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## 2017 Coastal Master Plan

# Appendix C: Modeling

## Chapter 1 – Introduction

Report: Final

Date: April 2017

Prepared By: The Water Institute of the Gulf

# Coastal Protection and Restoration Authority

This document was prepared in support of the 2017 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every five years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

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# Executive Summary

Coastal Louisiana has experienced dramatic land loss since at least the 1930's. A combination of natural processes and human activities has resulted in the loss of over 1,880 square miles since the 1930's and a current land loss rate of 16.6 square miles per year. Not only has this land loss resulted in increased environmental, economic, and social vulnerability, but these vulnerabilities have been compounded by multiple disasters, including hurricanes, river floods, and the 2010 Deepwater Horizon oil spill, all of which have had a significant impact on the coastal communities in Louisiana and other Gulf coast states. To address this crisis the 2007 Coastal Master Plan was developed under the direction of the Louisiana Legislature. 2012 marked the first five-year update to the plan, and the second update is scheduled for 2017.

A number of substantial revisions have been made in preparation for the 2017 Coastal Master Plan modeling effort. Chapter 1 provides an overview of the modeling improvements and other components of the Master Plan with which the modeling is associated. Brief descriptions of project modeling and the interaction of the modeling with the Planning Tool are included, as is an overview of the external peer review of the 2012 modeling tools and the 2017 model improvement planning process. Lastly, Chapter 1 provides information on the Predictive Models Technical Advisory Committee (PM-TAC), external reviews, and a comprehensive list of 2017 Coastal Master Plan modeling team members.

Additional details for the modeling components are provided in a series of attachments.

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# List of Abbreviations

| | |
|---|---|
| ADCIRC | Advanced Circulation |
| BIMODE | Barrier Island Model |
| CLARA | Coastal Louisiana Risk Assessment |
| CPRA | Coastal Protection And Restoration Authority |
| EAD | Expected Annual Damage |
| EwE | Ecopath With Ecosim |
| FEMA | Federal Emergency Management Agency |
| HSI | Habitat Suitability Index |
| ICM | Integrated Compartment Model |
| LACPR | Louisiana Coastal Protection and Restoration |
| LCWCRTF | Louisiana Coastal Wetlands Conservation and Restoration Task Force |
| PM-TAC | Predictive Models Technical Advisory Committee |
| SWAN | Simulating Waves Nearshore |
| TAC | Technical Advisory Committee |
| USACE | U.S. Army Corp Of Engineers |
| USGS | U.S. Geological Survey |

# Chapter 1: Introduction

## 1.0 Louisiana's Coastal Master Plan Overview and Purpose

Coastal Louisiana has experienced dramatic land loss since at least the 1930's (Couvillion et al. 2011). A combination of natural processes and human activities has resulted in the loss of over 1,880 square miles since the 1930's and a current land loss rate of 16.6 square miles per year (Couvillion et al. 2011). Not only has this land loss resulted in increased environmental, economic, and social vulnerability, but these vulnerabilities have been compounded by multiple disasters, including hurricanes, river floods, and the 2010 Deepwater Horizon oil spill, all of which have had a significant impact on the coastal communities in Louisiana and other Gulf coast states. For example, nine of the 10 costliest U.S. hurricanes have impacted a portion of the Gulf coast, and six of these have occurred in the last decade (Blake, Landsea, and Gibney, 2011). Hurricane Katrina resulted in at least $105 billion in direct property damages (Blake, Landsea, and Gibney, 2011).

Decades of planning have focused on addressing either risk reduction or coastal restoration, or only on specific regions of coastal Louisiana (e.g., Coast 2050 [LCWCRTF, 1998]; LACPR [USACE, 2009]; Morganza PAC [USACE, 2013]). It was not until the hurricanes of 2005 that planning efforts began to integrate coastal restoration planning with coastal protection planning. Under the direction of the Louisiana Legislature, the 2007 Coastal Master Plan was developed, and for the first time in Louisiana, emphasis on coordinated storm protection and coastal restoration planning was outlined. The Coastal Protection and Restoration Authority of Louisiana (CPRA), the state entity responsible for the planning, designing and implementation of coastal protection and restoration projects, is tasked by the Louisiana Legislature to update the master plan every 5 years. For the first update in 2012, CPRA focused on expanding the technical analysis to identify specific projects: those that represent sound investments for Louisiana considering resource and funding constraints and uncertain future conditions. The 2012 Coastal Master Plan built on previous efforts by including a detailed assessment of the future without action and an objective evaluation of the performance of hundreds of previously proposed projects, including nonstructural measures, over the next 50 years. The final 2012 Coastal Master Plan included a specific list of recommended restoration and protection projects and modeled predictions of how those projects might perform. This report supports the 2017 Coastal Master Plan, which builds on the work of all previous planning efforts in coastal Louisiana, leverages knowledge developed by generations of scientists and engineers, and utilizes decades of experience building and maintaining coastal restoration and protection projects across the coast.

