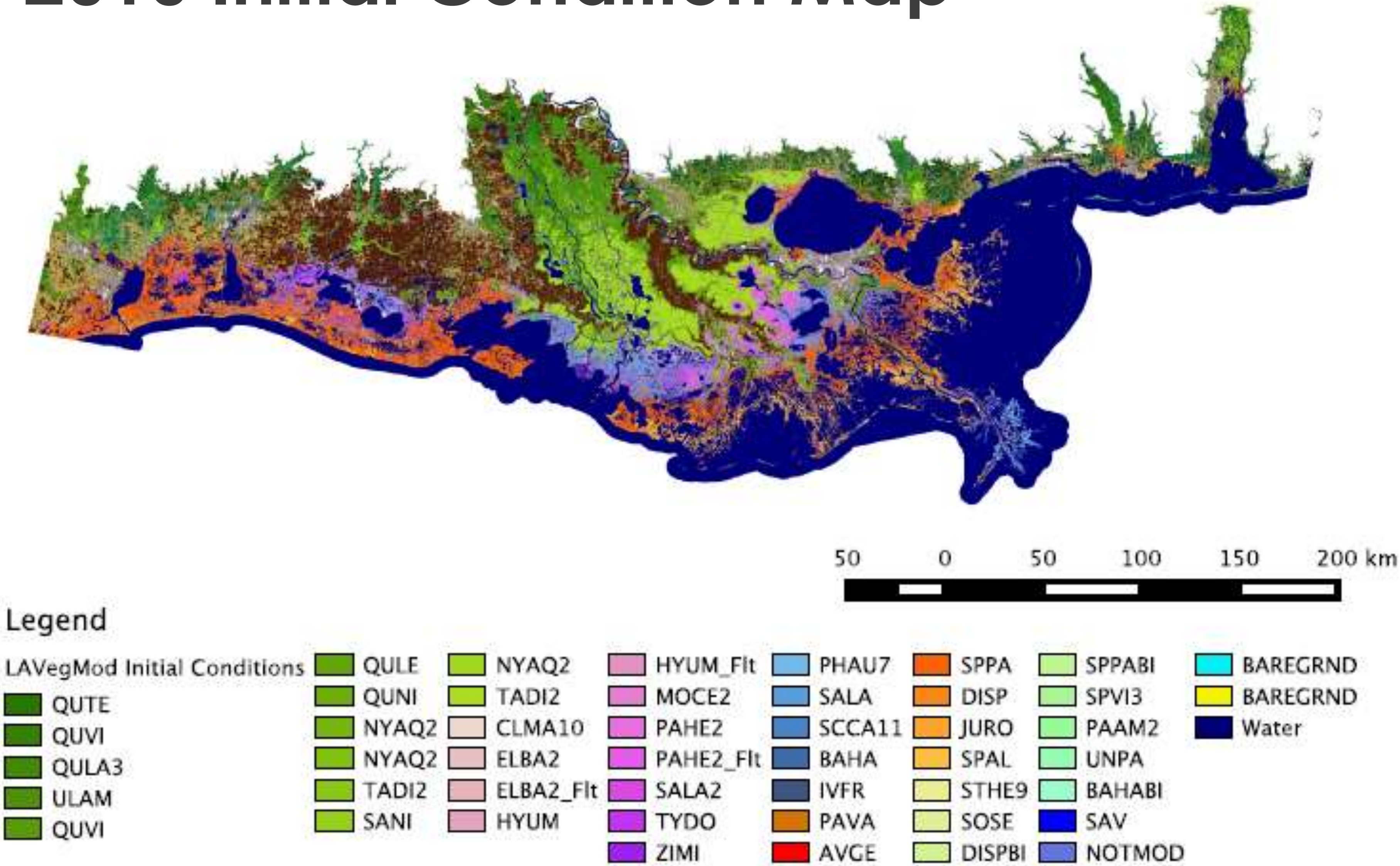
- Improvements
  - Species Dispersal
  - Germination requirements (Tree species only)
  - Proportional establishment
  - Updated mortality matrices
  - Updated establishment matrices

Comparison LaVegMod 2.0 and 1.0

Trends in vegetation the same, less interannual variation with 2.0

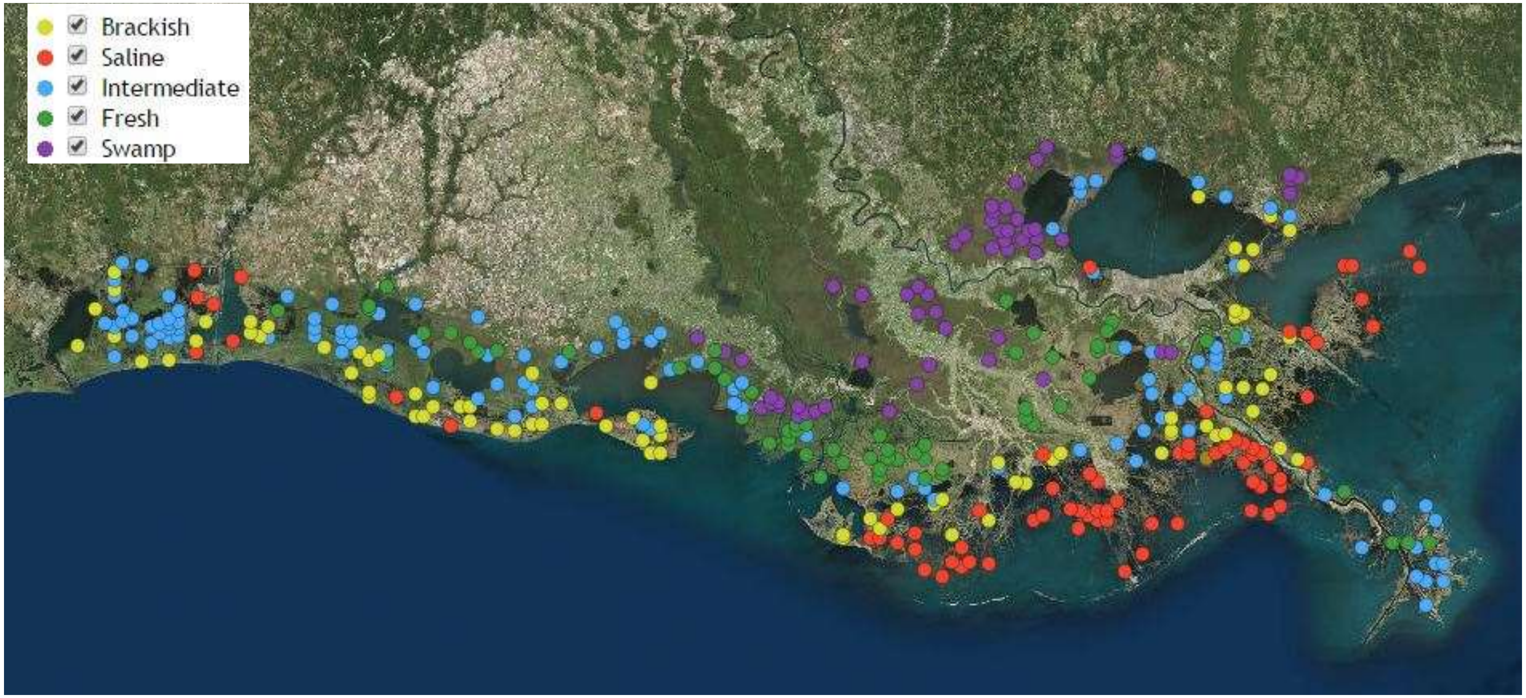


2010 Initial Condition Map



Data for Calibration

- Coastwide Reference Monitoring System
  - 56 Swamp stations surveyed in 2012
  - 336 Marsh stations surveyed annual from 2007 through 2014



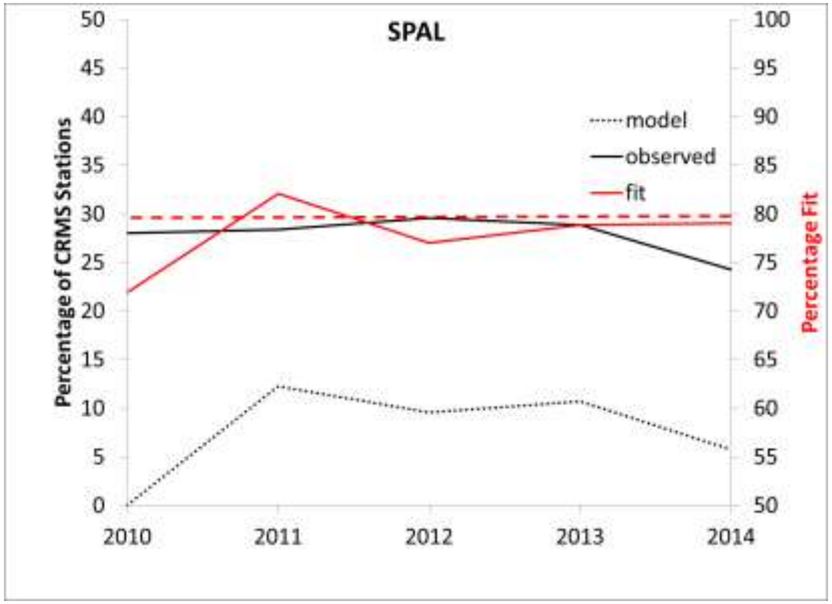
Calibration Data Comparison

	LaVegMod	CRMS
Area	500 x 500 = 250,000 m^2	10 x 2 x 2 = 40 m^2
Represents	All habitat Includes ridges	Target habitat Marsh or Swamp
Cover	Dominants	All species
Presence	> 5% cover	> 5% cover in one of the plots

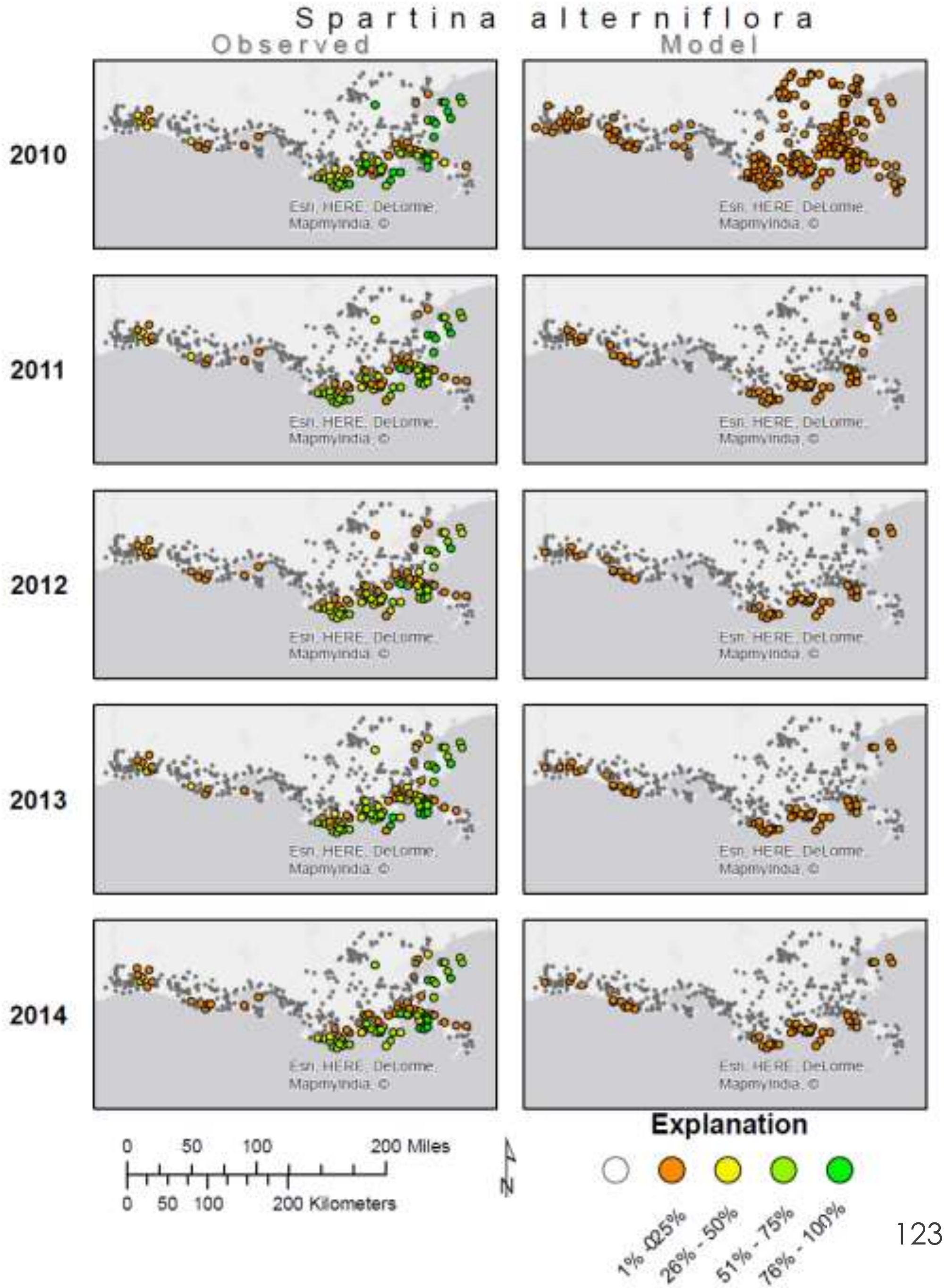
Because of these differences we only considered presence/absence not % cover

Bottomland Hardwood and Barrier Islands are not included in the CRMS design. However they make up only a small percentage of the coastal zone.

