Final Project Report: Facilitating Accurate and Effective Application of Coastal Marsh Models

Administrative Information

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Public Summary

Salt marshes are integral to coastal communities, providing habitat for important species, such as shrimp and fish, and reducing the frequency and intensity of flood impacts on our homes and businesses. As sea levels continue to rise it is important that we understand how the health and extent of these marshes is expected to change so we know what actions we can take to maintain their critical function. There are many models that have been developed to characterize how marshes may respond to rising seas, each with a different approach and focus. As with any emerging scientific field, it is important to assess if the models' predictions reflect what we observe; however, only recently have we had the ability to do that with marsh models because we lacked the detailed observations that were required.

We convened the leading marsh modelers from around the U.S. to devise a scientifically robust method for conducting a retrospective analysis. A retrospective analysis is where all the models are run with the same input information and from the same starting year from the past and the outputs are analyzed to see if they reflect what marshes look like today. It took a whole workshop and a team of modelers to devise an approach because each model is different, with different requirements for what needs to be put into the model and how the model produces its results. With this workshop we were able to devise a plan that worked for all the models and build buy-in to the processes among the modeling community. With this plan in place we are now able to perform the essential step of conducting the retrospective analysis so that we can understand which models work best in which coastal systems and for answering which management questions.

Technical Summary

We successfully convened marsh modelers representing six different models on April 11-12, 2022. The models that were represented consisted of: Marsh Equilibrium Model (MEM); Hydrodynamic-Marsh Equilibrium Model (Hydro-MEM); Wetland Accretion Rate Model of Ecosystem Resilience (WARMER); Sea Level Affecting Marshes Model (SLAMM); Sea Level Rise Viewer (SLR Viewer); and the Louisiana's Integrated Compartment Model (ICM). There were six objectives of the workshop outlined:

1) Learn about stakeholder perceptions of marsh models to ensure that the work resulting from the workshop is informed by the needs expressed by stakeholders;
2) Reach a consensus about what a marsh model retrospective would look like and be able to accomplish;
3) Explore the historical data that are available for performing a marsh model retrospective analysis;
4) Select locations and other technical details such as how to develop historic DEMs, estimate sea level rise over the period record of the retrospective, etc.;
5) Determined the next steps to assess and prepare the model input data;
6) And agreed upon a timeline for completing the next steps for performing the marsh model retrospective analysis

By the end of the workshop, the marsh modelers understood how stakeholders perceive marsh models, the need for and goals of a marsh model retrospective, what data are available for performing a marsh model retrospective, and where additional gaps may lie. This laid the foundation for the marsh modelers to collaborate with the Project Team to complete a framework for performing the marsh model retrospective, including what parameters to include, next steps, and a timeline for completing the prerequisite work for the marsh model retrospective. Overall, this two-day workshop successfully prepared the Project Team and marsh modelers to gather necessary data and move the marsh model retrospective forward.

In addition to the tangible outcomes of concrete next steps for the retrospective analysis and consensus among modelers of how to productively move forward, relationships were established between modelers, many of whom had not previously met. This will strengthen future efforts to connect modelers and explore ways of understanding and improving marsh models.

Purpose and Objectives

Purpose: The overarching purpose of this work is to initiate a paradigm-shift in the approach and interpretation of coastal marsh models to enhance natural resource management; one that will move from single model use to ensemble model application. This large effort will be accomplished in distinct, achievable phases. This project represented Phase 1 wherein we convened a workshop among top marsh modelers to 1) inventory available data sources required for marsh models, 2) scope an approach to an 'apples-to-apples' comparison across the range of coastal marsh system models, aimed at exploring differences in their prediction of marsh conditions under climate change, and 3) deliver to managers guidance on how best to utilize the existing marsh tools to inform land management decisions. This project benefits managers immediately and lays the foundation of a larger effort with additional benefits.

Objectives:
Specific objectives for this project were:

- Conduct additional stakeholder engagement to scope the needs, questions, and perspectives of coastal managers around marsh models,
- Develop a compilation of potential datasets to support conducting a marsh modeling retrospective in the southeast, and
- Conduct a workshop with marsh modelers to assess the currently available data and scope a retrospective analysis
- Report out to coastal managers the planned retrospective approach and any additional insights gained into applying marsh models

Organization and Approach

Workshop Design
In preparation for the workshop, results from the 2018 workshop, which convened modelers and natural resource managers to discuss modeling outputs, were reviewed, additional interviews with stakeholders were conducted, and data mining and compilation were conducted.

Stakeholder Input to Workshop Design
During the 2018 workshop and the interviews from this project it became clear that managers have hesitancy in applying the model outputs for a variety of reasons ranging from suitable timesteps and scale to undefined uncertainty in model outputs. We were also able to characterize what actions managers would like to take with model outputs and when model outputs have been used, what their applications were. This information was then used to review our draft framework for a retrospective analysis and ensure that outputs from a retrospective would address multiple gaps and needs expressed from managers including questions around uncertainty and which models may be better suited for different types of management questions.

Data Mining and Compilation
Multiple locations originally identified by stakeholders, marsh modelers, and the Project Team were explored to determine where there may be sufficient data to conduct a marsh modeling retrospective. The data collected were determined based on the individual model requirements and then reviewed prior to the workshop by the marsh modelers to ensure that there were no other types of data that needed to be compiled. All data were publicly available data and the data viewer only served to access them in one place. Ultimately, locations in Mississippi, Alabama, and North Carolina were presented. The data viewer can be found here: https://arcg.is/0CL9D90.

Workshop Implementation
During the two day workshop, marsh modelers gathered with the Project Team to discuss the approach and timeline for a marsh model retrospective.

The first day of the workshop (April 11) consisted of presentations, discussions, and activities developed and led by the Project Team to prepare the marsh modelers for an in-depth discussion of the technical details required to perform a marsh model retrospective. On day two of the workshop, the Project Team and marsh modelers determined the technical details needed to develop a proposal to advance the marsh model retrospective project. This was accomplished through discussions that shared the knowledge that the Project Team had accumulated and the professional expertise of the marsh models. Discussions from day one and day two included: 1) Stakeholder perceptions on marsh modeling; 2) Big picture questions for the marsh model retrospective; 3) Available data for performing a marsh model retrospective; 4) Details for performing a marsh model retrospective.

Discussion summaries for both day one and day two of the workshop can be found in the workshop report on the marsh modeling retrospective project page (placeslr.org/our-work/projects/marsh-model-comparison/) and at the end of this report.

Project Results

During the close of day one, workshop attendees reviewed the primary outcomes from the discussions which consisted of a list of outputs to compare from the marsh model retrospective:

1) Vertical elevations
2) Horizontal habitat changes
3) Landscape (holistic output)

At the end of day two, workshop attendees focused on the details for performing a marsh model retrospective. This included details regarding vegetation input layers, appropriate DEMS, timesteps, sea-level rise, locations, and model uncertainty. The specific decision points and next steps for each marsh model input are outlined in the workshop report. By standardizing these inputs across all marsh models, the results of this analysis will highlight true differences in model skills and not input data sources. Additionally, by comparing the results to historical data, we will gain a better understanding of the accuracy of the marsh models to “real-world” conditions.