The 2017 Coastal Master Plan has five objectives:

1. Reduce economic losses from storm surge-based flooding
2. Promote a sustainable coastal ecosystem by harnessing the processes of the natural system
3. Provide habitats suitable to support coast wide commercial and recreational activities
4. Sustain the unique cultural heritage of coastal Louisiana
5. Promote a viable working coast to support important businesses and industries

The master plan focuses the State's efforts and guides the actions needed to sustain the coastal ecosystem, safeguard coastal populations, and protect economic and cultural resources. The master plan also provides the context needed to evaluate other activities in the coastal zone, including: transportation, navigation, and port projects; oil and gas development; ground water management; and land use planning. It is the guiding document of CPRA and the State of Louisiana's efforts to protect and restore the Louisiana coast.

# 2.0 2012 Coastal Master Plan Modeling

During the development of the 2012 Coastal Master Plan, 397 individual projects were evaluated within a systems context using a suite of predictive models, as depicted in Figure 1. The linked models predicted change in the conditions of the Louisiana coastal system under two different types of future management strategies, a future without the implementation of additional restoration and risk reduction projects (Future Without Action - FWOA) and a future with implementation of additional projects. The concept of linked models in Louisiana coastal planning was not new, as linked models were applied to aid restoration planning for the 2004 Louisiana Coastal Area Study (USACE, 2004) and several linked models were used to inform the 2007 Coastal Master Plan (CPRA, 2007; Appendix G). However, substantially improved or entirely new feedbacks and linkages among models were developed and utilized to support the 2012 Coastal Master Plan process (Peyronnin et al., 2013). Each of the models provide inputs to other models and/or produce outputs that were used to estimate how the landscape might change and/or how projects might perform on the landscape over time.

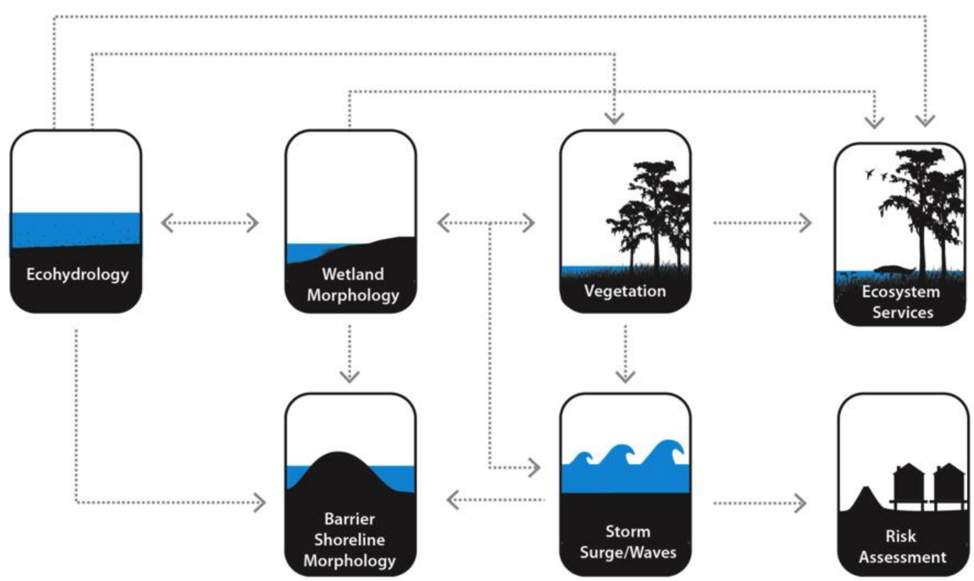


**Figure 1: 2012 Coastal Master Plan Predictive Models.**

The 2012 Coastal Master Plan modeling components were:

- Eco-hydrology - The eco-hydrology model consisted of three individual models (encompassing the Chenier Plain region, the Atchafalaya-Terrebonne region, and the Pontchartrain-Barataria region) that were integrated to provide coast wide outputs (Meselhe et al., 2013). Each model predicted the salinity, stage, and other selected water quality constituents of the open water bodies (including channels) within estuaries using a mass balance approach to estimate the exchanges of solids and chemicals due to advection and dispersion.