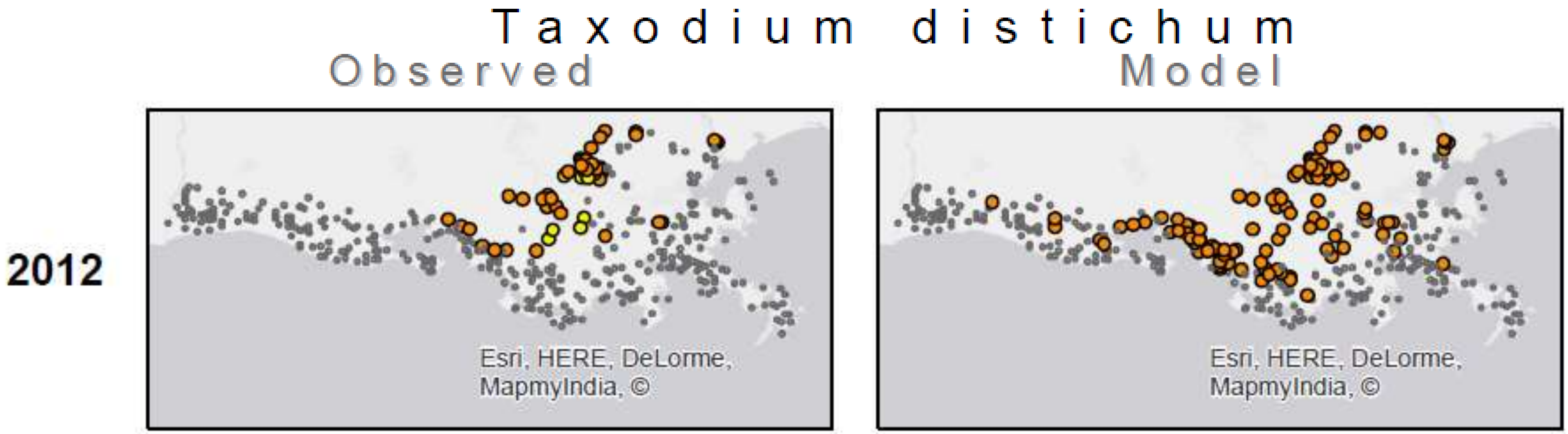
Calibration Oyster Grass



Model underestimates some species, but fit improves over time, and spatial distribution reflects areas where the species is dominant



Calibration Bald Cypress



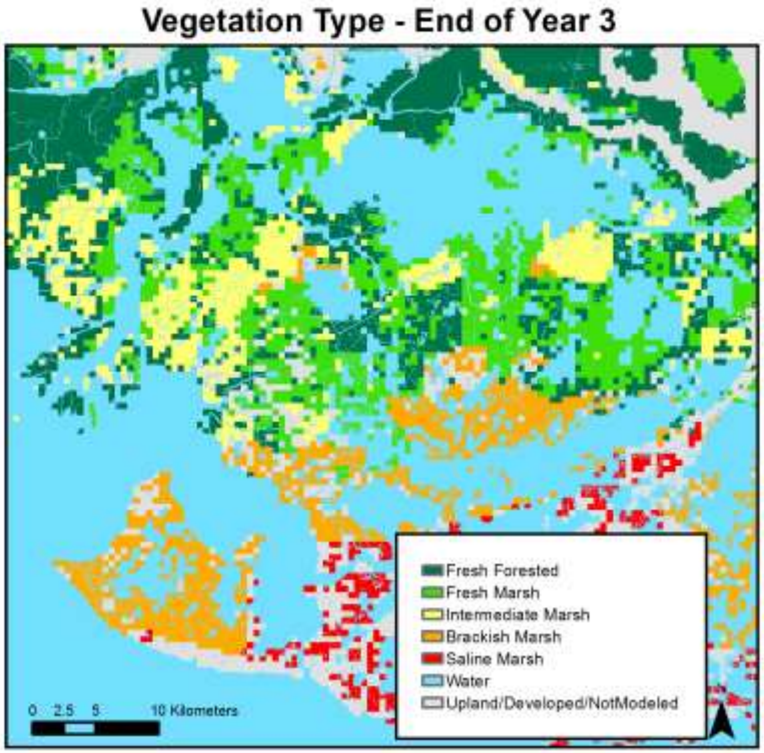
Bald cypress is overestimated by the model. This may be due to the larger area in the model, compared to the CRMS observations. However, the pattern shown in the model does not conflict with known distributions of bald cypress.

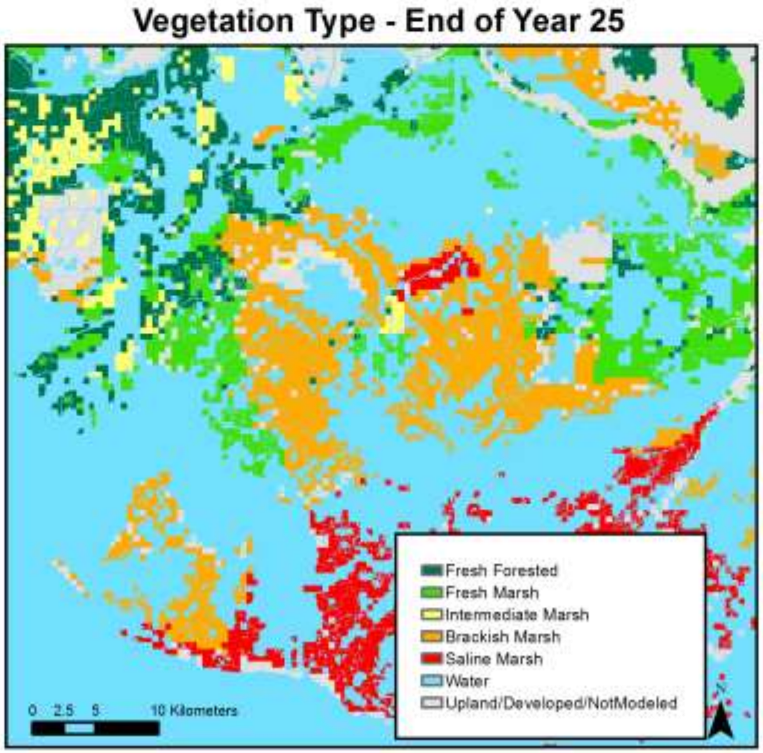
Calibration Overview

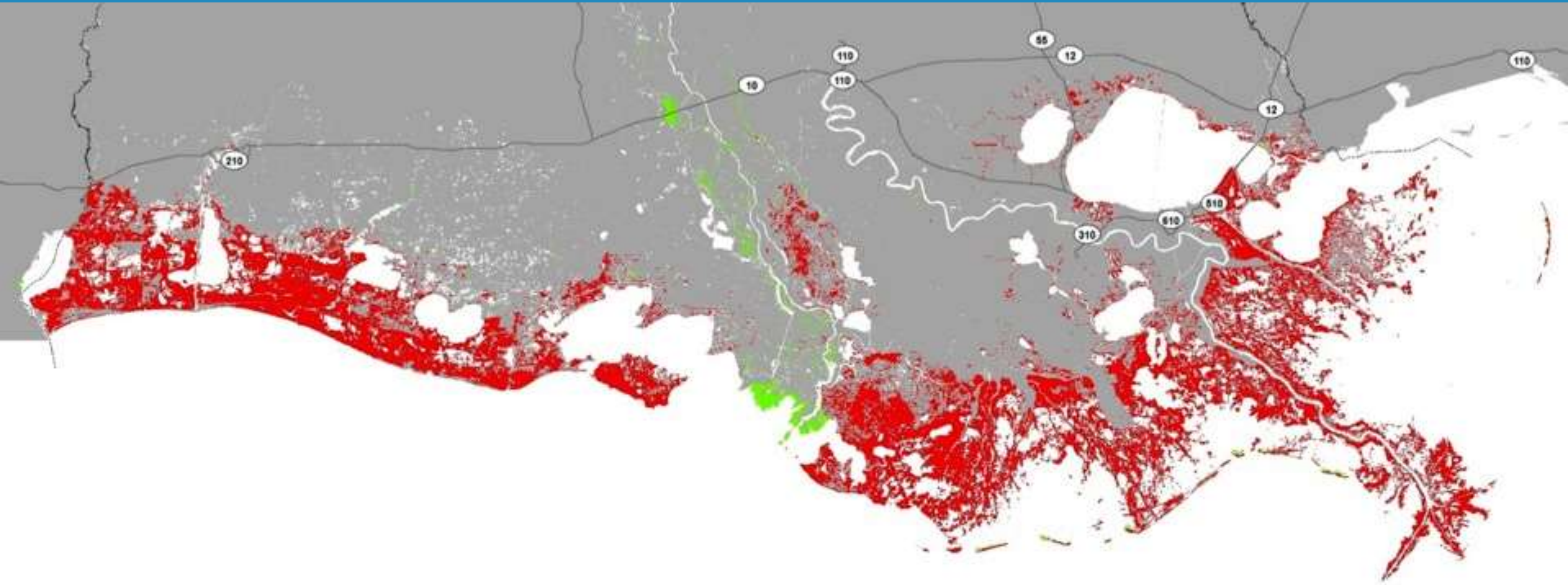
Swamp		Fresh Marsh		Intermediate Marsh		Brackish Marsh		Saline Marsh	
Species	Fit	Species	Fit	Species	Fit	Species	Fit	Species	Fit
TADI2	**79**	TYDO	82	SALA	82	SPPA	**63**	SPAL	**79**
NYAQ2	91	PAHE2	95	PHAU7	86	JURO	87	DISP	**69**
SANI	93	HYUM	99	IVFR	92	PAVA	88	AVGE	99
		SALA2	98	BAHA	92				
		ZIMI	97	SCCA11	96				
		CLMA10	97						
		MOCE2	99						

Fit is percentage of CRMS stations that were correctly classified for presence/absence of the species at the end of the 4 year 2010-2014 run.
For all species fit at the end of the run was better than at the start. Only 4 of the 21 species did not reach the 80% fit goal.

Example output - vegetation change







Questions?

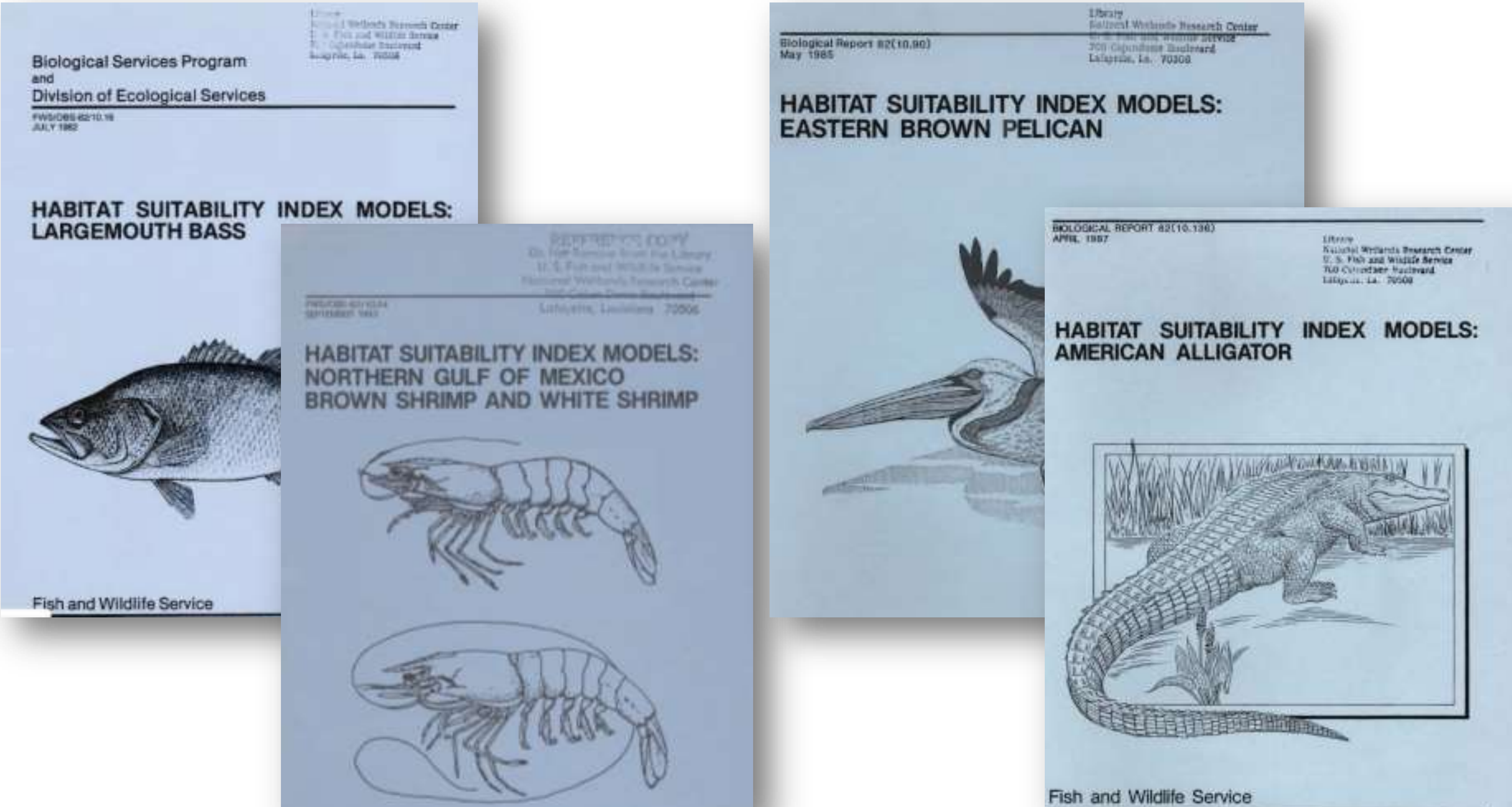
Habitat Suitability Index Models

Ann Hijuelos

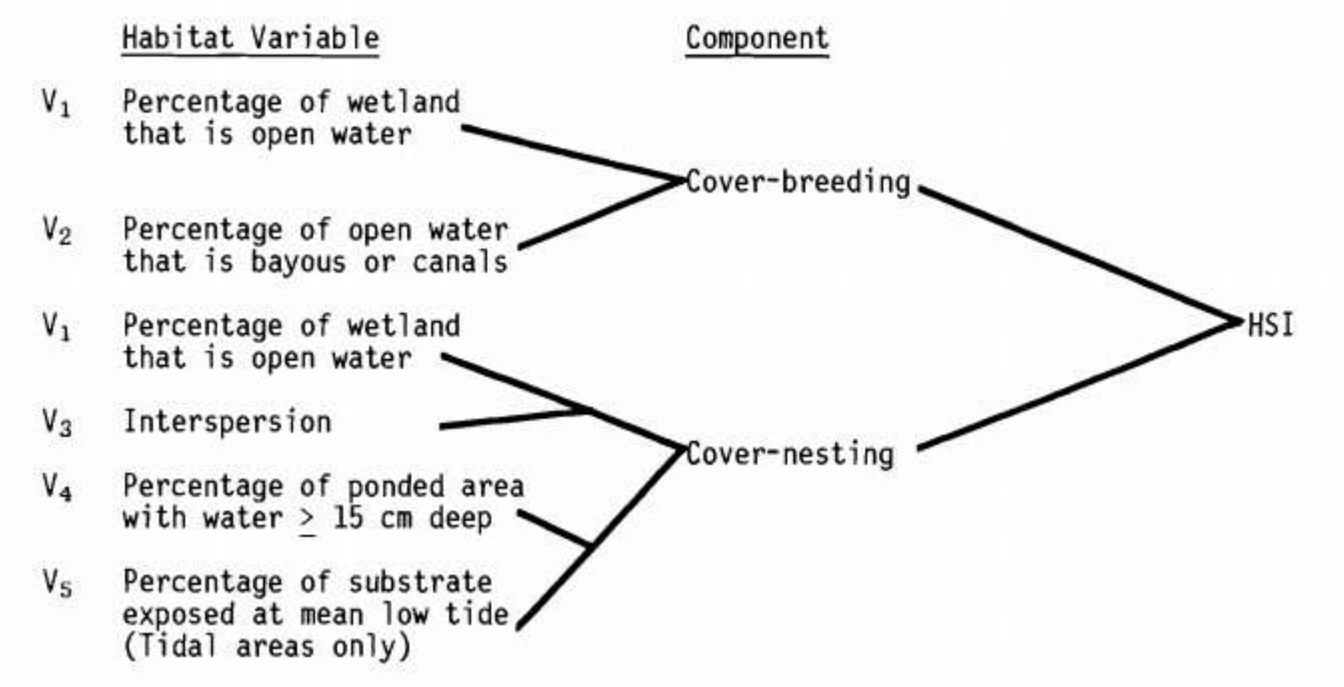
Team Members

- Ann Hijuelos
- Buddy Clairain
- Shaye Sable
- Meg O'Connell
- Paul Leberg
- Robert Romaire
- Hardin Waddle
- James Geaghan
- Stokka Brown
- David Lindquist