Analysis and Findings

Retrospective Feasibility

This work confirmed the feasibility of conducting a retrospective analysis given the available data at various locations around the country. Marsh observing and other related data needs - high resolution digital elevation models, rates of accretion and subsidence, etc. - were not available until recently. We needed the availability of sufficient input data coupled with enough time passing for sea-level rise to impact the extent and health of marshes. Through this workshop we were able to determine there is enough data to effectively conduct a retrospective analysis.

Retrospective Analysis Plan

This work also produced a plan for both conducting the retrospective and the necessary next steps for beginning to undertake the retrospective. The specific next steps and the plan are outlined in the workshop report. For the plan decisions were made around locations for conducting the retrospective, digital elevation model construction, and output classification. Next steps included additional data to be collected including assessing how many cores exist from the target areas, availability of data from the National Wetlands Inventory, and synthesis of sea-level change data at those locations.

Conclusions and Recommendations

Conclusions

This project took a critical step forward in effectively conducting a marsh model retrospective by scoping the process in collaboration with top marsh modelers from around the U.S. This project had the expected outputs of successfully producing a plan and a series of next steps. It also had the expected outcomes of establishing and strengthening relationships between marsh modelers, funders and outreach professionals effectively beginning a community of practice wherein the members are collaboratively pursuing enhanced function and application of marsh model outputs.

Recommendations

The project did face difficulties regarding COVID-19, delaying the ability to have the workshop because it was determined that an in-person meeting was essential to effectively achieving the project objectives. The work was highly technical which is not well suited for remote environments, additionally many of the modelers did not know each other. Meeting in-person allowed for stimulating and effective engagement during the workshop and for the opportunity to build trust and connections across the participating members. Meeting in-person proved to be worth the wait and it is recommended for similar projects and actions that in-person meetings be prioritized.

Management Applications and Products

In the process of the workshop, additional guidance for marsh managers was identified and is being integrated into the outreach and extension programming for all three Sea Grant programs. This guidance will help managers frame the appropriate application of the current marsh model outputs and consider additional approaches for applying the data.

After the retrospective has been conducted, a wealth of knowledge for management will be available. Ideally, this will trigger a shift in choosing a single model to run in a specific location, to an ensemble model approach, with managers using a suite of models to assess different questions and/or locations for the areas for which they are responsible. Additionally, the retrospective will identify strengths and opportunities for improvement of the models - identifying additional areas in which to improve marsh models to even more so meet the needs of the managers.

Outreach and Communication

Outreach

We worked with natural resource managers, researchers, and consultants to understand the perceptions around the marsh model comparison, marsh models, and preferred analyses and outputs. We also engaged with marsh modelers to ensure understanding of and participation ahead of the workshop.

During the workshop, there were two outreach materials that were identified in the workshop to create and share: 1) What marsh modelers want natural resource managers to know; 2) What managers want marsh modelers to know. The marsh modelers requested a product, such as a two pager, outlining the materials above. The Project Team will also create an extension and outreach product to aid stakeholders in understanding of marsh model outputs and provide guidance on applying them based on feedback from the marsh modelers.

Communication

Communication materials will consist of detailing the appropriate utility of existing model outputs for relevant management options. Opportunities to use multiple model approaches simultaneously from an ensemble model approach, will be addressed. Combining multiple outputs via an ensemble marsh model will improve the understanding of the future range of conditions as well as the certainty of those conditions under sea-level rise.

MARSH MODEL RETROSPECTIVE WORKSHOP

APRIL 11 -12, 2022

MASGP-22-055

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List of Acronyms

CCAP	Coastal Change Analysis Program
DEM	Digital Elevation Model
Hydro-MEM	Hydrodynamic-Marsh Equilibrium Model
ICM	Integrated Compartment Model
MEM	Marsh Equilibrium Model
NERR	National Estuarine Research Reserve
NOAA	National Oceanic and Atmospheric Administration
NWI	National Wetland Inventory
PLACE:SLR	Program For Local Adaptation to Climate Effects: Sea Level Rise
RTK	Real Time Kinematic
SC	South Carolina
SET	Surface Elevation Table
SLAMM	Sea Level Affecting Marshes Model
TSS	Total Suspended Sediments
USGS	United States Geological Survey
WARMER	Wetland Accretion Rate Model of Ecosystem Resilience

1.0 Introduction

On August 7-9, 2018, natural resource managers and decision makers from across the Gulf of Mexico were convened to explore comparisons of already existing marsh model outputs and discuss potential drivers of the differences and how this may impact choices when selecting models to support natural resource decision making. The purpose of this comparison was not to identify the "best" model, but to instead work on understanding the different outputs of each model and how managers might utilize the different marsh models for different purposes. At this workshop, there was agreement amongst the participants that a retrospective analysis needed to be performed with all the models utilizing the same data inputs across multiple geographies. The results of the retrospective analysis would enhance guidelines on the model application and identify potential areas of research to enhance the existing models' predictive capabilities.

A Project Team comprised of marsh model funders, coastal resilience specialists who support coastal managers, data analysis and visualization specialists, and modeling experts secured funding to convene marsh modelers from a range of marsh models in order to scope a retrospective analysis. On April 11–12, 2022, marsh modelers representing six marsh models (Table 1) gathered with the Project Team to discuss an approach and timeline for a marsh model retrospective at the Beaufort Hotel in Beaufort, North Carolina. This workshop had six objectives that were achieved throughout the course of the two days.

Table 1. List of marsh models and the representative in attendance at the April 11-12, 2022 workshop.

Marsh Model Name	Model Representative
Hydro-MEM	Karim Alizad
Integrated Compartment Model (ICM)	Eric White
Marsh Equilibrium Model (MEM)	James Morris
Sea Level Affecting Marshes Model (SLAMM)	Jonathan Clough
Sea Level Rise Viewer (SLR Viewer)	Connor Levy
Wetland Accretion Rate Model of Ecosystem Resilience (WARMER)	Kevin Buffington

The first day of the workshop (April 11) consisted of presentations, discussions, and activities developed and led by the Project Team to prepare the marsh modelers for in depth discussion of the technical details required to perform a marsh model retrospective. These introductory sessions were conducted to accomplish the following objectives. To:

1. learn about stakeholder perceptions of marsh models to ensure that the work resulting from the workshop is informed by the needs expressed by stakeholders;
2. reach a consensus about what a marsh model retrospective would look like and be able to accomplish; and
3. explore the historical data that are available for performing a marsh model retrospective analysis.

Through activities and robust discussions, each of these objectives were accomplished during day one of the workshop. See sections 3.1-3.4 for day one discussion summaries.

The overarching goal of day two (April 12) of the workshop was to determine sufficient technical details to develop a proposal to advance the marsh model retrospective project. This was accomplished through detailed discussions that shared both the knowledge that the Project Team had accumulated in preparation for the workshop and the professional expertise of the marsh modelers, in addition to collaboration between both groups for future planning. During day two, workshop participants (the Project Team and the modelers in collaboration) accomplished the following objectives:

1. selected locations and other technical details such as how to develop historic DEMs, estimate sea-level rise over the period of record of the retrospective, etc.;
2. determined the next steps to assess and prepare the model input data; and
3. agreed upon a timeline for completing the next steps for performing the marsh model retrospective analysis.

See sections 3.5-3.7 for day two discussion summaries.