- Wetland morphology - This model tracked the changes in wetland-dominated landscapes over time including the loss of existing wetlands, the creation of wetlands by both natural and artificial process, and the fate of those newly created wetlands (Couvillion et al., 2013). Whereas previous modeling efforts simply projected past trends into the future, this model considered more characteristics of the landscape as predictors of change.
- Barrier shoreline morphology - Changes in barrier shorelines and headlands were derived from a simple shoreline change model driven by analysis of historical shorelines that are a part of the Barrier Island Comprehensive Monitoring project (BICM; Hughes et al., 2012).
- Vegetation - The vegetation model predicted the extent of 19 types/communities of emergent vegetation and submerged aquatic vegetation (Visser et al., 2013). It estimated spatial and temporal changes in vegetation types/communities based on environmental drivers such as salinity and water level change.
- Ecosystem services - These models were used to predict how well Louisiana's future coast will provide habitat for commercially and recreationally important coastal species, and key services for coastal communities (Nyman et al., 2013). In total, 19 ecosystem service models were utilized to reflect species habitat, surge/wave attenuation potential (restoration projects only), nature-based tourism, freshwater availability, potential for agriculture/aquaculture, nitrogen uptake potential (Rivera-Monroy et al., 2013), and carbon sequestration potential (CPRA 2012).
- Storm surge/waves - For risk reduction projects or groups of projects, this model used the widely-adopted ADCIRC large domain storm surge model coupled with the unstructured SWAN wave model (Cobell et al., 2013). ADCIRC uses an unstructured mesh that allows for variation of resolution from coarse in the open ocean to very fine near islands, channels, levees, and areas where flow gradients are large (such as in channels and wave breaking zones).
- Risk assessment - This model estimated residual economic damage from storm surge flooding by predicting the overtopping of flood risk reduction structures due to surge and waves, assessed probabilistically any flooding due to breaching of hurricane risk reduction systems, calculated flood elevations, and identified economic consequences (Johnson, Fischbach, and Ortiz, 2013).

An uncertainty analysis was also conducted for the models addressing change in the coastal landscape and ecosystem (Habib and Reed, 2013). Typically, an uncertainty analysis is implemented such that all sources of parameter uncertainties are propagated starting from the first model (e.g., eco-hydrology), through the intermediate models (e.g., wetland morphology) and ending with the last model(s) (e.g., ecosystem service models). This approach, however, requires an excessively large number of simulations. Instead, the adopted analysis started from the end of the modeling components, focusing on the important outputs, and then worked back to determine the most 'uncertain' parameters that were most relevant for such outputs. This approach was driven by the master plan focus on assessing both near and long-term effects of proposed protection and restoration projects. The analysis found that model predictions of land area 20 years into the future in most regions have uncertainty bounds of less than ±5% if a confidence interval of (25-75%) is used, and less than ±10% if a confidence interval of (10-90%) is used. Furthermore, the uncertainty in land area predictions was similar across the different regions along the coast, and uncertainties of model predictions of land area became larger as the prediction extended into the future years.

# 3.0 Modeling Improvements

Following the completion of the 2012 Coastal Master Plan, a thorough technical peer review of the models was conducted, and the process generated a number of recommendations for model improvements. The 2012 Habitat Suitability Indices (HSIs) did not undergo review. Recommendations for improvement were also made by the 2012 Coastal Master Plan modeling teams. To consider potential improvements in the models for use in support of the 2017 Coastal Master Plan, local, national, and international experts were engaged during two 'brainstorming workshops' in fall 2012 to discuss and establish the technical aspects for developing a refined modeling approach. In general, recommendations pointed to the development of a more integrated and process-based modeling framework for hydrodynamic, morphological, and ecological components, as well as an increase in the resolution and detail. For models supporting risk assessment, the focus was on improving data sources and consideration of parametric uncertainty.

Based in part on the recommendations of the technical peer review of the 2012 models and input from the modeling teams, a Model Improvement Plan (CPRA, 2013) was developed, which called for a number of desired improvements in the modeling approach including:

- Refining the size of the compartments in the hydrology model to increase the spatial resolution;
- Developing and integrating the simulation of physical and ecological processes controlling landscape and ecosystem dynamics;
- Integrating landscape model components where possible to reduce manual data transfer and facilitate an increase in output frequency; and
- Improving spatial resolution within the risk assessment model, using updated data, and understanding of parametric uncertainty.

Specific recommendations from the external peer review process that were either partially or completely addressed as part of the 2017 modeling update effort are listed below:

**Eco-hydrology**

- Regional integration
- Better representation of the water, sediment and nutrient budgets
- Improve how sediment flux calculations are implemented in the models
- Synthesize missing data required to drive long-term simulations

**Wetland Morphology**

- Include mechanistic improvements to soil processes
- Incorporate stochastic effects of storms

**Barrier Islands**

- Examine and consider developing hybrid models
- Couple island and inlet models more frequently than 25 years
- Incorporate stochastic effects of storms
- Carry out both calibration and validation phases

**Vegetation**

- Incorporate additional processes into the model (e.g., dispersal/recruitment mechanisms)
- Test/validate the model
- Address model integration and error propagation

**Storm Surge**

- Improve bottom friction and surface wind stress parameterizations
- Include a larger set of synthetic storms
- Increase commitment of computational resource

# 4.0 2017 Coastal Master Plan Technical Components

## 4.1 Modeling

The 2017 modeling effort largely builds on the 2012 Coastal Master Plan models. It was directed by a team made up of CPRA and Water Institute personnel (the Model Decision Team) and carried out largely by a multi-disciplinary team of experts from state and federal agencies, academia, and the private sector; see Table 2 in the 2017 Modeling Team Section. As noted above, the first step was the development of the Model Improvement Plan (CPRA, 2013), which laid out a path forward for the improvements to be made to the modeling tools prior to use for the 2017 Coastal Master Plan. The result was substantial revisions and improvements to the 2012 models, including entirely new modeling approaches in some cases (e.g., barrier islands, fish and shellfish community models). Additional details regarding the modeling are provided in Chapter 3 and in the Attachments to this appendix.