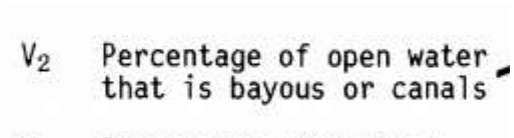
Overview of HSI Models

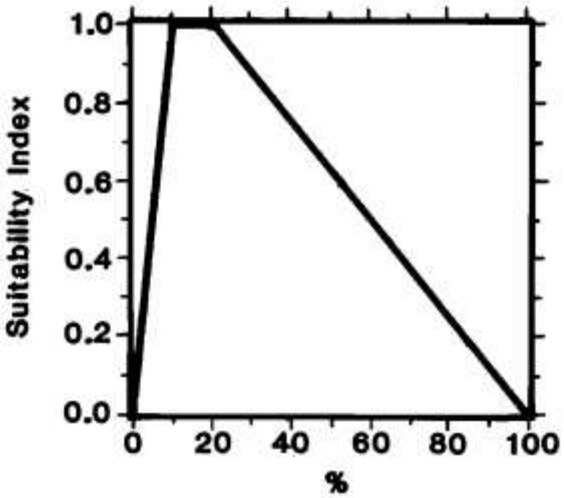


Overview of HSI Models

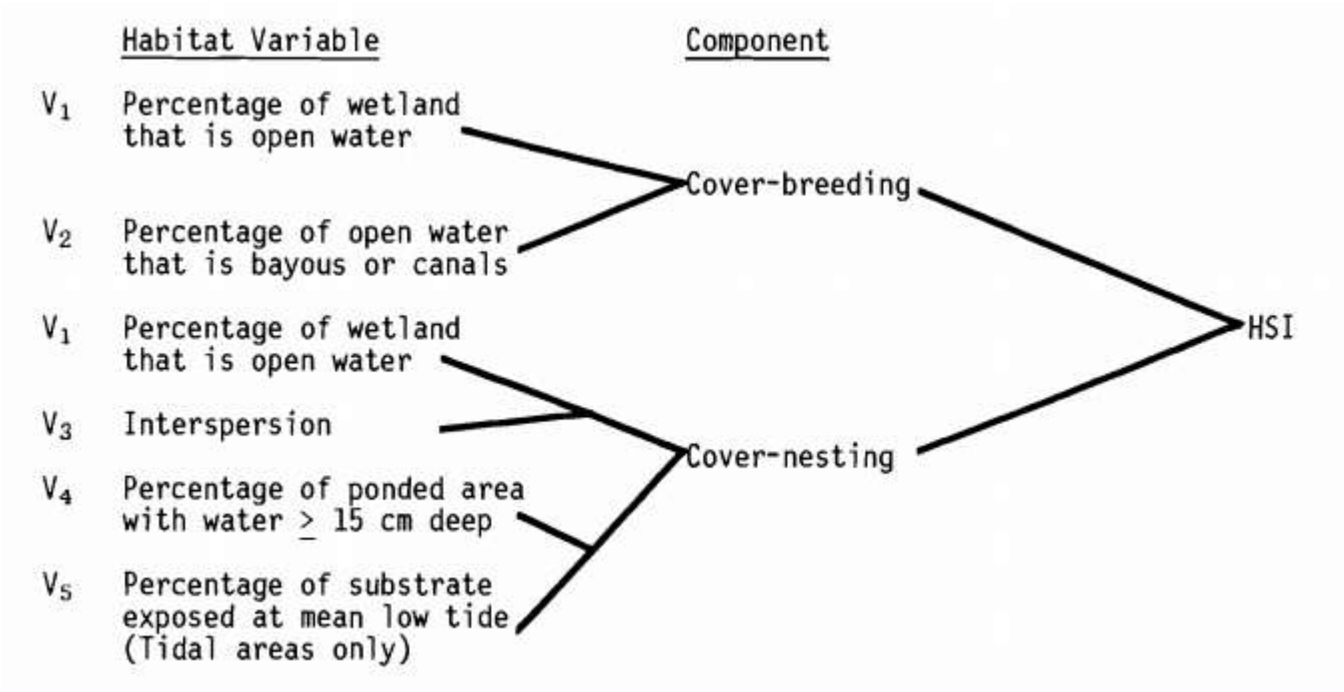


Overview of HSI Models





Overview of HSI Models

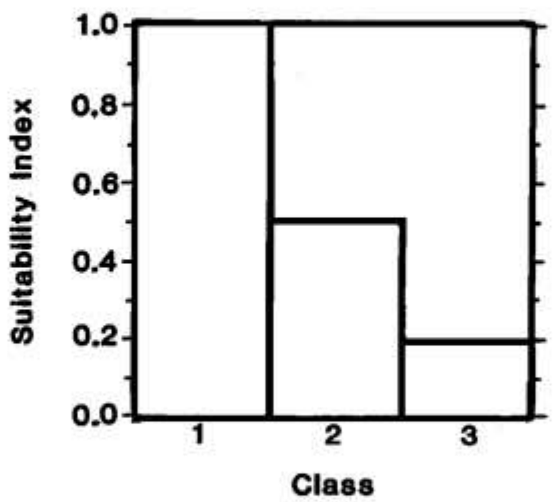


Overview of HSI Models

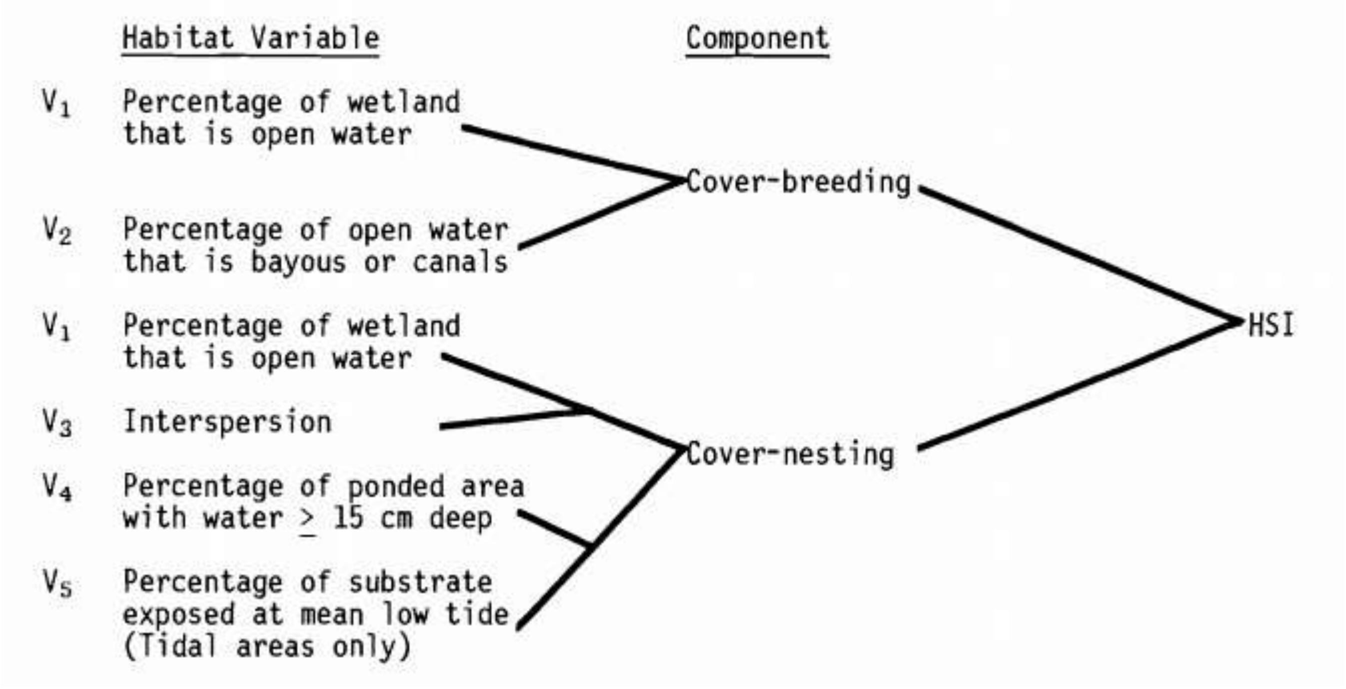
V_3 Interspersion

V_3 Interspersion class

1. High interspersion; 10-15 ponds (≥0.2 ha) per 6 ha.
2. Medium interspersion; 3-9 ponds per 6 ha or 15-20 ponds per 6 ha.
3. Low interspersion; 2 or fewer ponds per 6 ha, or highly eroded and fragmented marsh.



Overview of HSI Models



Strategy for 2017 MP

- Conduct literature review of all species to ensure key variables are included in models
- Determine appropriate life stages to model
- Obtain existing datasets to refine or build new models
- Conduct analyses, where possible, to generate relationships between variable and habitat suitability
- Test and verify models using preliminary ICM output

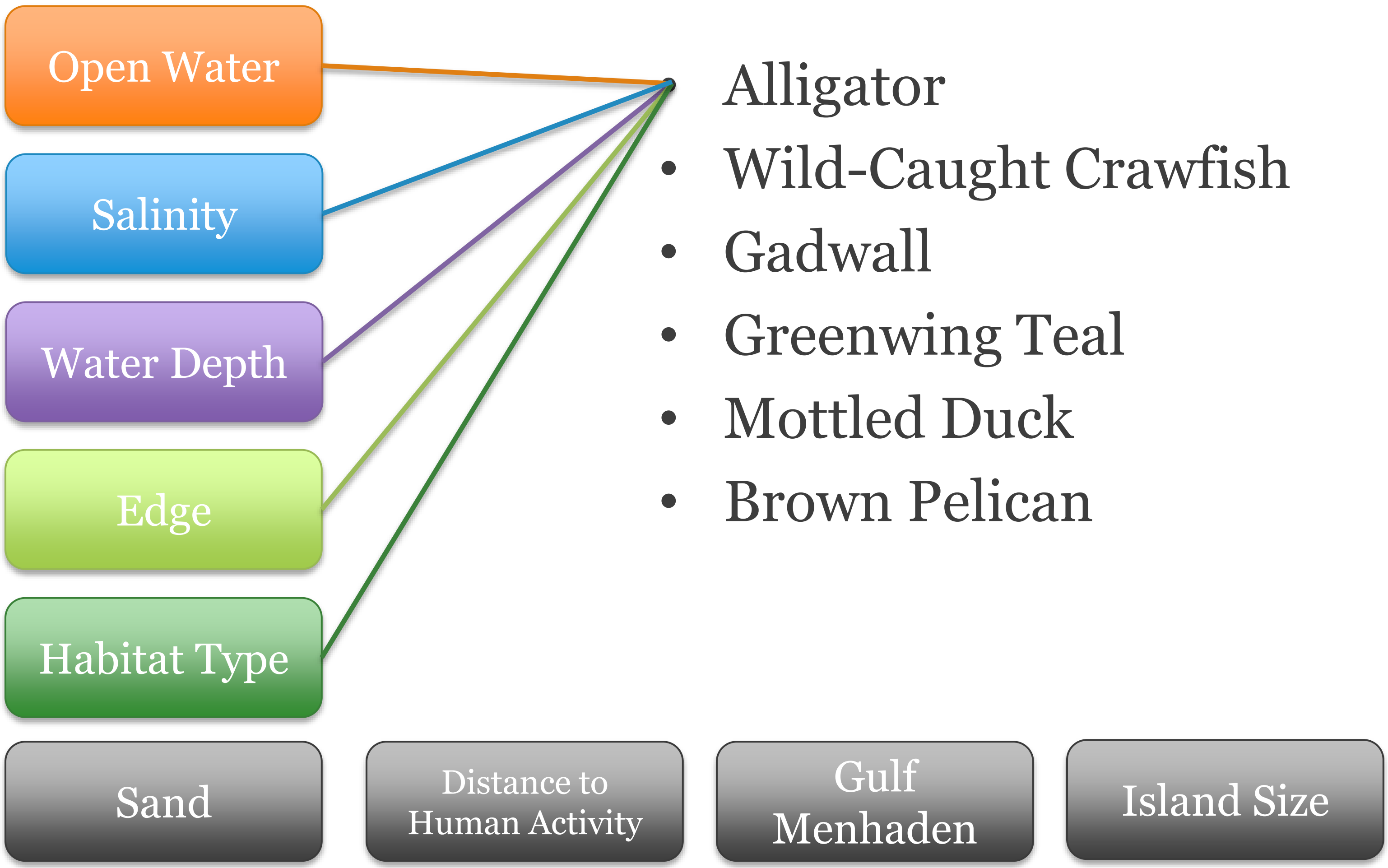
2012 MP Modeled Species

- Alligator
- Wild-Caught Crawfish
- Gadwall
- Greenwing Teal
- Mottled Duck
- Muskrat
- River Otter
- Neotropical Migrant
- Roseate Spoonbill
- Largemouth Bass
- Eastern Oyster
- Juvenile Brown Shrimp
- Juvenile White Shrimp
- Juvenile Spotted Seatrout