By the end of the workshop, the marsh modelers understood how stakeholders perceive marsh models, the need for and goals of a marsh model retrospective, what data are available for performing a marsh model retrospective, and where additional data gaps may lie. This laid the foundation for the marsh modelers to collaborate with the Project Team to complete a framework for performing the marsh model retrospective, including what parameters to include, next steps, and a timeline for completing the prerequisite work for the marsh model retrospective. Overall, this two-day workshop successfully prepared the Project Team and marsh modelers to gather necessary data and move the marsh model retrospective forward.

1.1 Objectives

Day One (April 11, 2022)

- The marsh modelers will understand how stakeholders use and perceive marsh model outputs in their decision-making.
- The project team and marsh modelers will agree upon the scope of the marsh model retrospective and understand what it will accomplish.
- The marsh modelers will have a better understanding of what historical data is available for performing a marsh model retrospective.

Day Two (April 12, 2022)

- The marsh modelers and project team will determine the priority locations and select other technical parameters for performing the marsh model retrospective analysis.
- The marsh modelers and project team will collaborate to develop next steps and assign responsibilities for the next steps to move the marsh model retrospective analysis forward.
- The marsh modelers and project team will develop and agree upon a timeline for all next steps for the marsh model retrospective analysis.

2.0 Attendee List

Karim Alizad	United States Geological Survey
Harris Bienn	The Water Institute of the Gulf
Christine Buckel	National Oceanic and Atmospheric Administration
Kevin Buffington	United States Geological Survey
Charley Cameron	The Water Institute of the Gulf
Juan Cervera	National Oceanic and Atmospheric Administration
Jonathan Clough	Warren-Pinnacle Consulting, Inc.
Renee Collini	Program for Local Adaptation to Climate Effects: Sea-Level Rise
Christopher Esposito	The Water Institute of the Gulf
David Kidwell	National Oceanic and Atmospheric Administration
Connor Levy	National Oceanic and Atmospheric Administration
Sara Martin	Program for Local Adaptation to Climate Effects: Sea-Level Rise
Stephen Medeiros	Embry-Riddle Aeronautical University
James Morris	University of South Carolina
Mary Schoell	National Estuarine Research Reserve Association
Sarah Spiegler	North Carolina State University, North Carolina Sea Grant
Eric White	Coastal Protection and Restoration Authority

3.0 Discussion Summaries

This section includes summaries of the discussions that took place over the course of the workshop, including all pertinent decision points and next steps. Sections 3.1–3.4 summarize discussions from day one, while Sections 3.4–3.7 summarize those from day two.

3.1 Stakeholder Perceptions on Marsh Modeling

On April 11, 2022, marsh modelers convened with the project team to discuss an approach to performing a marsh model retrospective analysis. Before entering these discussions, Sara Martin (PLACE:SLR) and Mary Schoell (National Estuarine Research Reserve [NERR] Association) presented their findings about stakeholder perceptions and use of marsh models. The goals of this session were for marsh modelers to understand 1) how stakeholders use marsh models, 2) what makes a marsh model output most useful for stakeholder applications, and 3) what other model outputs stakeholders would like to see from marsh models.

The presentation contained data obtained through interviews and surveys conducted with stakeholders by Martin, Schoell, and other members of the Project Team. The stakeholders consulted by the project team consisted of researchers and land managers. Stakeholder were interviewed to the point of saturation (i.e., no new trends or information was being gained) for a total of 7 interviews. Following the presentation, the marsh modelers asked questions to further understand how stakeholders use and think about marsh model outputs. Discussion was aided by a posted flipchart page that listed key points from the stakeholder presentation labeled “Managers Want Models That” (Table 2). Following the presentation, marsh modelers were able to ask questions and provide their own perspectives on the use of their models. Feedback from the marsh modelers was captured on a flipchart page labeled “Things for Managers to Know” (Table 3). See the presentation and flipchart page images provided in Appendix A.2 and Appendix D.2-3 respectively.

Table 2. Managers Want Models That…

Managers Want Models That	
1.	are easy to understand
2.	are specific to their managed lands
3.	include outputs for various time steps and sea-level rise scenarios
4.	are transparent about the input data
5.	are clear about what any uncertainty means
6.	can analyze management options

Table 3. Things for Managers to Know

Things for Managers to Know	
1.	Age of National Wetlands Inventory (NWI) Data: NWI vegetation data are outdated in some areas
2.	Clarify difference between time steps and (model version) updates
3.	Stage of development = generalities: tipping points should be considered by decades, not by year
4.	“Elevation capital” = elevation of the marsh above the minimum required for vegetation growth
5.	Managers are the tuners for marsh models: their feedback helps modelers to fine tune the models
6.	Models are describing vulnerability overall of marsh areas and are not trying to predict the future of exactly what will happen.
7.	Models are useful for understanding marsh processes and vulnerabilities

From this discussion, the marsh modelers were able to learn about stakeholder perceptions, identify actions for aiding stakeholders understanding of marsh model outputs, and set goals for continuing to build a dialog between modelers and stakeholders. Furthermore, two *Decision Points* and two *Next Steps* were determined.

3.1.1 Decision Points

1. Stakeholders would be better served by marsh model outputs if they viewed the outputs as a means by which to determine vulnerabilities in a particular marsh, rather than to identify the year that a marsh will reach a "tipping point."
2. It is important for marsh models to include adequate explanation of source of uncertainty to increase stakeholder confidence in the outputs.

3.1.2 Next Steps

1. Marsh modelers requested a product, such as a two pager, which describes stakeholder perceptions on marsh modeling.
2. The Project Team will also create an extension and outreach product to aid stakeholders understanding of marsh model outputs and provide guidance on applying them based on feedback from the marsh modelers.

3.2 Big Picture Questions for the Marsh Model Retrospective

To prepare the marsh modelers for investigation of the data available for the marsh model retrospective, Trevor Meckley (NOAA) presented details regarding the background of the marsh model retrospective, including why the retrospective is needed, further discussion of the relevance of stakeholder perceptions of marsh models, and summarized the challenges that decision-makers face in applying marsh model outputs. Meckley also highlighted the goals of the workshop and the "big picture questions" that the Project Team seeks to address with the marsh model retrospective. Big picture questions included Example Application Questions and Scoping Questions. See Appendix A.3 and Appendix B.2 for presentation slides and workshop handout listing the questions, respectively.

Following the presentation, the marsh modelers were given time to ask questions and voice any concerns about the marsh model retrospective. The marsh modelers suggested seven considerations for scoping the retrospective process, which were captured on a flipchart (Appendix D.6) and added to the list of scoping questions to consider (Table 4).

As a result of this discussion, the marsh modelers obtained a greater understanding of what the marsh model retrospective will accomplish and the scoping questions for the Project Team and marsh modelers were refined.