The Integrated Compartment Model (ICM) replaces four previously independent models (eco-hydrology, wetland morphology, barrier shoreline morphology, and vegetation) with a single model code for all regions of the coast (Figure 2). It also includes the components of the previous ecosystem services models that are being carried forward for 2017, and enables integrated execution of the new fish and shellfish community models. Such integration allows for coupling of processes and removes the inefficiency of manual data hand-offs and the potential human error that may occur during the transfer of information from one model to another. The ICM is computationally efficient and can be used for a large number of 50-year, coast wide simulations in a reasonable timeframe. The ICM serves as the central modeling platform for the 2017 Coastal Master Plan to analyze the landscape and ecosystem performance of individual projects and alternatives (groups of projects) under a variety of future environmental scenarios. Key outputs include hydrodynamic variables (e.g., salinity and stage), changes in the landscape (e.g., land-water interface and elevation change, including the barrier islands), and changes in vegetation.

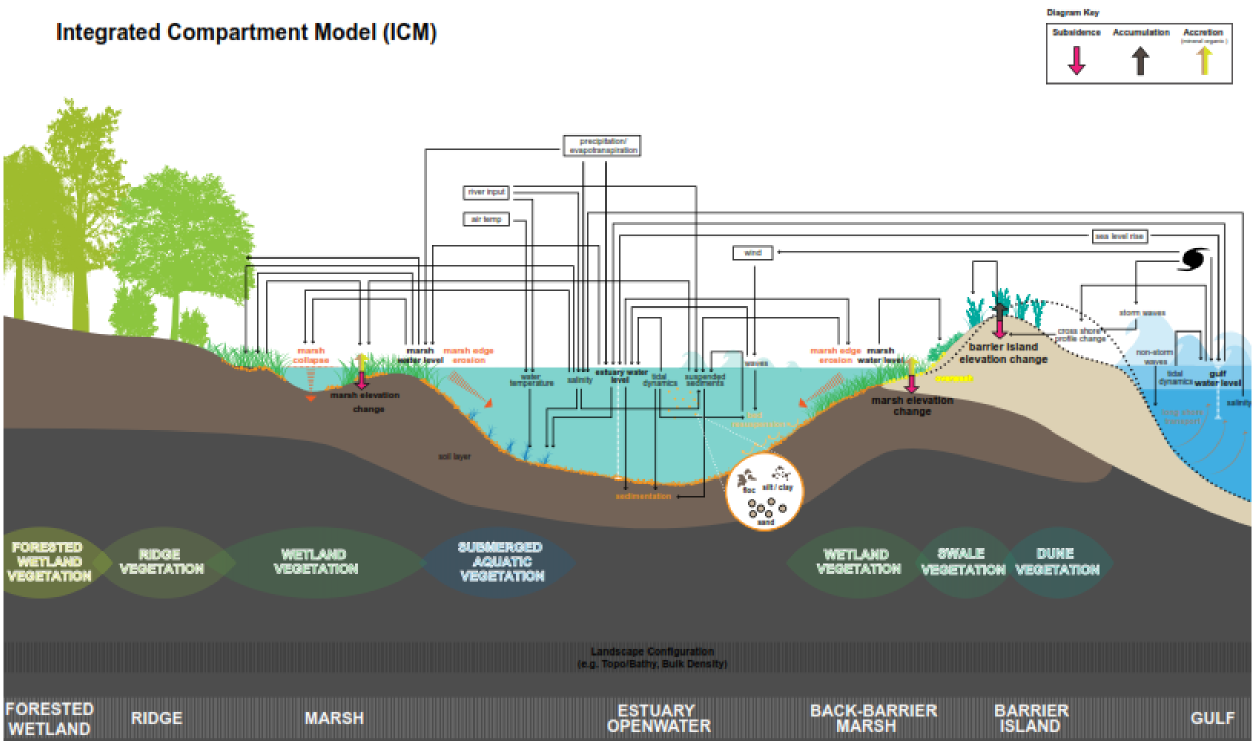


**Figure 2: Coastal Components and Processes Represented by the Integrated Compartment Model (ICM).**

One new element of the 2017 modeling is the inclusion of fish and shellfish community modeling. A thorough review of fish and shellfish community modeling options was conducted, and ideas were provided on how to select one model over another for use in the 2017 Coastal Master Plan (Rose and Sable, 2013). As a result of this effort, two paths were pursued for improving the representation of fish and shellfish changes in the modeling. A number of improvements were made to the habitat suitability index models (HSIs), including the development of new relationships for many key fish and shellfish based on rigorous statistical analysis and the inclusion of several new indices including blue crab and brown pelican. A total of 19 HSIs are being used for the 2017 Coastal Master Plan and have been integrated into the ICM. In addition, a community modeling approach will be used to evaluate effects of restoration and protection projects on fish and shellfish communities. The model is a spatially explicit ecosystem model (Ecospace model) developed in Ecopath with Ecosim (EwE).