2017 MP Modeled Species

- Alligator
- Wild-Caught Crawfish
- Gadwall
- Greenwing Teal
- Mottled Duck
- ~~Muskrat~~
- ~~River Otter~~
- ~~Neotropical Migrant~~
- ~~Roseate Spoonbill~~
- Brown Pelican
- Largemouth Bass
- Eastern Oyster
- Juvenile Brown Shrimp (2)
- Juvenile White Shrimp
- Juvenile Spotted Seatrout
- Adult Spotted Seatrout
- Juvenile Gulf Menhaden
- Adult Gulf Menhaden
- Juvenile Blue Crab
- Juvenile Bay Anchovy
- Adult Bay Anchovy

Summary of Inputs

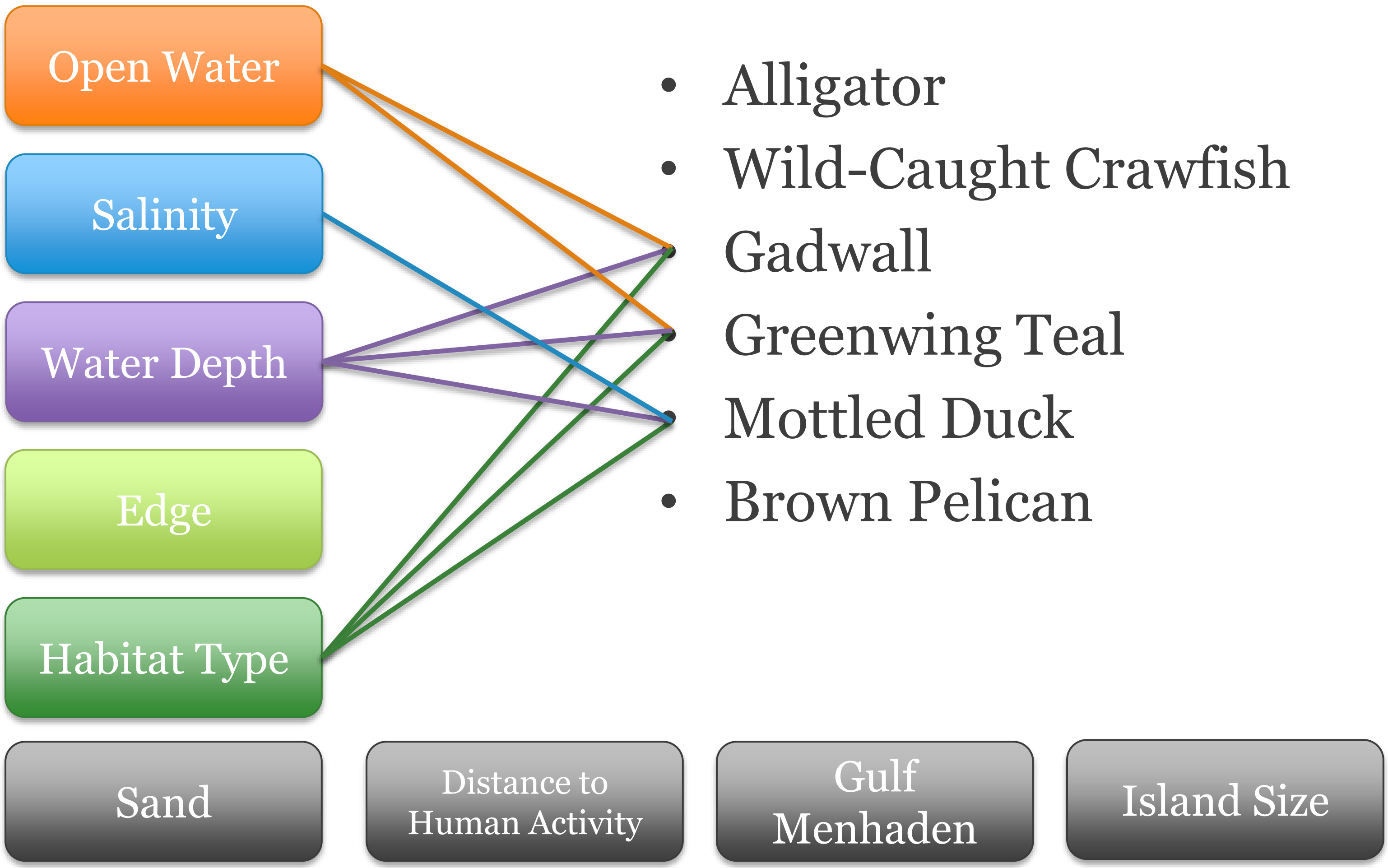


Summary of Inputs

- Open Water
- Salinity
- Water Depth
- Edge
- Habitat Type
- Sand
- Distance to Human Activity
- Gulf Menhaden
- Island Size

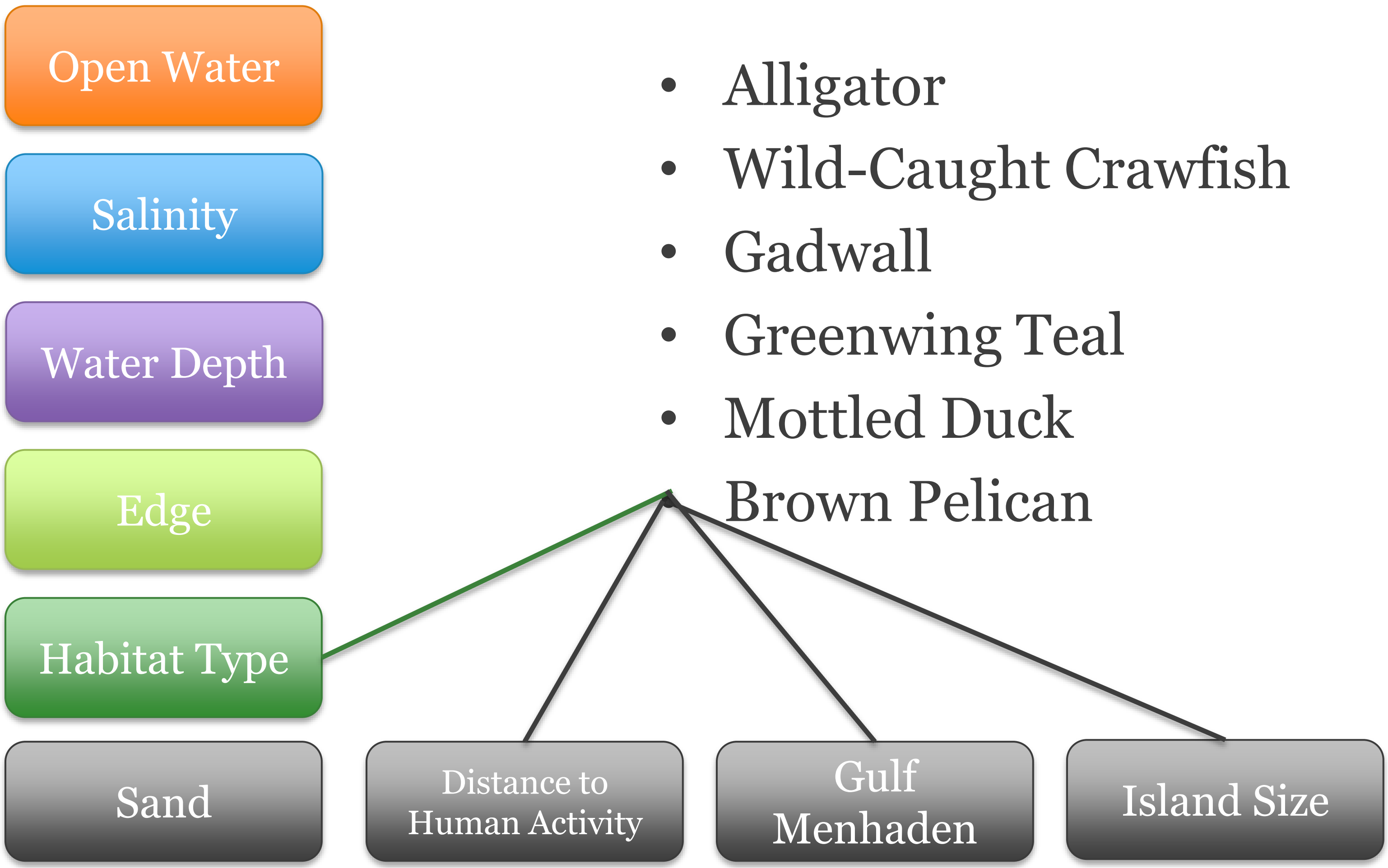
- Alligator
- Wild-Caught Crawfish
- Gadwall
- Greenwing Teal
- Mottled Duck
- Brown Pelican

Summary of Inputs



Summary of Inputs

- Alligator
- Wild-Caught Crawfish
- Gadwall
- Greenwing Teal
- Mottled Duck
- Brown Pelican

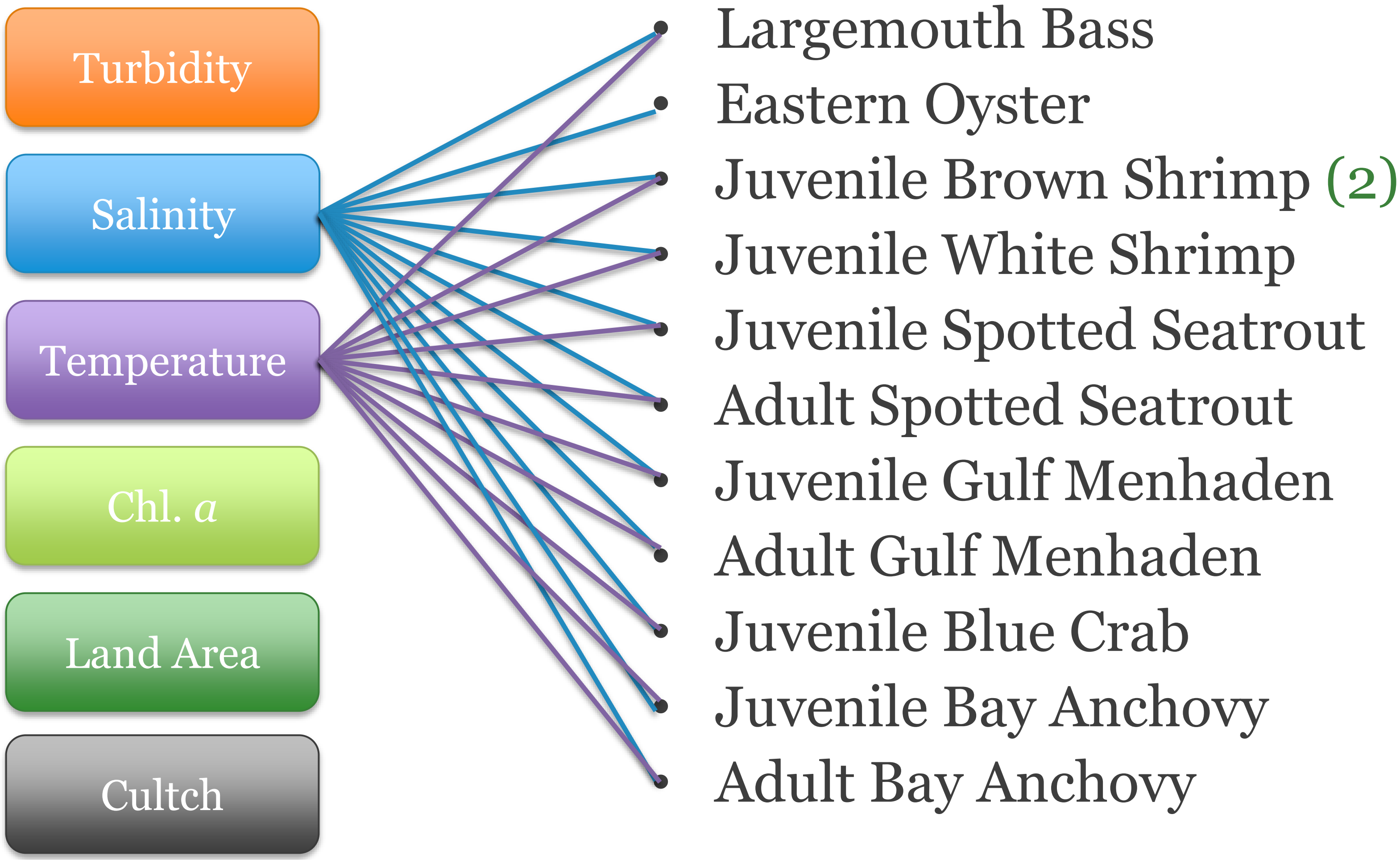


Summary of Inputs

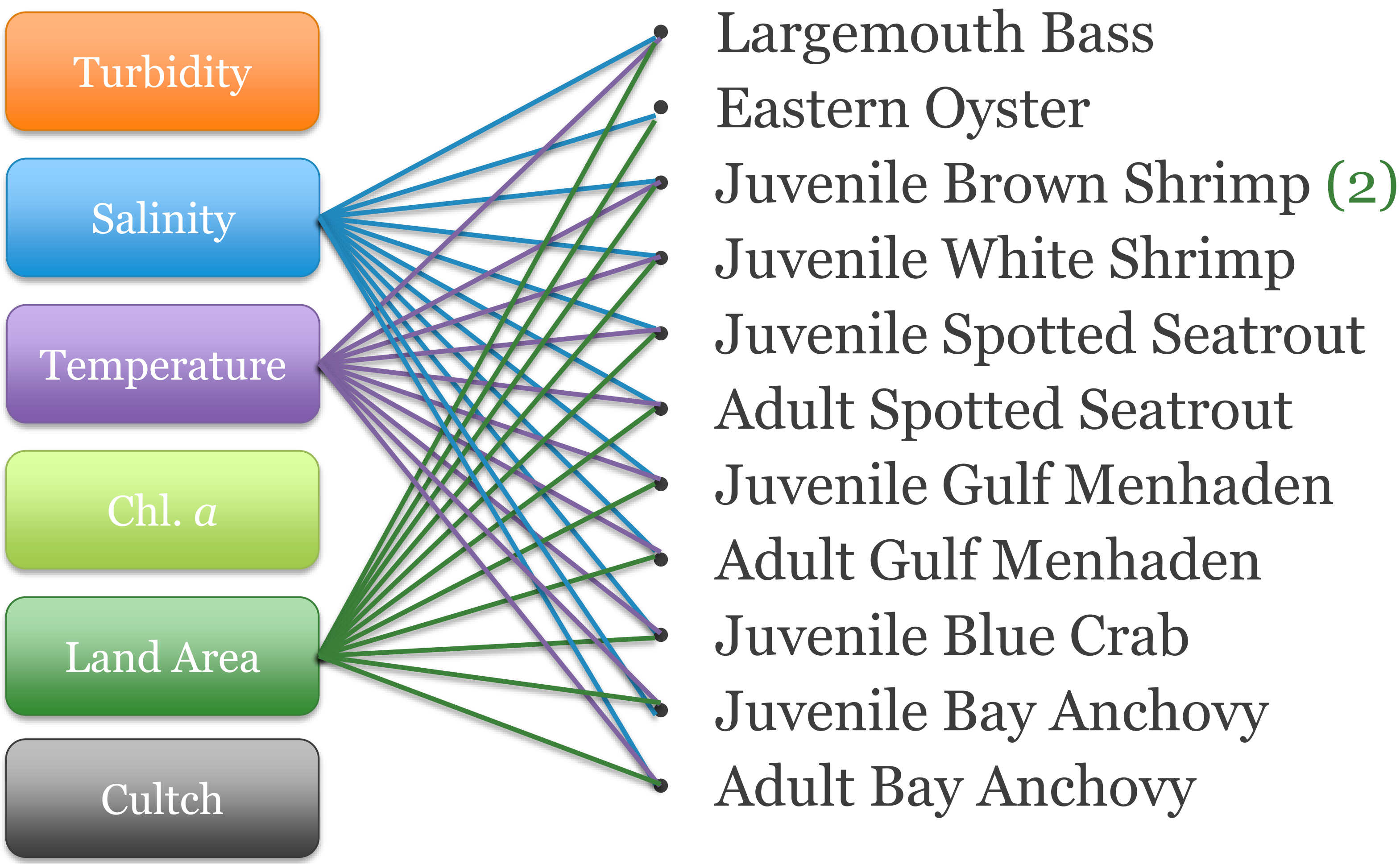
- Turbidity
- Salinity
- Temperature
- Chl. *a*
- Land Area
- Cultch