Table 4. Considerations for Scoping the Marsh Model Retrospective

	Considerations for Scoping the Marsh Model Retrospective
1.	Need to discern the impact of sea-level rise from other factors (e.g., storms, human changes)
2.	Need to include models in the marsh model retrospective that are transferable to multiple locations
3.	Sites have experienced enough change in sea level to drive change in a marsh
4.	Sometimes things other than sea-level rise, like logging, are driving the marsh changes
5.	Sea-level rise should be a primary driving factor of change in any location selected for inclusion in the marsh model retrospective
6.	The marsh model retrospective analysis will have to avoid sites with punctuated changes or account for any event, management actions, or restorations that have occurred.
7.	River diversions and barrier islands can change the hydrodynamics of distant locations of the system – need to ensure this is acknowledged and addressed if necessary during a retrospective

3.3 Available Data for Performing a Marsh Model Retrospective

Members of the Project Team from The Water Institute of the Gulf guided the marsh modelers through an exploration of the data currently available to run a marsh model retrospective in three locations: Apalachicola NERR, Florida; Grand Bay NERR, Mississippi; and three NERRs in North Carolina (Currituck Banks, Rachel Carson, and Masonboro Island Reserves). The exploration was done through a web-based mapping platform (Figure 1) built by The Water Institute of the Gulf. This mapping tool can be found at https://arcg.is/0CL9D90. It included digital elevation model (DEM), tidal datum, land cover, surface elevation table (SET) elevations, and real-time kinematic (RTK) elevation layers for each location across three decades (1990s, 2000s, and 2010s). This data exploration was facilitated by a data inventory handout and a guided exploration activity sheet (see Appendix B.3 and Appendix B.4).

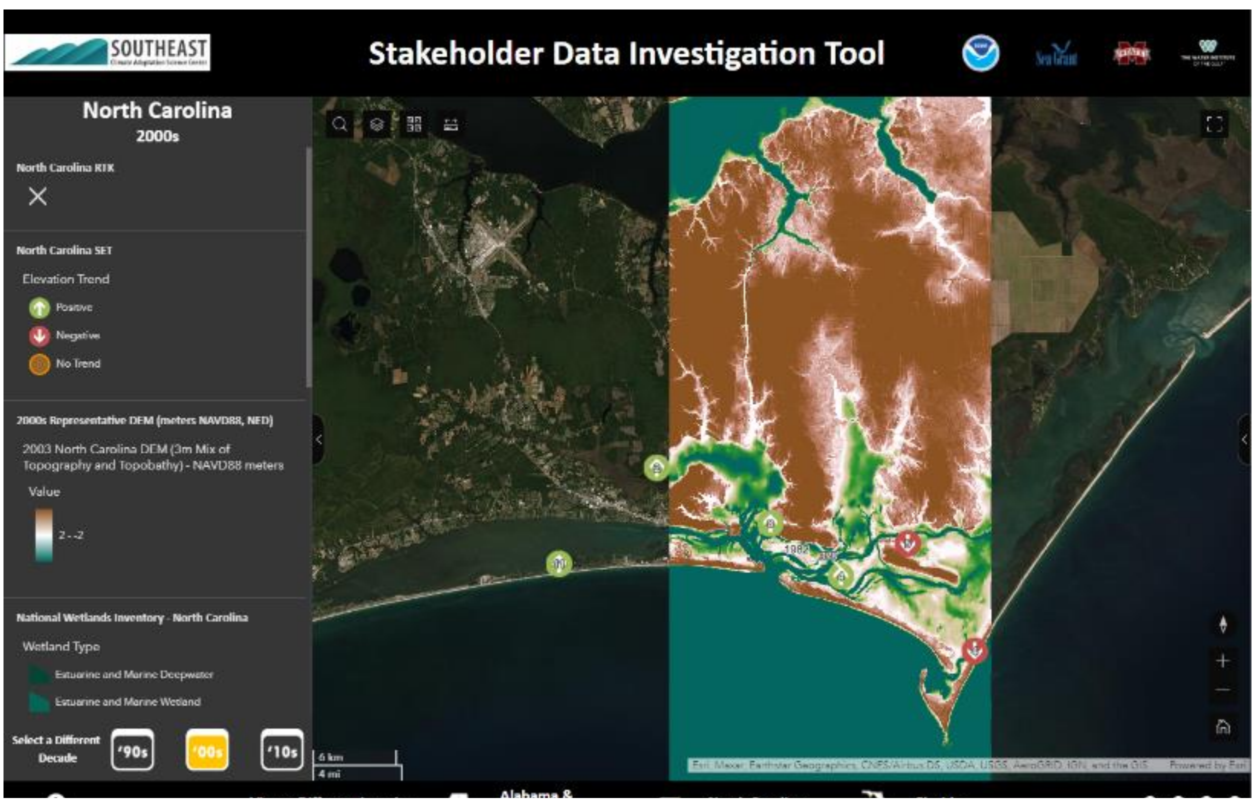


Figure 1. Screenshot of the web mapping platform used for the data exploration by the marsh modelers.

The data exploration was followed by a discussion of the presented data as well as additional data that the marsh modelers identified as beneficial to include. Overall, the marsh modelers found that the tool had an intuitive and easy to use interface and particularly appreciated the inclusion of SET data. The marsh modelers discussed concerns for assessing the results of the marsh model retrospective analysis. Primarily, they discussed how to address the bias of knowing what the retrospective output should look like. For instance, if it is already known that over a twenty-year period there is a 20% decline in vegetation cover how does the project team ensure that the bias does not influence adjustments in the retrospective model?

However, the primary purpose of the data exploration was to determine if there is sufficient data to perform a marsh model retrospective. In addressing that question, the marsh modelers had six concerns (Table 5), identified six data needs (Table 6), and one data want (Table 7). Overall, the group reached two decision points and one next step was identified.

Table 5. Data Concerns

	Data Concerns
1.	**Data quality was not clear.** Only the most recent data was shown for many of the layers. In particular, the analysis will need historic NWI vegetation data.
2.	**NWI data changes over time.** The imagery may need to be reclassified so that changes over time reflect actual change rather than changes in classification categories.
3.	**SETs are not randomly distributed.** Because they are typically located in convenient locations and rarely in “unimpacted” ones, which can give a misleading estimate of rate of change. SET elevations may be biased to eroding edges.
4.	**SETs are not routinely monitored.** Half of the SETs in North Carolina are not currently monitored due to a lack of funding, so the data may not be available for target time periods. Rather, data from a particular SET may be relevant just to a snapshot in time.
5.	**Site selection may have confounding factors.** These factors could include salinity, freshwater input, heavy rainfall, etc. This concern could be addressed by including multiple types of sites in the retrospective analysis.
6.	**Poor quality or lack of historic DEMs.** Performing the marsh model retrospective will require quality DEMs for whatever period is decided on for the analysis. These may not be available, and the need will have to be addressed.

Table 6. Data Needs

	Data Needs
1.	**Salinity.** The analysis will require long term salinity monitoring.
2.	**Total suspended sediments (TSS).** A time series of TSS may be needed. This could be acquired from the NERRs System Wide Monitoring Program (SWMP) datasets.
3.	**Dated soil cores.** These will be required for building a historic DEM.
4.	**Water level time series.**
5.	**Stream gauge data points.**
6.	**Data trends and points.**

Table 7. Data Want

	Data Want
1.	**Habitat layer that identifies change.** Layers that show drowned forests or ghost trees would be useful.

3.3.1 Decision Points

1. In order to perform the marsh model retrospective, a significant amount of work and funding will be required to support necessary data gathering. In particular, future costs will include processing, adjustment, or standardization of historic NWI data, and gathering the dated soil cores.
2. An objective referee will be needed to evaluate the marsh model retrospective analysis.

3.3.2 Next Steps

1. The marsh modelers requested that the Project Team share the North Carolina and Gulf of Mexico SET inventories with them.

3.4 Day One Wrap-Up

At the close of day one, Renee Collini (PLACE:SLR) reviewed with attendees the accomplishments of the day and provided a brief description of what would be covered in day two of the workshop. The primary outcome from discussions to wrap up day one was a list of outputs to compare from the marsh model retrospective analysis. This list of outputs was determined by the marsh modelers.