The hydrodynamics, morphology (including barrier islands), and vegetation components of the ICM underwent calibration and validation. Calibration of each component was conducted to the extent possible considering data availability and time in the overall schedule. The EwE model was also calibrated and validated using observed data, and the HSIs underwent 'expert validation' based on best professional judgment of the model's projections of habitat quality. Additional information is provided in Chapter 3 and in the individual attachments.

Fewer changes were made to the approach used for surge and risk modeling. The ADCIRC-SWAN model is being used for storm surge and waves. The model geometry was updated to improve prediction in some areas, and the revised model was validated with observed data from Gustav and Ike. Approaches to incorporate raised features in the model grid, adjust the wind drag formulation, and assess symmetrical versus asymmetrical storm patterns were also explored. Improvements to the Coastal Louisiana Risk Assessment model (CLARA) include expanding the model domain to account for a growing floodplain, creating a high resolution spatial unit designed to inform local planning in coastal communities, updating and improving the inventory of coastal assets at risk, and developing new scenarios of levee fragility to capture the wide range of uncertainty.

The future environmental scenarios that were used in 2012 (CPRA, 2012) were revised based on updated literature reviews, newly data and technical understanding, as well as sensitivity testing of the ICM to the various parameters (e.g., eustatic sea level rise, subsidence, precipitation). See Chapter 2 Future Scenarios and associated attachments for additional details regarding the revised scenarios.

## 4.2 Project Information

The models are used to assess the individual and collective effects of groups of projects on the coastal ecosystem and the level of risk to which coastal communities are exposed. Projects are generally categorized as restoration or protection projects and evaluated according to their restoration or protection effectiveness. However, the effects of individual restoration projects (i.e., a protection effect) on coastal flooding can be generally evaluated using the ICM. When restoration and protection projects are combined in alternatives, both the ICM and the surge/risk models can be used to evaluate the net effect on both the ecosystem and levels of risk. Table 1 below provides a general description of the project types. Additional information regarding project development can be found in Appendix A: Project Definition.

**Table 1: Project Information for Evaluation by the Modeling Tools.**

| | Project type | General description |
|---|---|---|
| Restoration | Hydrologic restoration | Hydrologic restoration projects aim to maintain coastal wetlands and improve ecosystem outcomes by altering hydrology. They often include combinations of culvert, gates, locks, plug, weirs, etc. Links between compartments in the ICM are adjusted to reflect the changes. |
| | Shoreline protection | Shoreline protection projects seek to maintain land by reducing the amount of erosion along bay and channel shorelines using structures in the open water adjacent to the shoreline. Within the ICM, the marsh edge erosion rate in the influence area behind the structure is adjusted. |
| | Bank stabilization | Bank stabilization projects reinforce bank lines by adding material, thus reducing the erosion of the shoreline. Within the ICM, the marsh edge erosion rate in the area influenced by the additional material is adjusted. |
| | Oyster barrier reef | Oyster barrier reef projects build a submerged structure similar in elevation to a natural oyster reef with the aim of maintaining land by reducing the amount of erosion along adjacent bay and lake shorelines. Within the ICM, the marsh edge erosion rate in the area influenced by the reef is adjusted and the availability of cultch for oyster habitat is increased. |
| | Ridge restoration | Ridge projects seek to recreate the skeleton of the coastal wetlands along previous distributary channels, providing diverse, higher-elevation habitats and more structure for estuarine hydrology. Within the ICM, the ridge is represented in the topography, and hydrology links are adjusted to account for flow changes. |

| | Project type | General description |
|---|---|---|
| | Marsh creation | Marsh creation projects use fill material to convert shallow open water areas (<0.76 m deep) into wetlands. Vegetative plantings are usually included. Within the ICM, topography and bathymetry are adjusted, vegetation cover is changed, and hydrology links are adjusted as necessary. |
| | Diversion | Sediment and freshwater diversion projects seek to convey freshwater and associated sediments from either the Mississippi or Atchafalaya rivers into adjacent wetlands. Within the ICM, freshwater and sediment are released into the compartment(s) adjacent to the diversion location and are distributed throughout the estuarine basins by the hydrology subroutine. |
| | Barrier island restoration | For barrier island projects, a standard 'restored' template is applied to the area being restored, and cross-shore elevation profiles within the barrier island (BIMODE) subroutine are changed within the footprint of the island restoration. Within BIMODE, the new profiles are then subject to barrier island processes such as cross-shore and long-shore changes and breaching. |
| Protection | Structural protection | Structural protection projects usually include systems of levees, floodgates, floodwalls, and pumps designed to reduce the flooding of residential, commercial, and industrial assets. Within the ADCIRC/SWAN model, the grid is adjusted to account for the barriers and resulting flood depths are calculated for a set of synthetic storms. CLARA takes this information and develops more detailed flooding maps for the calculation of economic damages to these assets. |
| | Nonstructural protection | Nonstructural protection projects include structure elevations, floodproofing, or structure acquisitions. CLARA uses flood depths from ADCIRC/SWAN and examines the cost-effectiveness and other parameters of these projects in different communities across the coast. |