- Largemouth Bass
- Eastern Oyster
- Juvenile Brown Shrimp (2)
- Juvenile White Shrimp
- Juvenile Spotted Seatrout
- Adult Spotted Seatrout
- Juvenile Gulf Menhaden
- Adult Gulf Menhaden
- Juvenile Blue Crab
- Juvenile Bay Anchovy
- Adult Bay Anchovy

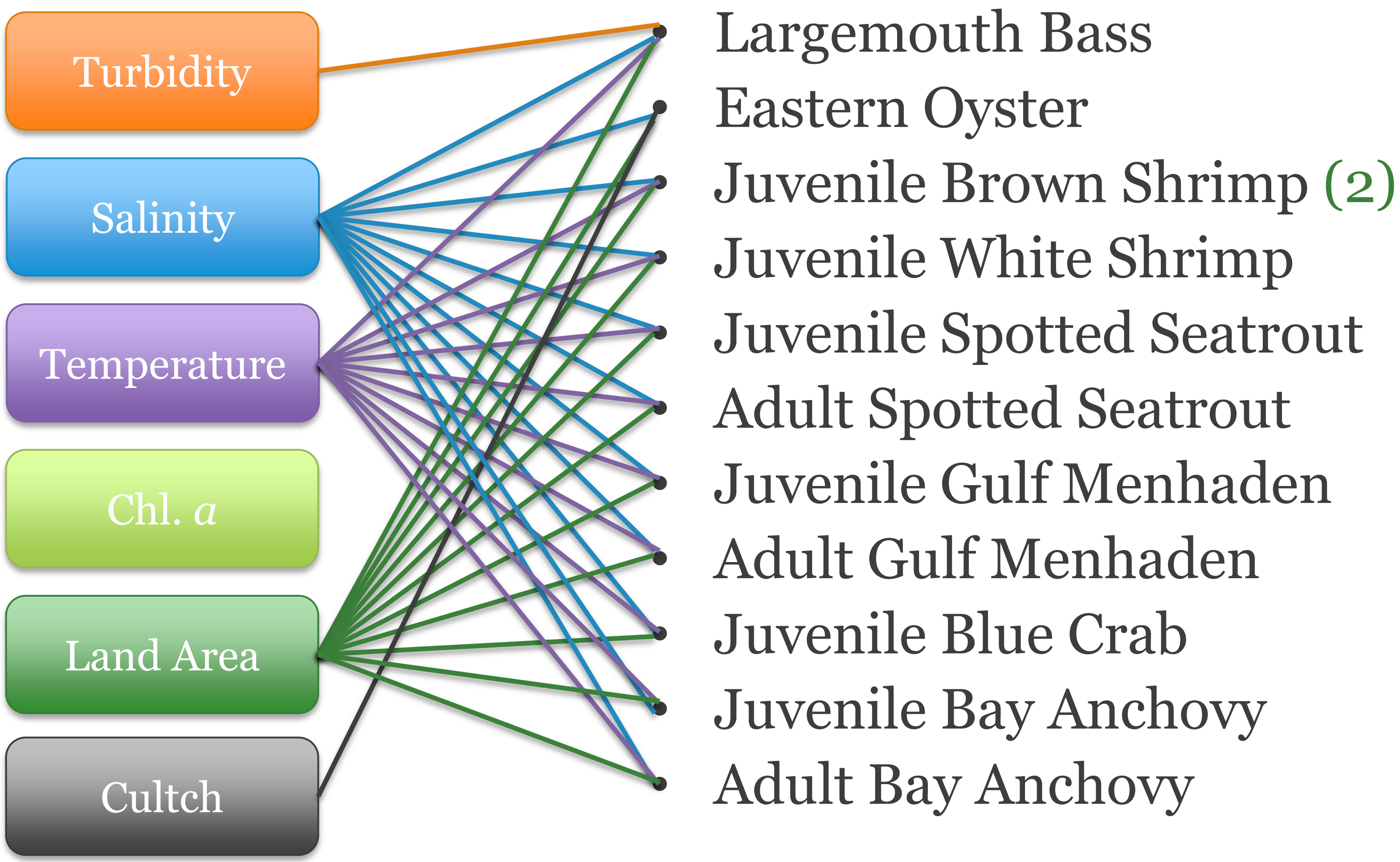
Summary of Inputs



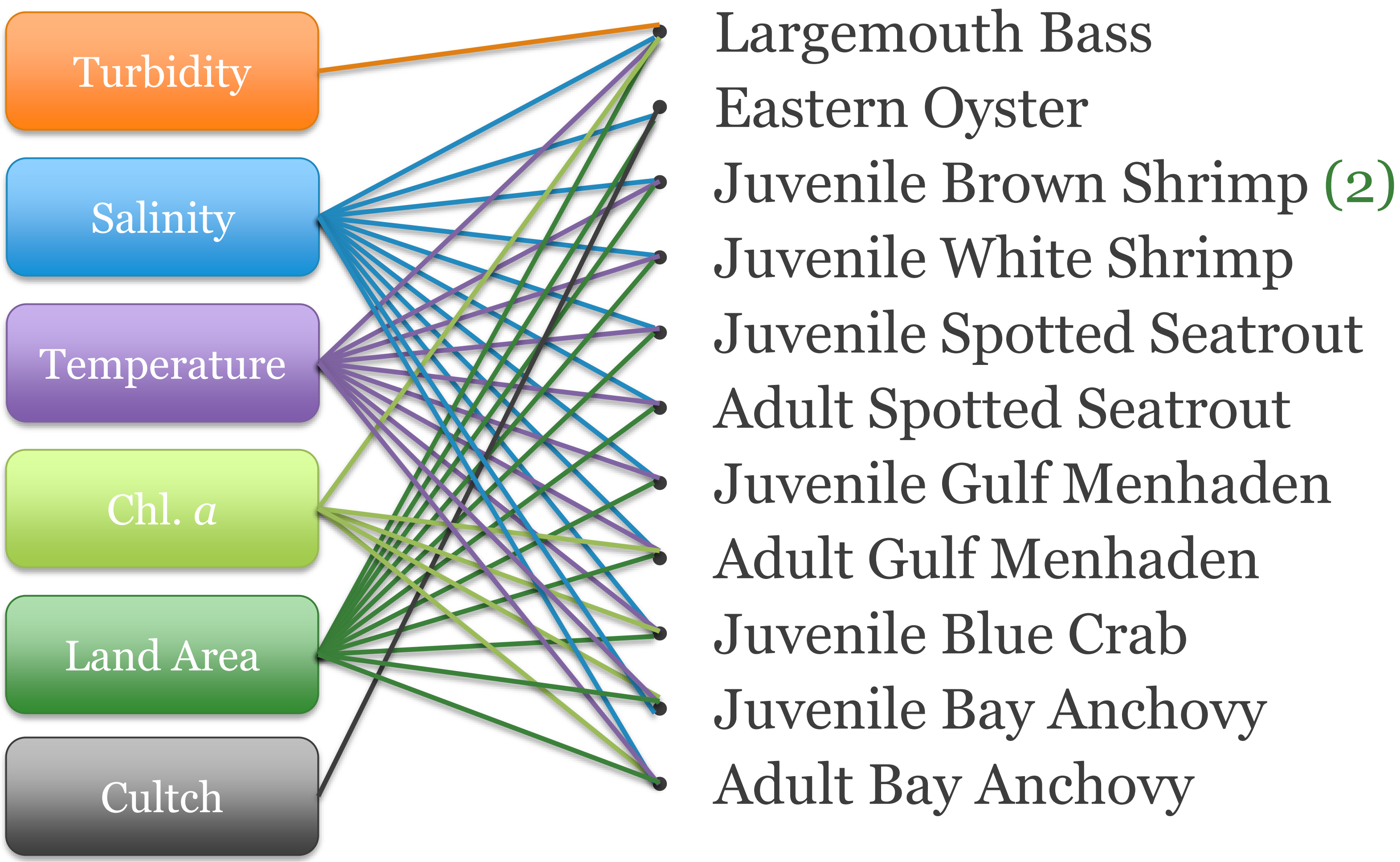
Summary of Inputs



Summary of Inputs



Summary of Inputs



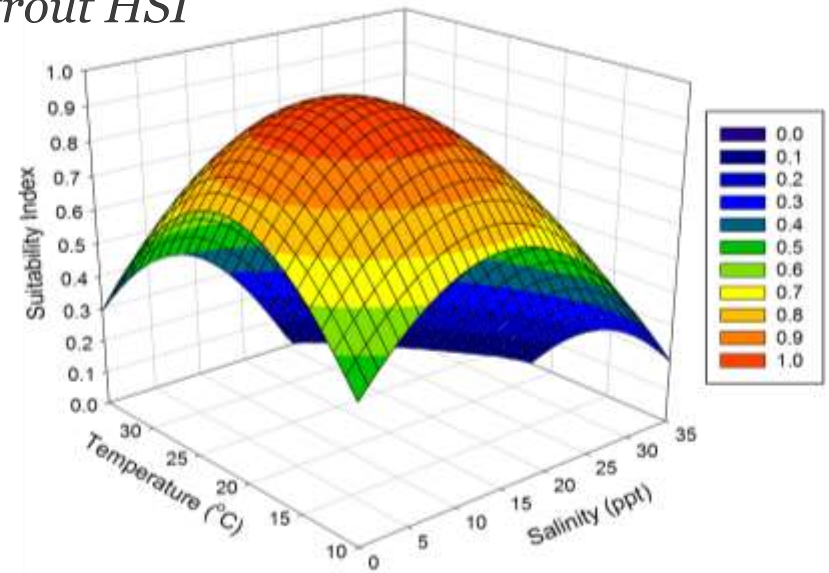
Summary of Key Updates

- Refined assumptions and updated formulas based on additional literature and data from LDWF
- **Developed statistical models relating species catch per unit effort to environmental variables**
- Examined coastwide patterns of HSI values for each species to verify model performance

Example updates from alligator HSI

Variable	Description	Source
SI_1	Percent Open Water	Modified from Newsom et al. (1987) and Nyman (2012)
SI_2	Relative Water Depth	Modified from Nyman (2012)
SI_3	Habitat Type	Modified from Newsom et al. (1987) and Nyman (2012)
SI_4	Edge	Same as Nyman (2012)
SI_5	Salinity	Same as Nyman (2012)
SI_6	Percent Deep Water	Same as Newsom et al. (1987)

Example statistical output from spotted seatrout HSI



Overview of Statistical Analysis

- Predict mean catch per unit effort (CPUE) in response to environmental variables
- Used polynomial regressions and commonly used SAS procedures (PROC GLMSELECT, PROC MIXED)
  - Designed for systematic application across the coast.
  - Analysis needed to be consistently and efficiently applied to count data for species with different life histories and environmental tolerances.
- Same statistical approach was used for each of the fish and shellfish species

Overview of Statistical Analysis

- Subset data for months species was present
- Use natural log-transformed CPUE by gear types (don't combine gears!)
- Use salinity, temperature, and in some instances, turbidity (NTU), their squared terms and interactions
- Run analysis to develop polynomial regressions that look like this....