Table 8. Marsh Model Retrospective Outputs to Compare

Marsh Model Retrospective Outputs to Compare
Vertical elevations
Horizontal habitat changes
Landscape (holistic output)

3.5 Details for Performing a Marsh Model Retrospective

The second day of the workshop focused on discussion of the details for performing a marsh model retrospective analysis. This included details regarding vegetation input layers, appropriate DEMs, timesteps, sea-level rise, locations, and model uncertainty. The overarching goal of this discussion was to refine the input details for the marsh model retrospective so that the project team and modelers pursue funding to perform the retrospective analysis. Important discussion notes and decision points were captured on flipchart pages throughout the discussion (Appendix D.4-5). Detailed discussion of each topic is provided below.

3.5.1 Vegetation Input Layers

For a model to accurately project changes in marsh habitat, there must first be accurate and reliable layers for existing habitat. However, the project team and marsh modelers identified complications with easily accessible vegetation layers, particularly those available through NWI. Discussions among the project team and the marsh modelers are detailed below.

One of the first concerns raised was that NWI habitat classes have changed over time. Because of this, comparisons of NWI layers over time can be difficult. To remedy this, historic NWI layers will need to be reclassified to ensure that all time periods in the retrospective analysis are comparable. The marsh modelers suggested several ways to complete this task. First habitat re-classification could be accomplished using aerial imagery. To train the reclassification, ground truth data points may be required. However, it is not known if this data exists. Furthermore, historical imagery may be of a lower resolution and therefore the classifications may have to be on the scale of fresh marsh, salt marsh, etc.

In some locations and for some time periods, the historic data for metrics that affect vegetation changes (i.e., accretion, biomass density, TSS, etc.) do not exist. The marsh modelers recommended that site-specific calibration of these metrics could be conducted for the current, existing condition. Then, the relationship between those metrics and vegetation could be assumed to be consistent for historical time periods. By applying those relationship assumptions to historical vegetation layers, metrics such as accretion can be accounted for with reasonable accuracy.

Throughout the discussion, it became clear that each marsh model may have different definitions of "vegetation data." There was a short pause in the discussion to allow each marsh modeler to define what "vegetation data" means in their model (Table 9). Following that, the project team and marsh modelers discussed what definition should be used for the marsh model retrospective analysis. It was widely agreed, based on what each model already considers for their vegetation layers, that each model could use high, mid, and low marsh categories for the retrospective analysis. However, the Louisiana ICM is an exception. Because of the low elevation of Louisiana coastal marshes, the elevation-based categories may not apply. However, Eric White (CPRA) suggested that the dominant species could be assigned and be used to create comparable categories for Louisiana marshes.

Table 9. Model Vegetation Data Definitions and Other Important Data

Model	Vegetation Data Definition	Other Important Data
ICM	Uses species level that is then scaled up to the community level	Vertical accretion
Hydro-MEM and MEM	Can be species specific, but generally uses high, mid, and low marsh categories	Biomass and accurate RTK elevations
SLAMM	Needs marsh habitat classes (e.g., high, low, tidal fresh), but can use species mixtures	SET data could be useful, but is not absolutely necessary
WARMER	Uses high and low marsh classifications, but also incorporates dominant species	

The final vegetation topic discussed was how to proceed with the vegetation data layer. Initially, the conversation centered on choosing between NWI or Coastal Change Analysis Program (CCAP) data layers, or an entirely separate dataset. CCAP does not distinguish between high and low marsh, so that would create extra steps in the retrospective process. NWI is likely to provide historical data if provided with a detailed, specific request, but the project team will also need details on the workflow and classification scheme used by NWI. The marsh modelers and project team briefly discussed deriving their own vegetation dataset. However, that would be a more substantial task than building on an existing dataset. It was determined that the project team would begin with historical NWI imagery and reclassify the data to include high, mid, and low marsh while ensuring that each marsh category has a clear definition.

3.5.1.1 Next Steps

- Obtain raw, historical NWI imagery
- Reclassify the imagery to include standardized high and low marsh categories across all time steps; consider other classifications such as mid
- Create clear definitions of high and low marsh, and mid as well if necessary

3.5.2 Digital Elevation Models

An accurate DEM is considered to be a necessity for contemporary marsh models. However, accurate and high resolution DEMs are unlikely to be available for historical time periods due to the lack of LiDAR data, as LiDAR surveys were rarely performed prior to 2007. The marsh modelers first discussed what other historical options are available.

Jonathan Clough (SLAMM) discussed how SLAMM addressed elevation before LiDAR DEMs were available. He suggested that prior approaches would not be applicable for the retrospective because the resulting elevation model would be too coarse to be useful. Even with interpolation, artifacts had big impacts on the marsh model results. Because of the lack of existing historical options, it was decided that the project team and marsh modelers would attempt to build a DEM using historical data. The methodology with which to accomplish this was the focus of conversation for the duration of the DEM discussion. It was acknowledged that building a pre-LiDAR DEM would be a significant undertaking, but the project team and modelers developed a list of the necessary steps and pieces to accomplish the task while also accounting for concerns raised during the discussion.

The first piece that was discussed was the use of dated soil cores to adjust a contemporary DEM to an agreed upon starting point. The marsh modelers agreed that this could be a blunt approach to rolling back time followed by more fine scale modeling. They also agreed that this could be a good approach, but it may be limited by the necessary assumption that the plant community has not changed much over time. To address that limitation, the marsh modelers suggested that historical vegetation data may be able to improve the built DEM resolution. Theoretically, the marsh modelers thought that this would be a good working solution but acknowledged that the accuracy of the resulting DEM may not be sufficient for the marsh model retrospective. Kevin Buffington (WARMER) has experience using dated soil cores to adjust DEMs with success but has not attempted it on a large scale. Jonathan Clough also expressed concern that this may not be valid on dry land adjacent to coastal marshes, which would limit application of the marsh model outputs for marsh migration questions.

Despite the concerns, the marsh modelers agreed that building a new DEM by using soil cores to adjust a good, contemporary DEM would be the best option for the marsh model retrospective analysis.

3.5.2.1 Next Steps

- Choose a good, contemporary DEM
- Obtain data from dated soil cores
- Use soil cores to adjust the DEM to the target time period
- Further increase resolution of the built DEM using historical vegetation data, if needed

3.5.3 Time Steps

To perform a marsh model retrospective analysis, it is critical to agree upon the time steps and time period to consider.

The project team and marsh modelers first discussed what is meant by “time steps.” The marsh modelers pointed out that with modeling there are two types of time steps to consider. There is an internal time step and an external time step. Internal time steps refer to the intervals of data that the model uses in the background processing, like hourly water levels. External time steps refer to the time steps presented in the model outputs. The project team clarified that for the purposes of this discussion, the marsh modelers should consider external time steps.

To begin selection of time steps to use in the marsh model retrospective, the discussion referred to what stakeholders could be expected to want to see in model outputs. Because stakeholders would be most interested in intermediate time spans for the comparison, it was agreed that five-year time steps would be ideal. However, the marsh modelers felt that this would primarily depend on data availability. Point elevations, rather than landscape ones (i.e., LiDAR DEMs) would be most useful for achieving five-year time steps. Overall, the project team and marsh modelers agreed that five-year time steps would be possible. However, a starting and ending time point was not agreed upon. Rather, it was agreed that data availability would have to be further explored at target locations to make this decision.