## 4.3 Planning Tool

As part of 2012 Coastal Master Plan, CPRA supported the development of a computer-based decision-support tool called the Planning Tool. The Planning Tool was used to: (1) make analytical and objective comparisons of hundreds of different risk reduction and restoration projects, (2) identify and assess groups of projects (called alternatives) that could make up comprehensive solutions, and (3) display the tradeoffs interactively to support iterative deliberation over alternatives (Groves and Sharon, 2013). Similar to the proposed improvements for the models that will support the 2017 Coastal Master Plan, the Planning Tool has also undergone a number of revisions (e.g., improved visualization of outputs, ability to compare 2012 versus 2017 information, adjustments to project selection procedures) described in Appendix D: Planning Tool.

The two fundamental model outputs used by the Planning Tool are the extent of land (output from the ICM) and reduction in expected annual damages (EAD), which is output from the risk reduction model, CLARA. These are termed 'decision drivers.' For each restoration and protection (both structural and nonstructural) project, the cost-effectiveness of the project in terms of each of the decision drivers is used to select the optimal group of projects for a given stream of funding and environmental scenario.

In addition to the decision drivers, a number of additional metrics are derived from the model outputs and used by the Planning Tool to explore the effects of individual projects and groups of projects (alternatives) on other aspects of the coastal system. These include flooding of historic properties, effect on navigation, changes to traditional fishing communities, etc. Many of these metrics combine information derived from CLARA analysis of protection projects and ICM analysis of restoration projects, and thus can only be used to consider the effects of alternatives. Other metrics, such as the effect on navigation or flooding of historic properties use only outputs from CLARA or the ICM and can thus be used as constraints in the formulation of cost-constrained alternatives (e.g., the Planning Tool selects the most cost-effective set of projects that reduces EAD but also ensures only a limited number of historic properties are flooded). Descriptions of these metrics and the inputs they use from the various models are described in Attachment C4-11: Metrics.

# 5.0 Model Review

## 5.1 2012 Coastal Master Plan

Review of model development and application occurred throughout the development of the 2012 Coastal Master Plan. Several Technical Advisory Committees (TACs) were convened including one specifically for the Predictive Models (PM-TAC). Additionally, the Science and Engineering Board reviewed and commented on all aspects of the Master Plan development process, including the modeling.

The PM-TAC focused their review and comment on the effectiveness of the models for predicting project effects. The committee included four well known scientists with expertise and experience not only with issues concerning coastal Louisiana, but also issues of national and international concern. PM-TAC members participated in monthly conference calls and webinars with CPRA leads on the modeling effort, but formal reporting was not part of their role/task. They served in a more informal role of providing technical advice and guidance during the process. To close out the PM-TAC effort, each member was asked to write a brief overview of his or her experience as a PM-TAC member for the 2012 Coastal Master Plan modeling effort (CPRA, 2012b – Appendix H).

Following completion of the 2012 Coastal Master Plan, the model reports included as appendices to the master plan, were subject to an independent technical review (described previously). This review engaged 12 external topical experts and seven expert review editors. Many suggested improvements were undertaken as part of the 2017 Coastal Master Plan Model Improvement Plan.

## 5.2 2017 Coastal Master Plan Predictive Models Technical Advisory Committee

During the 2012 Coastal Master Plan process, the PM-TAC only met in person once with the modeling team. This limited their ability to interact and discuss problems and solutions directly with those working on model development. The 2012 PM-TAC unanimously recommended that more frequent in-person meetings during future efforts would enhance the overall efficacy of the review process. To convene a TAC for 2017, the Modeling Decision Team identified the five experts listed below (with their professional affiliations) to serve as “over the shoulder” technical advisors throughout the model improvement process. This team of experts comprised the 2017 PM-TAC. They were selected based on their technical area of expertise and their ability to share insight and experience from other relevant efforts.

- John Callaway (Chair), University of San Francisco
- Scott Hagen, University of Central Florida[1]
- Courtney Harris, Virginia Institute of Marine Science
- Wim Kimmerer, San Francisco State University
- Mike Waldon, Retired USFWS

In contrast to traditional peer review, which often only engages toward the end of efforts (e.g., once draft reporting is available,) the PM-TAC has ongoing engagement directly with the modelers, providing working-level assistance throughout the 2017 Coastal Master Plan modeling process. The PM-TAC participates in approximately quarterly in-person meetings in conjunction with the modeling leads for each of the main subroutines or model components. Additional information is provided as an attachment to Chapter 5.

## 5.3 2017 External Review

An external review of select technical components of the 2017 Model Improvement Plan has also been conducted. The intent was to ensure technical soundness of the modeling strategies and use of equations (particularly associated with the model improvements and newly developed processes) and alert CPRA to any limitations that were not identified by the modeling team. To encourage reviewers to express their views freely, reviewer comments and recommendations remained anonymous when submitted to the model developers. Reviewer comments and recommendations and model developer responses are tracked to provide a record of the process.