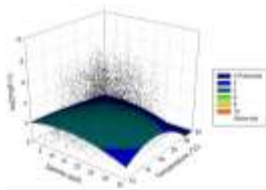
Overview of Statistical Analysis

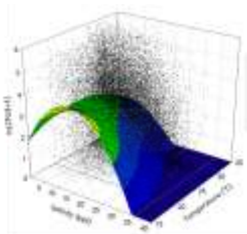
$$\ln(CPUE + 1) = -2.6496 + 0.8946(Day) - 0.1896(Day^2) - 0.00678(Salinity) + 0.4324(Temperature) - 0.0003(Salinity^2) + 0.000008(Salinity^2 * Temperature^2) - 0.00023(Temperararature * Salinity^2) - 0.00924(Temperature^2)$$

Overview of Statistical Analysis

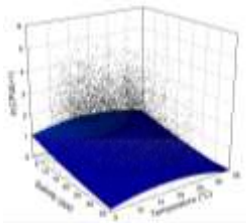
Seines | Trawls

white shrimp

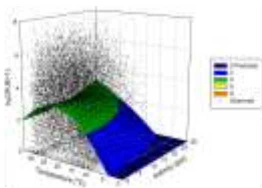


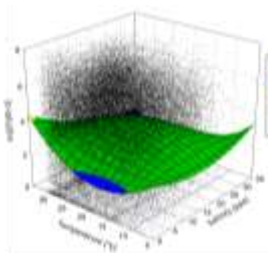


blue crab

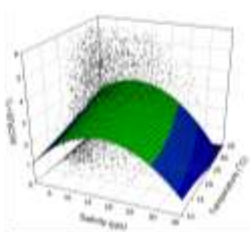


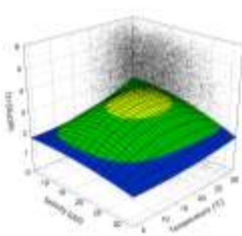
bay anchovy





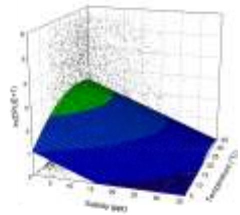
brown shrimp

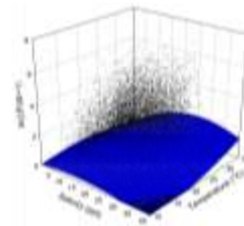




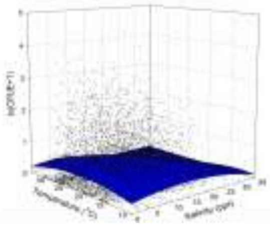
Seines | Gillnets

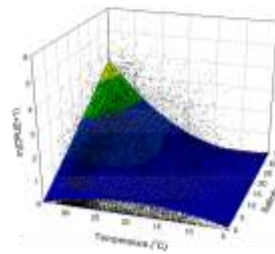
Gulf menhaden



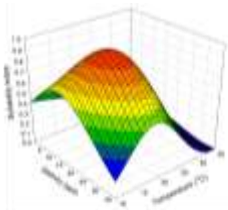
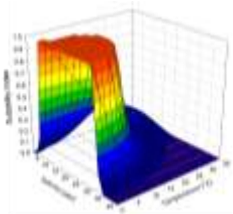
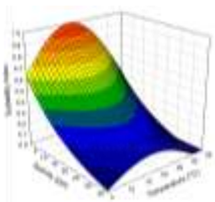
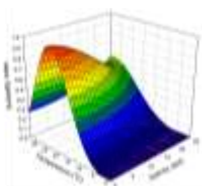
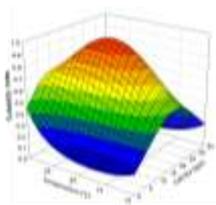
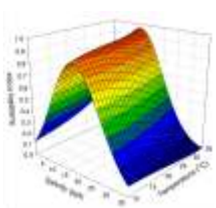
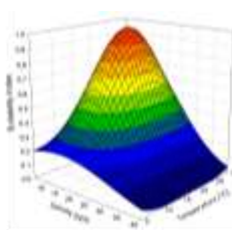


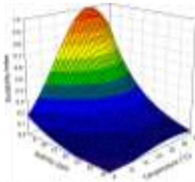
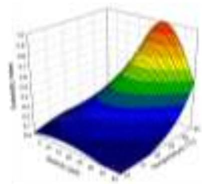
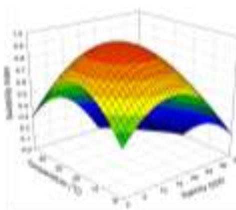
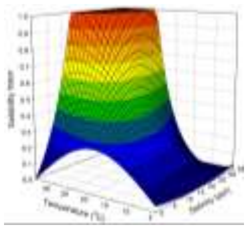
spotted seatrout





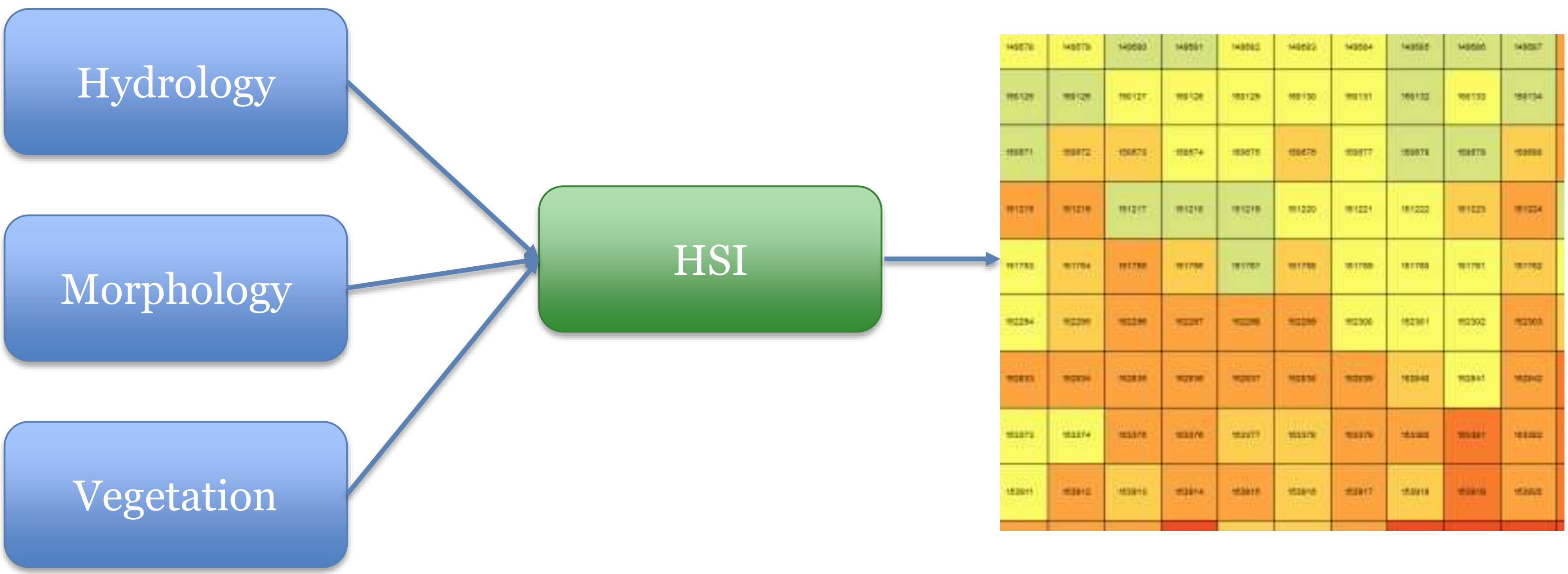
Overview of Statistical Analysis

	Seines	Trawls
white shrimp		
blue crab		
bay anchovy		
brown shrimp		

	Seine	Gillnets
Gulf menhaden		
spotted seatrout		

Integration into ICM

Input data feeds into HSI → Calculations performed annually → HSI scores generated per grid cell per species

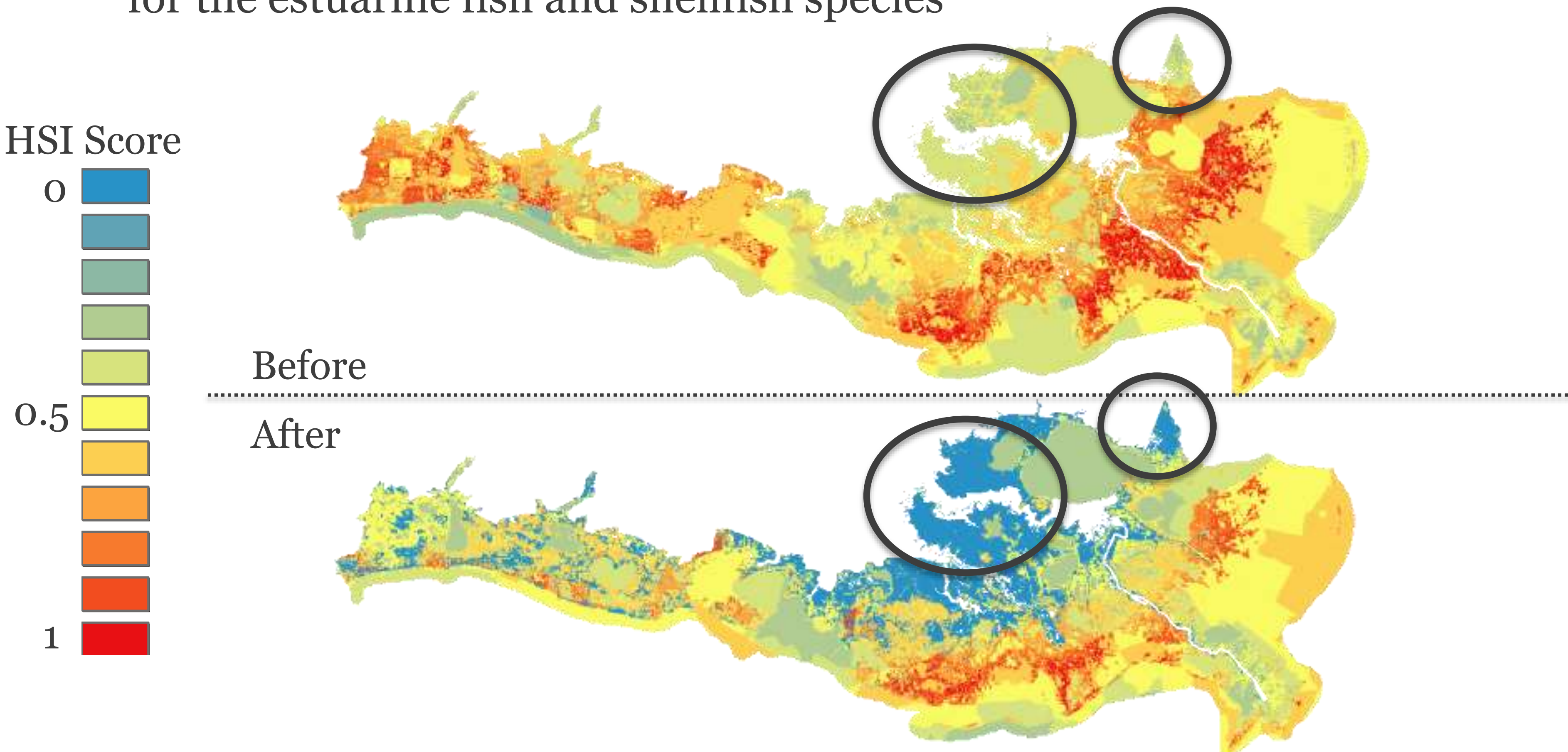


Verification – Overview

- Ensure distribution and patterns across the coast were realistic relative to current knowledge of species distributions.
- Test linkages from other subroutines to the HSI.
- Focused on the ‘big-picture’, not scores within individual grid cells.

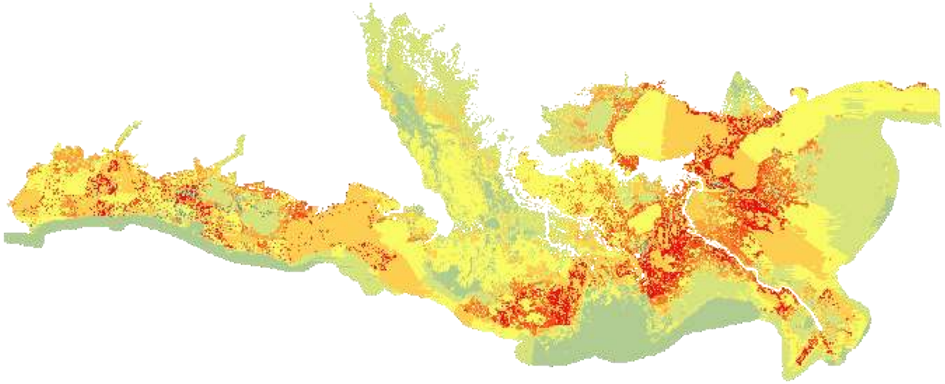
Verification – Key Findings

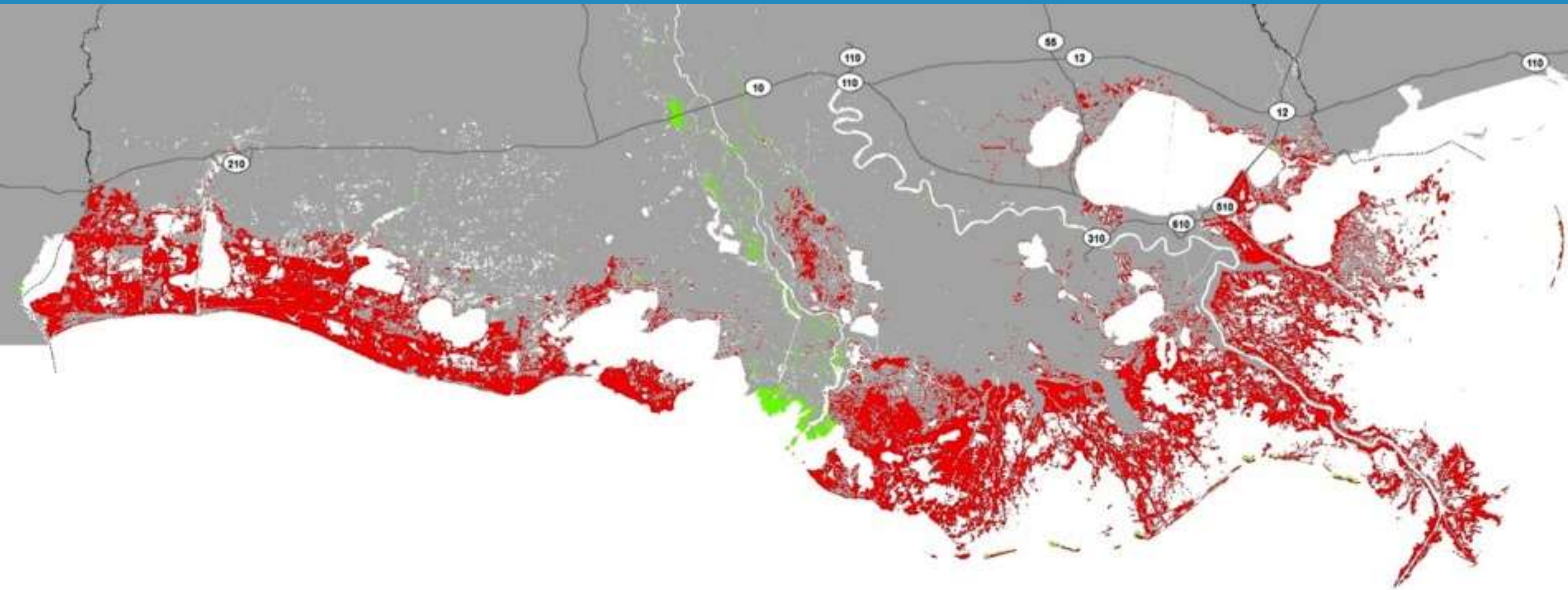
- Removal of fresh-forested wetlands from the 'habitat' calculations for the estuarine fish and shellfish species



Verification – Key Findings

- Removal of fresh-forested wetlands from the 'habitat' calculations for the estuarine fish and shellfish species.
- Adjustments in model code to improve connections from ICM sub-routines to the HSI.
- Identification of areas where results did not meet expectations (e.g., Rockefeller Wildlife Refuge).
- Addition of geographic constraints to prevent the models from generating HSI scores in areas where the species are not likely to occur.