3.5.3.1 Next Steps

- Obtain historical point elevations.
- For the marsh model retrospective analysis, the outputs will have five-year time steps.

3.5.4 Sea-Level Rise

Sea-level rise data are necessary in considering changes to coastal marshes in marsh models. While the retrospective analysis will use known inputs, sea-level rise is recorded in linear and non-linear trends. To determine which type of sea-level rise data to use in the marsh model retrospective, the marsh modelers discussed a few points.

First, Renee Collini presented information about the difference between the linear and non-linear sea-level rise trends. Based on her presentation, the marsh modelers needed clarification on using the observed data versus using a sea-level rise trend. If we have known data, then that would seem ideal for model applications, especially considering the high amount of variability in water levels over time. However, because the retrospective is intended to run from a starting point and forecast unknown conditions, a sea-level rise trend would be most appropriate.

Next, the marsh modelers discussed the choice between the linear and non-linear sea-level rise trends. They determined that it would be most useful to choose the trend to use based on the nearest tide station to the targeted locations. Each model would perform the retrospective based on the curve that has the best fit at each location. However, the marsh modelers also pointed out that this exercise could also be useful for identifying areas of uncertainty in each model if compared to model runs using the actual observed data. Therefore, outside of the marsh model retrospective analysis, the marsh modelers will run their model with observed data to support extension and outreach to stakeholders.

3.5.4.1 Next Steps

- Identify the sea-level curve with the best fit (linear or nonlinear) at tide stations nearest the target locations.
- Use the selected curve to run the models in the marsh model retrospective analysis.
- To create extension materials for stakeholders, compare the results of the analysis with another model run using observed sea-level rise data.

3.5.5 Locations

Throughout much of the discussion during day two of the workshop, it was mentioned that data availability by location may be a limitation for different input parameters. For this reason, the discussion moved towards narrowing down location choices for the marsh model retrospective analysis. This process began with the marsh modelers suggesting locations that they deemed to fit two criteria: 1) the location has a wealth of data, and 2) there has been enough change in the marsh that the models would be able to describe the change. Each location was then discussed to determine what data may be easily accessible.

3.5.5.1 Grand Bay NERR

The Grand Bay NERR was suggested because it has been well studied, several of the models represented in at the workshop have already been run there, and the marsh modelers believe that data would be easy to obtain. Grand Bay would also serve as a good representative of how the models perform in a microtidal system.

3.5.5.2 Apalachicola NERR

Apalachicola NERR, like Grand Bay NERR, has been well studied and several of the marsh models have already been ran there. However, Apalachicola is a relatively complex system that could create difficulties in the marsh model retrospective analysis. There have been many changes in the Apalachicola NERR that may have a variety of drivers. This would make it difficult to distinguish the effects of sea-level rise from other drivers.

3.5.5.3 North Carolina Reserve System

The North Carolina Reserve sites have been well studied (e.g.vegetation surveys, SETS, water level data) and were included in the data mining that was explored in day one of the workshop, so it is known that there is a lot of existing data in the region. The marsh modelers also pointed out that these locations would serve as a good comparison to the microtidal locations along the northern Gulf of Mexico that had already been suggested. However, some marsh models have not been run in this area.

3.5.5.4 Louisiana

Coastal marshes in Louisiana have experienced considerable amounts of change, and there is a breadth of data available. In particular, the marsh modelers specified available vegetation surveys, SETs, accretion, and water level data. USGS also has regularly updated aerial imagery that may be useful for reclassifying vegetation data layers for the marsh model retrospective analysis. Eric White indicated that CPRA is interested in doing a rigorous hindcast in the region, which could be leveraged for this effort. There were two concerns raised by the marsh modelers. First, the complexity of Louisiana marshes could prove difficult. Second, a specific location within Louisiana was not agreed upon during the workshop.

3.5.5.5 Plum Island, MA

Plum Island is a marsh that is data rich. In particular, James Morris and Karim Alizad expressed high levels of familiarity with the data available in that area. They also indicated that there has already been a lot of change in marsh extent at Plum Island. Plum Island could also be a representative location for marshes along the east coast of the United States.

3.5.5.6 Sacramento Delta

The marsh modelers were asked to suggest locations on the west coast in addition to those already suggested on the east and Gulf coasts of the United States. The Sacramento Delta was suggested as the best-known choice. However, areas of significant change may be hard to find in the area. Elkhorn Slough was suggested, but otters have played a key role in driving the change there. While there are data rich areas in the region, selecting one with significant change may be a challenge.

After discussion of the possible locations, the marsh modelers were asked to indicate their preference for where to run the marsh model retrospective by placing sticky dots next to their top three locations on the flipcharts. When they completed that task, the votes were tallied to decide which three locations to focus on for this effort. Through this, it was decided that the project team and marsh modelers would move forward in Louisiana, Grand Bay NERR, and Plum Island, MA. Primarily, these locations were selected due to the availability of data and the breadth of complexities and variables that the locations cover. The voting tally can be seen in Table 10 below or on the flip chart images (Appendix D.5).

Table 10. Votes for Marsh Model Retrospective Locations

Location	Votes
Apalachicola NERR	3
Grand Bay NERR	5
Louisiana	4
North Carolina Reserves	1
Plum Island, MA	5

3.5.5.7 Next Steps

- The marsh modelers decided to focus on Louisiana, Grand Bay NERR, and Plum Island, MA for the marsh model retrospective.
- A specific location will need to be selected in Louisiana.
- The project team and marsh modelers will work to inventory the available data at each of the three locations to ensure their applicability in the marsh model retrospective.

3.5.6 Model Uncertainty

Lastly, the marsh modelers discussed how to address model uncertainty based on stakeholder feedback. Stakeholders indicated that sources and meaning of uncertainty should be clear so that they can understand how to account for it in their decision making (for more information, see the Stakeholder Perceptions Presentation in Appendix A.2). The marsh modelers first defined the uncertainty in their models (Table 11). Then, they decided that for the marsh model retrospective they will set boundaries on the uncertainty based on the various models and the range of conditions that the models will use. The marsh modelers also pointed out that this effort for the marsh model retrospective could be used as an opportunity to characterize the uncertainty for stakeholders.

Table 11. Sources of Uncertainty in Models

Model	Sources of Uncertainty
SLAMM	This model has some uncertainty bounds around processes (including DEMs) that help to generalize the confidence intervals and relative vulnerability on marsh presence likelihood.
WARMER	This model samples from a distribution of accretion rates, decomposition, and other factors and runs Montecarlo simulations to get a confidence level.
ICM	This model has more scenario-based uncertainty. It has some model validation to generate statistics and then perturbs the model.
Hydro-MEM	No details about model uncertainty are provided in model outputs.
MEM	This model uses the Montecarlo approach with uncertainty

3.5.6.1 Next Steps

- Once the data are defined, bounds of uncertainty and the range of conditions that will be used in the marsh model retrospective analysis will be set.
- This effort will be leveraged to create extension products for stakeholders to explain uncertainty in model outputs.

3.6 Discussion Summary: Revisiting the Marsh Model Retrospective Framework

Following the discussions about what details to include in the marsh model retrospective analysis, the modelers and project team returned to the questions regarding framework to ensure that all the decisions that had been made will support the example application and scoping questions listed at the beginning of the workshop (questions are included in Section 3.2, and in the handout provided in Appendix B.2).