In addition to report-specific questions, each reviewer was asked to provide comments in relation to the following review questions:

- Does the documentation clearly / adequately reflect the modeling process?
- Is the overall strategy appropriate for large scale (entire Louisiana coast), long-term (50-year) planning efforts?
- Are the technical assumptions and use of equations acceptable?
- Are there any fundamental flaws or otherwise that should be noted and/or revised for future coastal planning efforts?

The reports that have been subject to review include:

- Sediment Distribution (Attachment C3-1)
- Marsh Edge Erosion (Attachment C3-2)
- Barrier Island Model Development (BIMODE; Attachment C3-4)
- Vegetation (Attachment C3-5)
- Habitat Suitability Indices (Attachments C3-6 through C3-19)
- EwE (Attachment C3-20)
- CLARA – Risk Assessment (includes discussion of storm surge/waves model analysis and improvements; Attachment C3-25)

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[1] Dr. Hagen transitioned to a new position at Louisiana State University after his engagement as a member of the TAC commenced.

# 6.0 2017 Modeling Team

As previously mentioned, the 2017 Coastal Master Plan modeling team was directed by a team made up of CPRA and Water Institute personnel (the Model Decision Team) and the technical work was carried out largely by a multi-disciplinary team of experts from state and federal agencies, academia, and the private sector (Table 2).

**Table 2: 2017 Coastal Master Plan Modeling Team Members.**

| Organization | Name |
|---|---|
| Model Decision Team | |
| Water Institute | Ehab Meselhe |
| Water Institute | Denise Reed |
| Water Institute | Alaina Owens Grace |
| Coastal Protection & Restoration Authority | Mandy Green |
| Coastal Protection & Restoration Authority | David Lindquist |
| Coastal Protection & Restoration Authority | Angelina Freeman |
| Sediment Distribution | |
| University of New Orleans | Alex McCorquodale (Subtask Leader) |
| Moffatt & Nichol | Jeff Shelden |
| USGS National Wetlands Research Center | Gregg Snedden |
| USGS National Wetlands Research Center | Hongqing Wang |
| USGS National Wetlands Research Center | Brady Couvillion |
| Water Institute | Ehab Meselhe |
| Water Institute | Ben Roth |
| Water Institute | Denise Reed |
| Water Institute | Eric White |
| Marsh Edge Erosion | |
| Water Institute | Mead Allison (Subtask Leader) |
| Water Institute | Brendan Yuill |

| Organization | Name |
|---|---|
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| Water Institute | Denise Reed |
| Water Institute | Eric White |
| Louisiana State University | Q. Jim Chen |
| University of New Orleans | Alex McCorquodale |
| USGS National Wetlands Research Center | Brady Couvillion |
| Barrier Islands | |
| Coastal Engineering Consultants | Michael Poff (Subtask Leader) |
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| Coastal Planning and Engineering - CBI | Morjana Signorin |
| Coastal Planning and Engineering - CBI | Samantha Danchuk |
| Coastal Planning and Engineering - CBI | Zhifei Dong |
| Deltares | Dirk-Jan Walstra |
| University of New Orleans | Mark Kulp |
| University of New Orleans | Ioannis Georgiou |
| Coastal Protection & Restoration Authority | Mark Leadon |
| Vegetation | |
| UL Lafayette | Jenneke Visser (Subtask Leader) |
| UL Lafayette | Scott Dyke-Sylvester |
| UL Lafayette | Mark Hester |
| UL Lafayette | Whitney Broussard |
| UL Lafayette | Jonathan Willis |
| UL Lafayette | David Horaist |
| Southeastern LA University | Gary Shaffer |
| USGS National Wetlands Research Center | Brady Couvillion |

| Organization | Name |
| --- | --- |
| USGS National Wetlands Research Center | Holly Beck |
| Habitat Suitability Indices | |
| Moffatt and Nichol | Buddy Clairain (HSI - Subtask Co-Leader) |
| Moffatt and Nichol | Stokka Brown |
| UL Lafayette | Paul Leberg |
| Louisiana State University AgCenter | Robert Romaire |
| USGS National Wetlands Research Center | Hardin Waddle |
| Louisiana State University | Jay Geaghan |
| Water Institute | Ann Hijuelos (HSI - Subtask Co-Leader) |
| Water Institute | Leland Moss |
| University of New Orleans | Meg O'Connell |
| Dynamic Solutions | Shaye Sable |
| Coastal Protection & Restoration Authority | David Lindquist |
| Ecopath with Ecosim | |
| George Mason University | Kim de Mutsert (Subtask Leader) |
| George Mason University | Kristy Lewis |
| Louisiana State University | James Cowan |
| Ecopath Research and Development Consortium | Jeroen Steenbeek |
| Ecopath Research and Development Consortium | Joe Buszowski |
| University of Southern Mississippi | Scott Milroy |
| Metrics | |
| Water Institute | Scott Hemmerling |
| Water Institute | Melissa Baustian |
| Water Institute | Denise Reed |

| Organization | Name |
|---|---|
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# 7.0 Structure of Appendix C

This appendix describes the modeling used to support the development of the 2017 Coastal Master Plan. This chapter provides a broad overview of what was done for the 2012 Coastal Master Plan modeling effort, updates that were made, and linkages between the modeling, projects, and the Planning Tool. The procedure for selection of the values included in the environmental scenarios is described in Chapter 2, and Chapter 3 includes a short description of each of the primary modeling components, including boundary condition data. The focus of Chapter 3 is on changes made since the 2012 Coastal Master Plan. More detailed descriptions for each of the main model components, subroutines, and supporting tasks are included in a series of Attachments. Chapters 4 and 5 provide overviews of model output and conclusions, respectively. Chapters that are forthcoming are indicated as such in the list below. Attachments will be posted to the CPRA website as they become available.