Questions?

EwE - Simulating effects on Fish and Shellfish

Kim de Mutsert

Team Members

- Kim de Mutsert
- Kristy Lewis
- Jeroen Steenbeek
- Joe Buszowski
- Scott Milroy

Ecosystem Modeling

- New addition since 2012 Coastal Master Plan
- Tool used: Ecopath with Ecosim and Ecospace (EwE)[1]
- Food web model that accounts for effects of environmental changes, fishing, and predator-prey interactions
- Simulates changes in biomass (tonnes km^{-2}) and catch (t km^{-2} yr^{-1}) of fish and shellfish species in response to proposed protection and restoration projects
- Use of end-to-end model construction

[1] www.ecopath.org

Model Development: Ecopath

Key inputs:

- Average biomass of species representative of Louisiana estuaries
- Parameters quantifying turnover and growth: P/B, Q/B, EE, age at maturity, Von Bertalanffy growth parameters
- Diet matrix
- Representative fishing fleets and annual landings

Key outputs:

- Virtual representation of the foodweb with quantified pools and flows of biomass
- Base model for temporal (Ecosim) and spatial (Ecospace) simulations

Groups in the Model

Fish

Atlantic croaker[1]

bay anchovy[1]

black drum[1]

blue catfish[1]

coastal sharks[1]

Gulf menhaden[1]

Gulf sturgeon[1]

killifishes

largemouth bass[1]

red drum[1]

sea catfishes[1]

sheepshead[1]

Fish

silversides

southern flounder[1]

spot[1]

spotted seatrout[1]

striped mullet[1]

sunfishes[1]

Invertebrates

benthic crabs

blue crab[1]

brown shrimp[1]

eastern oyster[2]

grass shrimp

Invertebrates

mollusks

white shrimp[1]

zoobenthos

zooplankton

Primary producers

phytoplankton

SAV[3]

benthic algae

Other

seabirds

dolphins

detritus

[1]Juvenile and adult; [2]spat, seed, and sack; [3]submerged aquatic vegetation

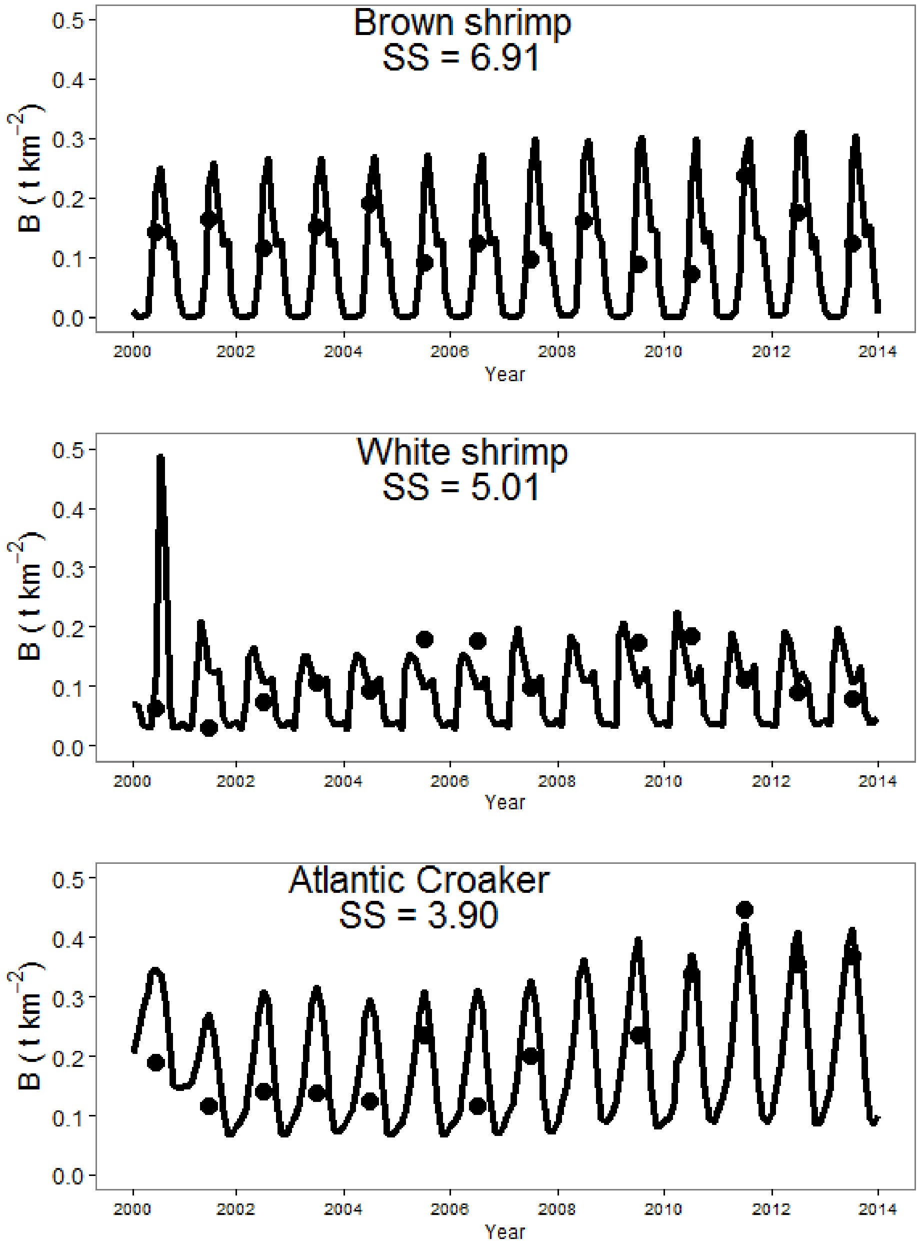
Model Development: Ecosim

Key inputs:

- Ecopath model
- Main environmental drivers of biomass change: salinity, temperature, nitrogen
- Fishing effort
- Biomass and catch time series (field observations)

Key outputs:

- Sensitivity analysis
- Calibration



Calibration

- Model output is fitted to biomass and catch observations from 2000-2013
- Model producing lowest total SS (sum of squares) is chosen

Model Development: Ecospace

Key inputs:

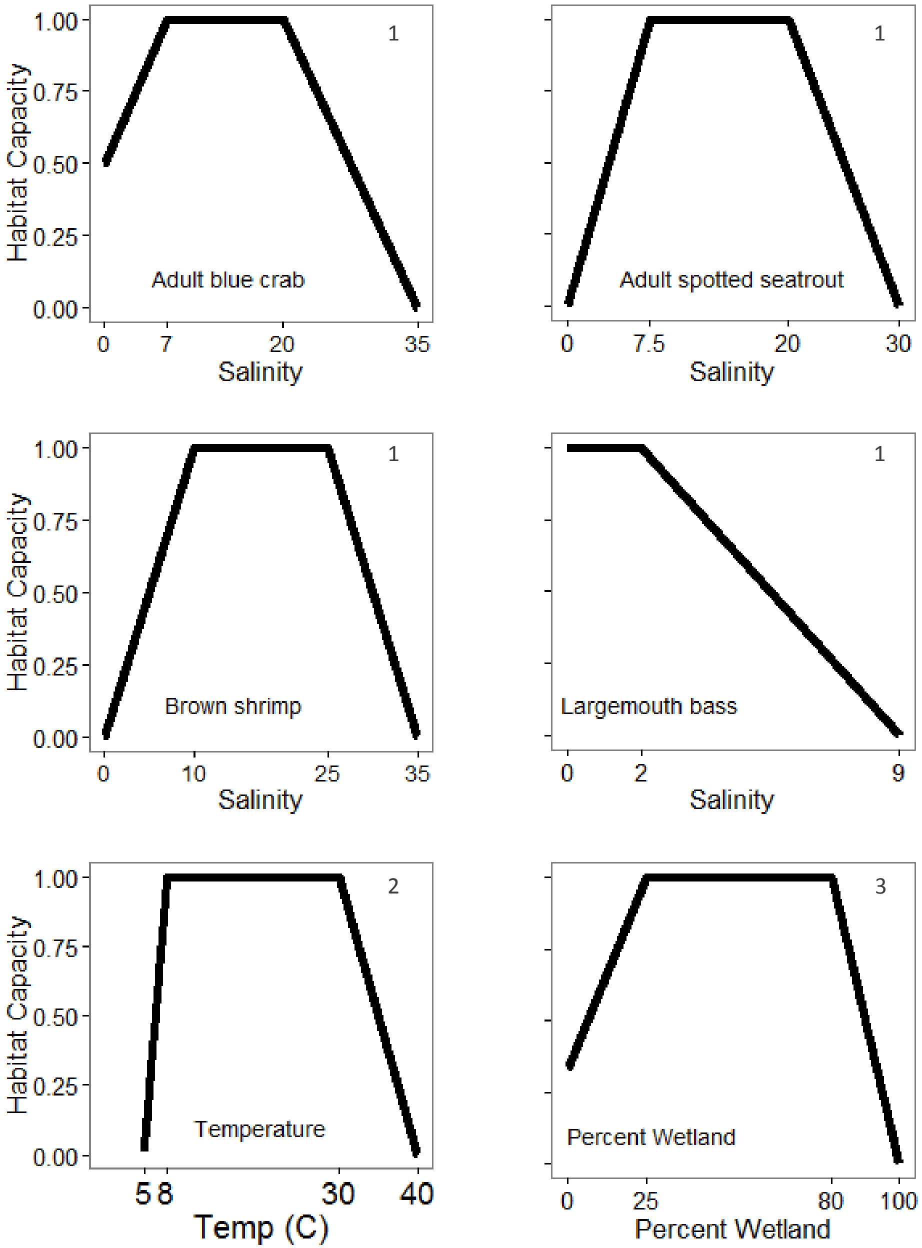
- Ecopath model
- Basemap of model area; coastal Louisiana with 1 km2 grid
- Ecosim fishing effort (annual pattern kept constant for future)
- Spatial and temporal dynamic environmental drivers: values per grid cell, per month for each decadal simulation
- Habitat features (can be dynamic when habitat changes through time)

Key outputs:

- Monthly estimated biomass and catch projections for each km2 grid cell for every 50-year simulation
- Used to determine if/where increases and/or decreases in biomass and catch can be expected under various future restoration options relative to a future without action

Environmental Driver Details

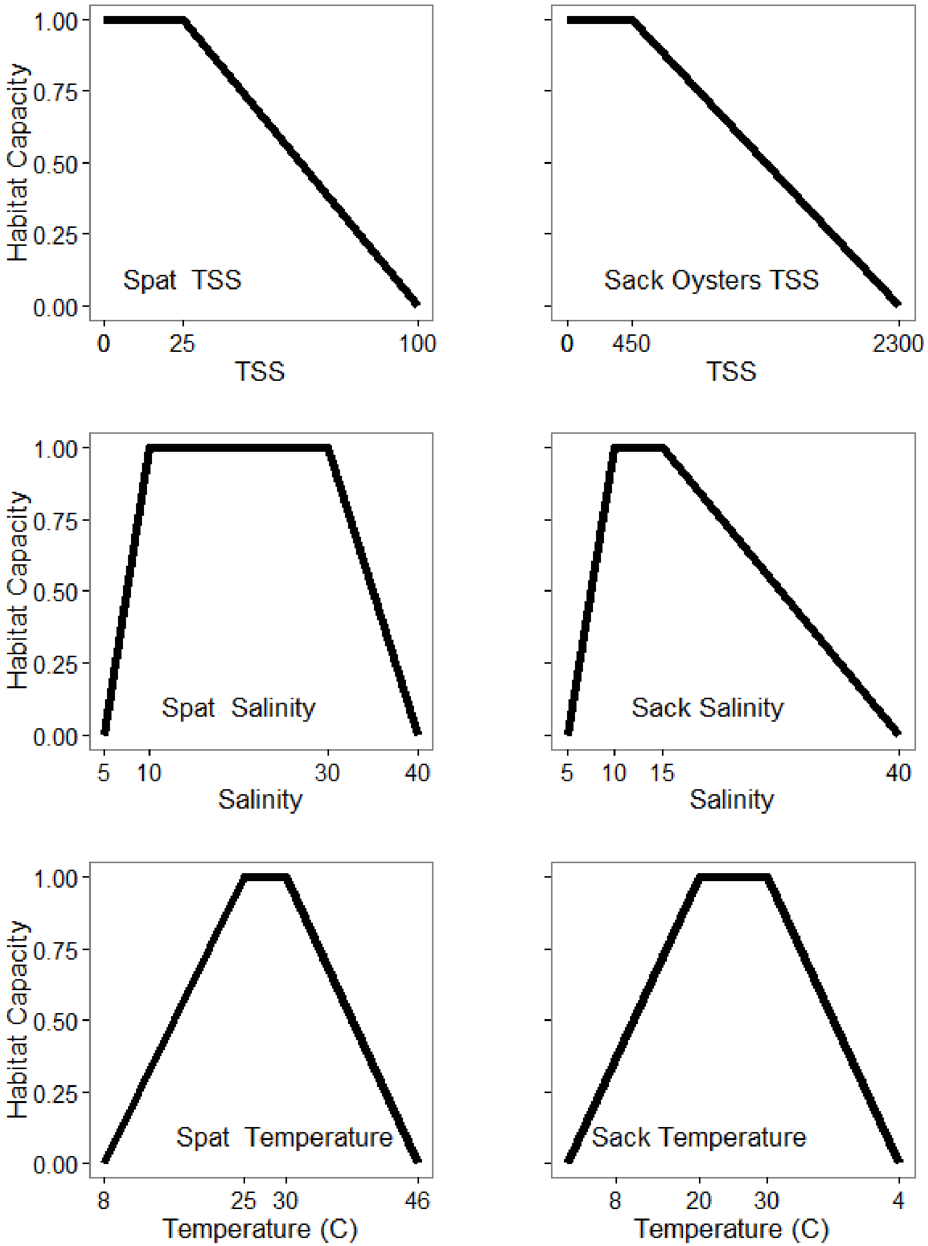
- Basemap:
  - USGS bathymetry/topography map
- Environmental drivers:
  - ICM output averaged by month for salinity, temperature, and nitrogen (TKN)
- Habitat features:
  - CPRA Cultch map
  - ICM output averaged by year for % wetland and % upland
- OECLs (oyster environmental condition layers)
  - Suitability index (0-1) for oysters based on ICM output averaged by day for salinity, temperature, and TSS (total suspended solids)