Below is a list of attachments associated with Appendix C:

- CHAPTER 1 – Introduction
- CHAPTER 2 – Future Scenarios
    - Attachment C2-1: Eustatic Sea Level Rise
    - Attachment C2-2: Subsidence
    - Attachment C2-3: Precipitation and Evapotranspiration
    - Attachment C2-4: Tropical Storm Intensity and Frequency
    - Attachment C2-5: Options for Sensitivity Analyses
- CHAPTER 3 – Modeling Components and Overview
    - Attachment C3-1: Sediment Distribution
        - Attachment C3-1.1: Sediment Distribution Supporting Information
    - Attachment C3-2: Marsh Edge Erosion
    - Attachment C3-3: Storms in the ICM Boundary Conditions
    - Attachment C3-4: Barrier Island Model Development (BIMODE)
    - Attachment C3-5: Vegetation
    - Attachment C3-6: Gadwall Habitat Suitability Index Model
    - Attachment C3-7: Green-winged Teal Habitat Suitability Index Model
    - Attachment C3-8: Mottled Duck Habitat Suitability Index Model
    - Attachment C3-9: Brown Pelican Habitat Suitability Index Model
    - Attachment C3-10: Alligator Habitat Suitability Index Model
    - Attachment C3-11: Blue Crab Habitat Suitability Index Model
    - Attachment C3-12: Oyster Habitat Suitability Index Model
    - Attachment C3-13: Brown Shrimp Habitat Suitability Index Model
    - Attachment C3-14: White Shrimp Habitat Suitability Index Model
    - Attachment C3-15: Gulf Menhaden Habitat Suitability Index Model
    - Attachment C3-16: Spotted Seatrout Habitat Suitability Index Model
    - Attachment C3-17: Bay Anchovy Habitat Suitability Index Model
    - Attachment C3-18: Largemouth Bass Habitat Suitability Index Model
    - Attachment C3-19: Crayfish Habitat Suitability Index Model
    - Attachment C3-20: Ecopath with Ecosim (EwE)
    - Attachment C3-21: Nitrogen Uptake
    - Attachment C3-22: Integrated Compartment Model (ICM) Development

        - Attachment C3-22.1: ICM-Hydro Flow Calculations
        - Attachment C3-22.2: File Naming Convention
    - Attachment C3-23: ICM Calibration, Validation, and Performance Assessment
        - Attachment C3-23.1: Hydrology Station Locations
        - Attachment C3-23.2: Model Performance - Stage
        - Attachment C3-23.3: Model Performance - Flow
        - Attachment C3-23.4: Model Performance - Salinity
        - Attachment C3-23.5: Model Performance - Total Suspended Solids
        - Attachment C3-23.6: Model Performance - Temperature
        - Attachment C3-23.7: Model Performance - Total Kjeldahl Nitrogen
        - Attachment C3-23.8: Model Performance - Total Phosphorus
    - Attachment C3-24: ICM Uncertainty Analysis
    - Attachment C3-25: Storm Surge and Risk Assessment
        - Attachment C3-25.1: Storm Surge
    - Attachment C3-26: Hydrology and Water Quality Boundary Conditions
        - Attachment C3-26.1: Monitoring Station List
        - Attachment C3-26.2: Flow Data
        - Attachment C3-26.3: Water Level Data
        - Attachment C3-26.4: Water Quality Stations and Locations
    - Attachment C3-27: Landscape Data
- CHAPTER 4 – Model Outcomes and Interpretations
    - Attachment C4-1: Model Quality Assurance and Quality Control (QA/QC)
    - Attachment C4-2: Mid-Breton Sound Diversion Model Output
    - Attachment C4-3: South Terrebonne Marsh Creation Model Output
    - Attachment C4-4: Calcasieu Ship Channel Salinity Control Measures Model Output
    - Attachment C4-5: Lake Hermitage Shoreline Protection Model Output
    - Attachment C4-6: Grand Lake Bank Stabilization Model Output
    - Attachment C4-7: Bayou Decade Ridge Restoration Model Output
    - Attachment C4-8: Barataria Pass to Sandy Point Barrier Island Restoration Model Output
    - Attachment C4-9: Biloxi Marsh Oyster Reef Model Output
    - Attachment C4-10: Draft Master Plan Output
    - Attachment C4-11: Metrics
        - Attachment C4-11.1: Metric Values by Project

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