Response Curves

- The response curves describe the suitability of the parameter values to each species on a scale from 0-1 based on the species tolerance range
- Movement to unsuitable cell reduced by multiplier based on all parameters affecting a species
- Unsuitable cells will have reduced availability of prey

[1]Expert advice from LDWF and NOAA; [2]empirical data; [3]Minello and Rozas (2002)

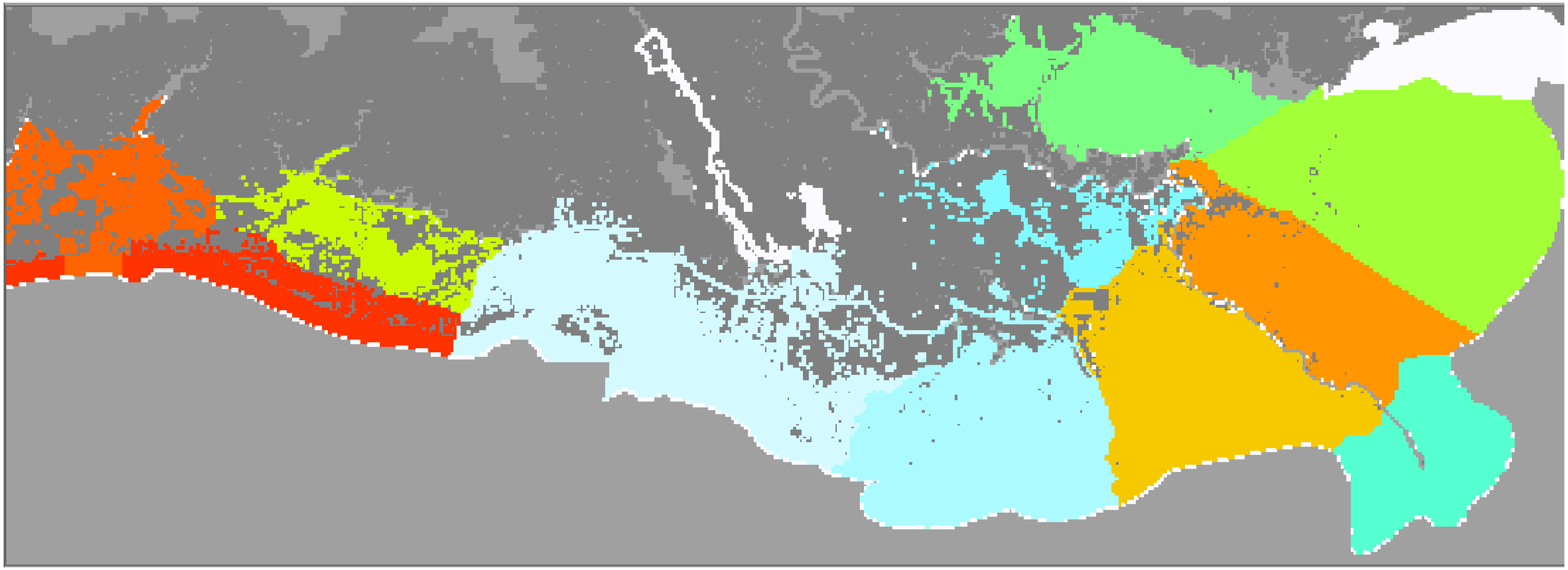


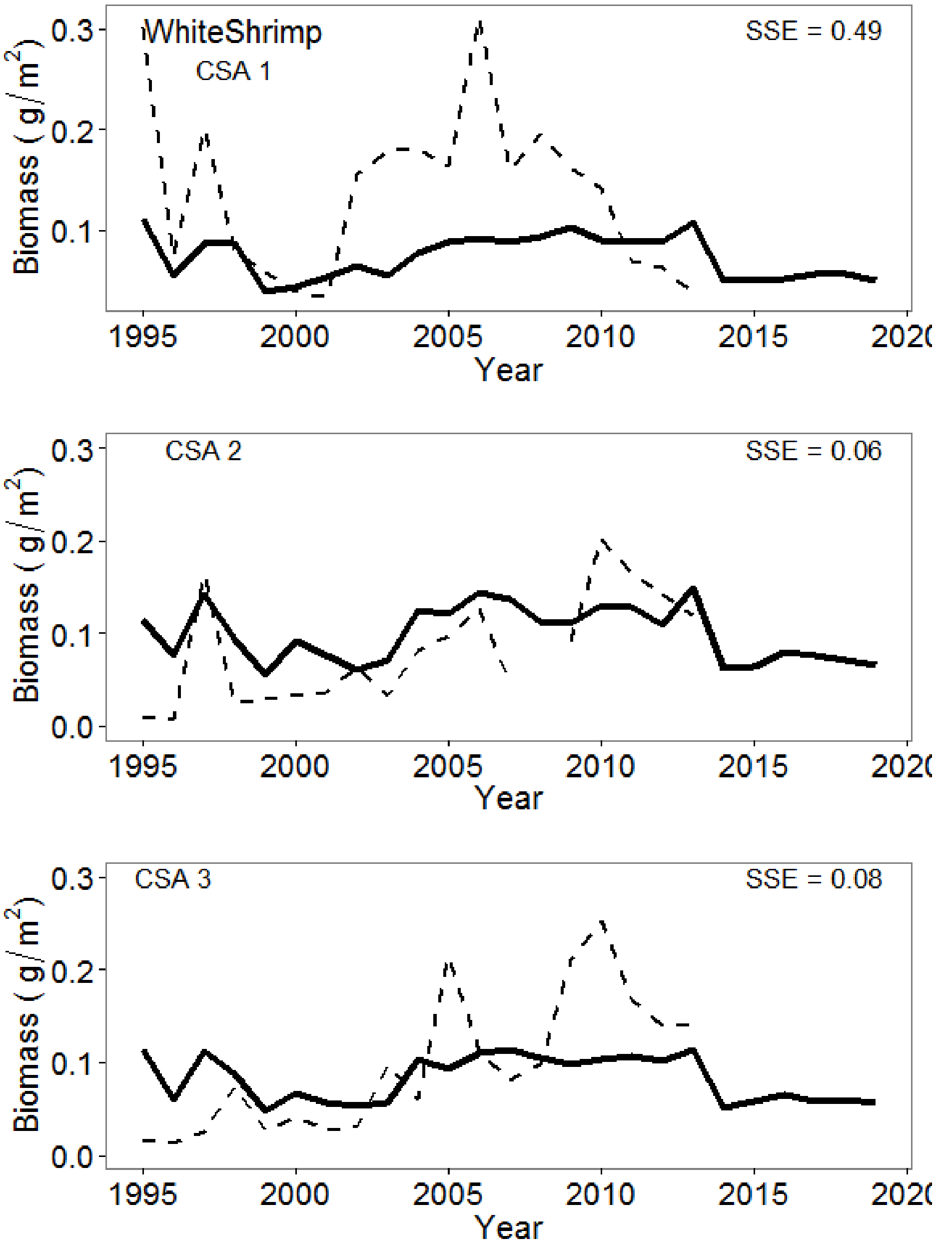
OECLs

- Oyster[1] habitat capacity in any month gets determined by combined daily temperature (°C), salinity, and total suspended solids (mg/l)
- This is to avoid missing short-term (< month) unsuitable conditions for oysters that could have an effect on long-term oyster biomass

[1]Determined separate for spat, seed oysters, and sack oysters

Model Area

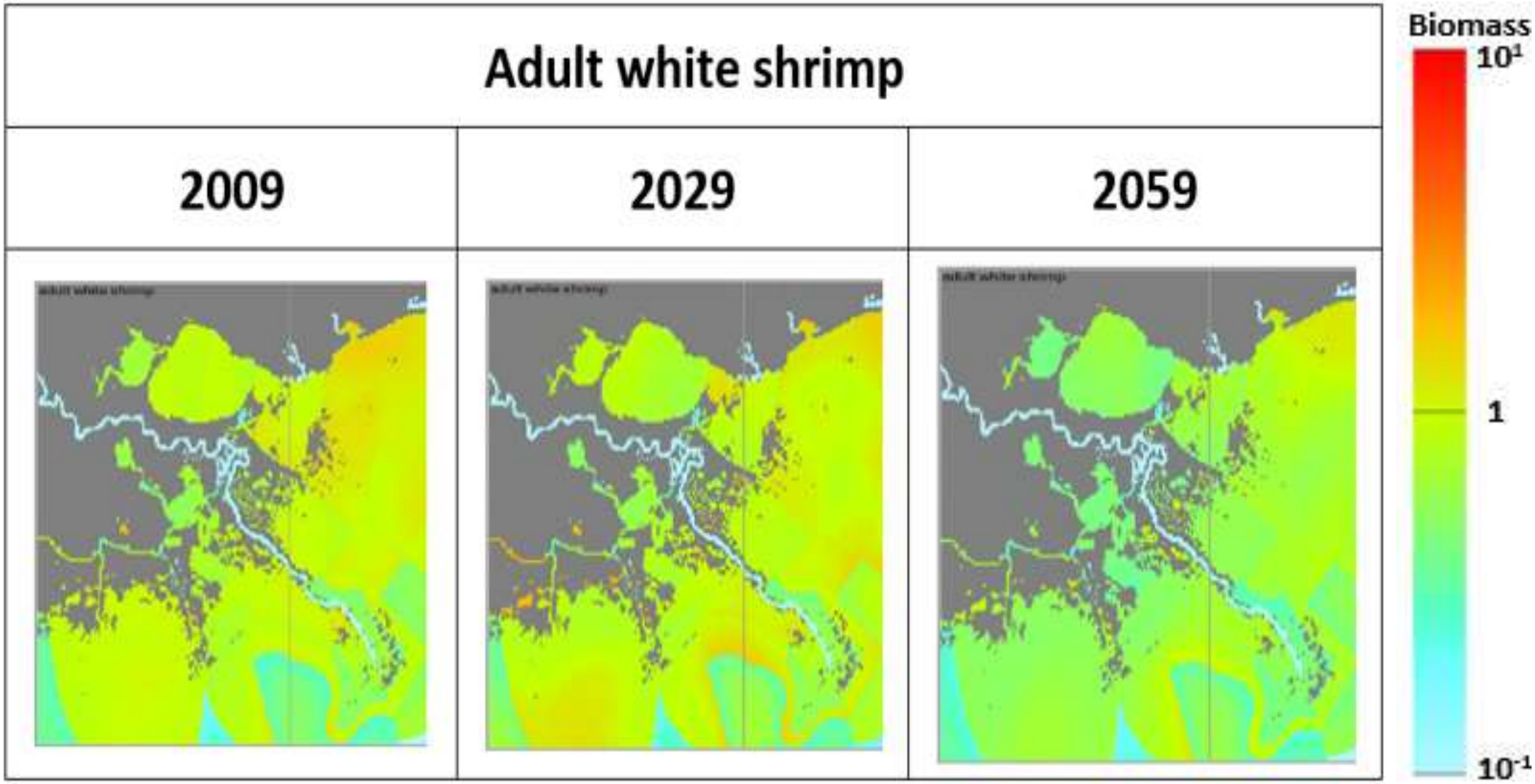


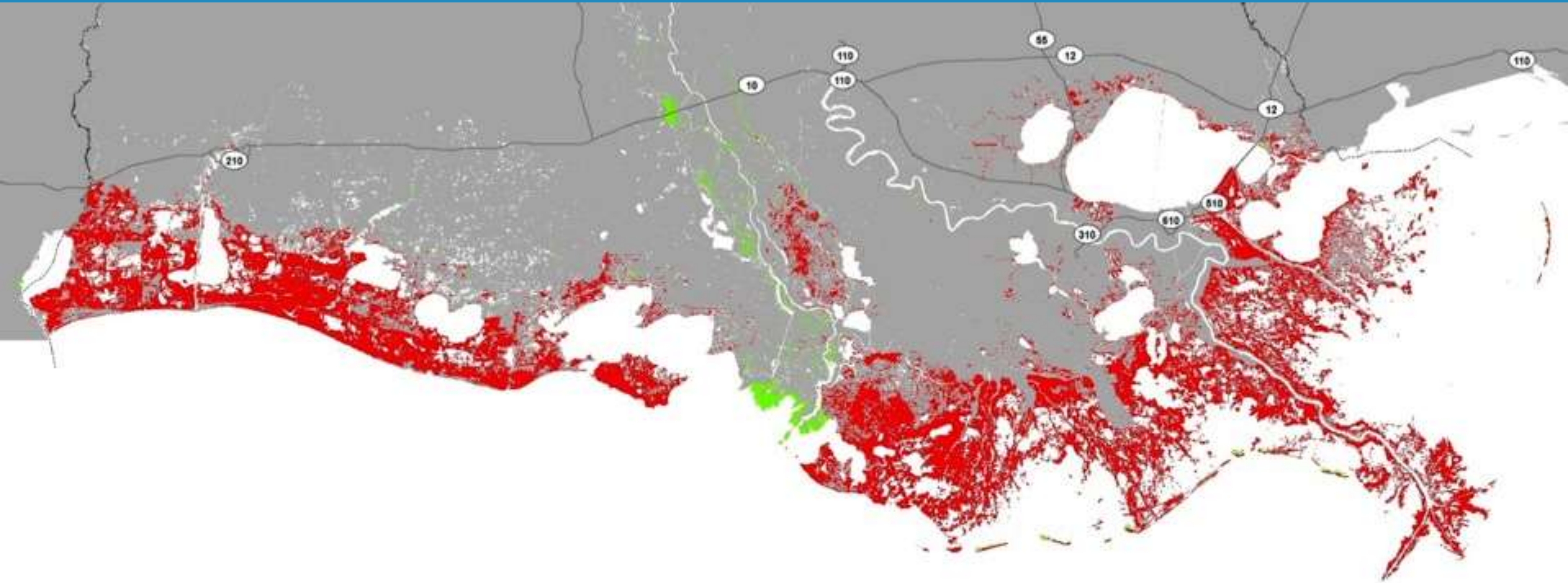


Validation Example

- Validation tests spatial distribution with regional spot-checks of model output versus local field collections
- Model output, not field data, is used for environmental drivers during validation period
- Spatial validation run from 2000-2013

Example Output Future Without Action





Questions?

Next Steps

- For additional information on the 2017 Coastal Master Plan including modeling technical reports: http://coastal.la.gov/a-common-vision/2017-master-plan-update/
- A recording of today's webinar will be posted to the master plan's Videos page: http://coastal.la.gov/resources/videos/#overview
- Please send any additional questions to masterplan@la.gov

THANK YOU

coastal.la.gov