The group first reviewed the scoping questions. Questions for which there was discussion are listed below, with specific discussion points noted.

1. What site specific variables do we need to evaluate for their influence on model performance?
    a. Estuary type and characteristics
        i. The modelers stated that the locations selected cover both a range of estuary types and site complexities that will sufficiently test the capabilities of the models.
2. How do we evaluate marsh model performance? What outputs do we compare?
    a. The modelers detailed two ways that the outputs could be compared: cell-by-cell in the output maps, by percent area, or both.
    b. Cell-by-cell is likely to be more reflective of the starting conditions and cell sizes.
    c. Percent land cover change may be more informative, but the modelers were unsure if it would answer questions related to where a model performs well.
        i. Instead of cell-by-cell analysis, the outputs could be divided into sub-domains, in which model "hits or misses" could be further explored.
    d. For the purposes of comparison, areas where the model outputs are predicting similar vulnerabilities should be highlighted.
    e. The comparison can be depicted using a histogram of vegetation types or classes.
3. Do we have enough data, and the needed data, to perform the retrospective analysis and to answer the research questions right now?
    a. The modelers agreed that there is too much uncertainty on the data availability to answer this question.

The group then reviewed the example application questions. The modelers were asked if the questions could be answered in the three selected locations based on what had been scoped throughout the workshop. The modelers primarily discussed the use of the retrospective in addressing questions of marsh migration. They expressed concerns that the limitations of a constructed DEM, as discussed in Section 3.5.2, would undersell migration potential and model certainty. This would need to be addressed in communications with the stakeholders about the retrospective analysis.

3.7 An Approach and Timeline for the Marsh Model Retrospective

The final discussion of the workshop was focused on gathering the information gained from the two-day workshop to outline an approach for performing the marsh model retrospective. This included listing next steps, assigning who will be responsible for each task, estimating costs, and setting a timeline for completing the tasks. The decisions were captured on a flipchart (Appendix D.7) and are outlined below. The purpose for each task was discussed in detail throughout the workshop and can be found in Section 3.5.

Task:	Acquire NWI Data
Responsibilities:	Christine Buckel and Trevor Meckley will reach out to the United States Fish and Wildlife Service to request NWI data layers.
Timeline:	Approximately two months
Estimated Costs:	No associated costs

Task:	Reclassify NWI Data
Responsibilities:	Renee Collini will facilitate discussions about classifications for the data. The project team will ask for volunteers to participate in the discussions once the NWI data is in hand. The Water Institute of the Gulf expressed interest in doing the data classification once funding is available.
Timeline:	6–8 months for the entire process once the data is in hand
Estimated Costs:	Funding will be required to pay for someone’s time to do the classification of the NWI data.

Task:	Gather DEM data for the selected locations
Responsibilities:	Responsibilities were discussed by site: Louisiana: Eric White will lead the effort for this site. Plum Island: Karim Alizad believes that Matt Kirwan has the existing DEM for Plum Island and will reach out to him. Grand Bay: The project team already has access to the DEM for Grand Bay.
Timeline:	2–4 months for all three sites,
Estimated Costs:	There are no estimated costs associated with this task.

Task:	Pick a specific location for Louisiana.
Responsibilities:	Eric White and Christopher Esposito will lead the selection of a site in Louisiana
Timeline:	Approximately 2 months because some data will need to be found, but not analyzed, before final site selection occurs.
Estimated Costs:	No associated costs.

Task:	Identify existing soil cores.
Responsibilities:	Trevor Meckley, James Morris, and Eric White will work together to first define what soil core data is needed for the retrospective analysis The leads for identifying soil cores differed based on location.

Louisiana: Eric White
Plum Island: Karim Alizad and James Morris
Grand Bay: Karim Alizad

Christine Buckel will be the point of contact for assuring this task is completed on time.

Timeline: Approximately 4 months.
Estimated Costs: No associated costs.

Task: Acquire Sea-Level Rise Data.
Responsibilities: Renee Collini will lead this effort.
Timeline: Renee indicated that this task can be done quickly once the final site selection is completed.
Estimated Costs: No associated costs.

Task: Acquire RTK data.
Responsibilities: The lead for this task differs by location:

Louisiana: Eric White
Plum Island: Karim Alizad
Grand Bay: Renee Collini

Timeline: 8 months
Estimated Costs: No associated costs.

Task: Build the historical DEMs
Responsibilities: Due to the complex nature of this task, the project team and modelers believe that someone will have to be hired to complete it.
Timeline: 18 months
Estimated Costs: Money will be required to hire someone to complete this task.

Task: Obtain new soil cores to fill in any gaps in the existing soil cores.
Responsibilities: Due to the complex nature of this task, the project team and modelers believe that someone will have to be hired to complete it.
Timeline: 2–5 years for full collection and analysis.
Estimated Costs: Money will be required to hire someone to complete this task.

Task: Determine specific model costs
Responsibilities: Trevor Meckley will reach out to each modeler to determine their specific model costs.
Timeline: 1 month.
Estimated Costs: No associated costs.

3.7.1 Next Steps

Following the discussion of the timeline and specific tasks to be completed before a marsh model retrospective analysis could be conducted, Renee Collini led discussion of the next steps to follow the workshop.

To ensure continued communication and that updates are shared with the entire project team, emails will be sent out quarterly. Virtual meetings will be held semi-annually or as needed based on project progress. These meetings will be organized using online polling to select dates, and available data will be sent to the project team ahead of any meetings. This will ensure that valuable time is spent on discussion in the meetings rather than extensive data presentations.

David Kidwell expressed concerns that the estimated timeline for the retrospective analysis (5 years) is too long; the need for the retrospective is too pressing. To hasten the timeline, the project team and modelers agreed to address the following tasks within six months of the workshop completion:

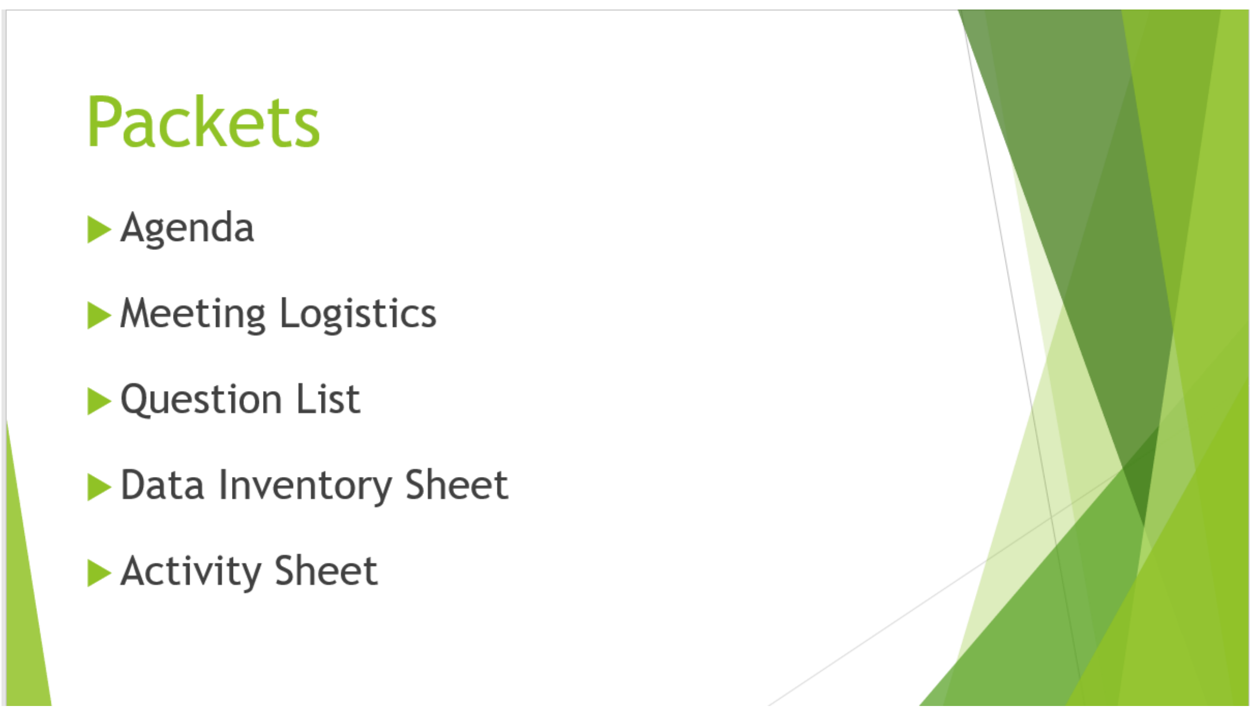
- Assess availability of existing soil cores
- Identify existing RTK data
- Obtain existing NWI data
- Obtain existing DEM data
- Pick a specific Louisiana location
- Determine costs for running each of the models

This list will form the checklist of tasks to be completed before the first virtual meeting.

4.0 Appendices

Appendix A: Workshop Presentations

A1: Introduction to the Workshop



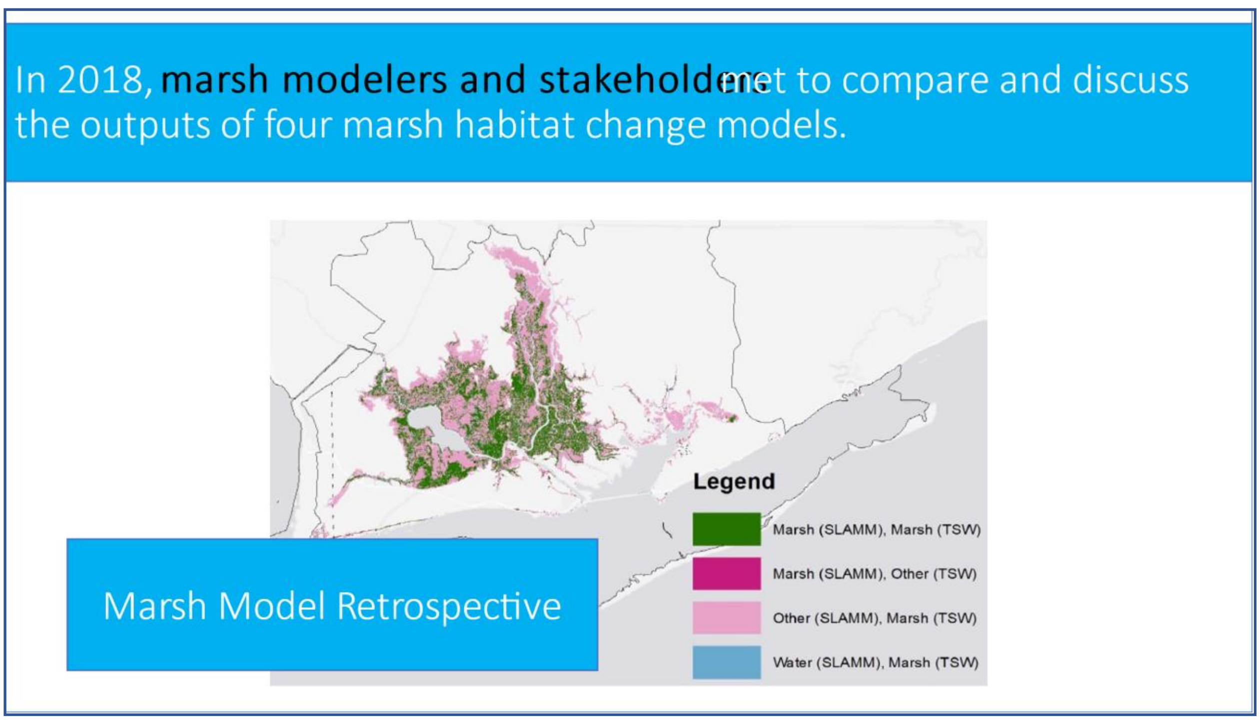
Agenda – Day One

- Background & Setting the Stage
  - Overview - Goals and Objectives
  - Stakeholder Input
  - What is a Retrospective
- Scoping Question
- Break
- Review Data Collected So Far
  - Introduction
  - Data Exploration
- Introduce Technical Details
- Review Scoping Questions
- **Dinner - Moonrakers**

Agenda – Day Two

- Review Day One
  - Progress – what we found
  - Reflection
- Technical Details
  - Veg Input Data
  - DEMs
  - Time Steps
- Break
- Technical Details
  - SLR
  - Locations
  - Anything else?
- Revisit Scoping Questions
- Revisit Example Application Questions
- Details of the Retrospective
  - Working **lunch** if need-be
- Next Steps & Wrap-Up
- **Field Trip**

A2: Stakeholder Perceptions of Marsh Models



Why do stakeholder perspectives matter?

Gathering Stakeholder Perspectives

The stakeholder interviews were driven by three main questions:

- How do stakeholders use marsh model outputs?
- If they are not using model outputs, then why not?
- What makes a marsh model output more applicable to stakeholders?

Interviews were conversational and generally covered 9 questions

1. How do you use marsh models in your work?
2. What models do you use most often?
3. What environmental inputs are important for models to consider?
4. How do you resolve differences between model outputs?
5. What time steps are most useful for your decision making?
6. What level of parcel averaging are you comfortable with?
7. What model outputs would be most useful other than marsh presence/absence?
8. How likely are you to trust the results of the retrospective analysis?
9. How should we report the results of the retrospective?

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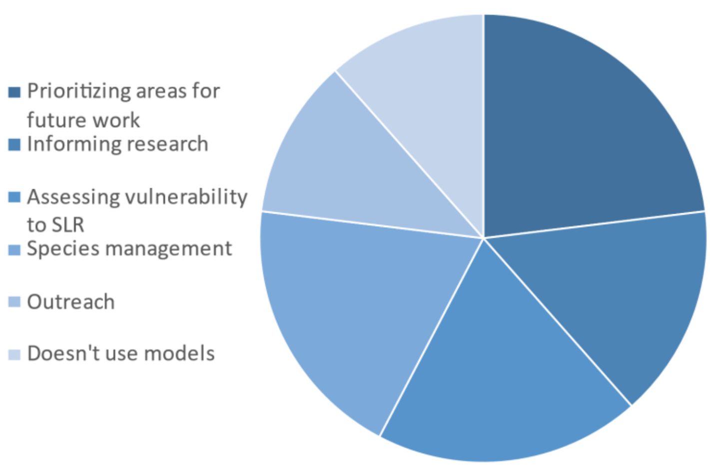
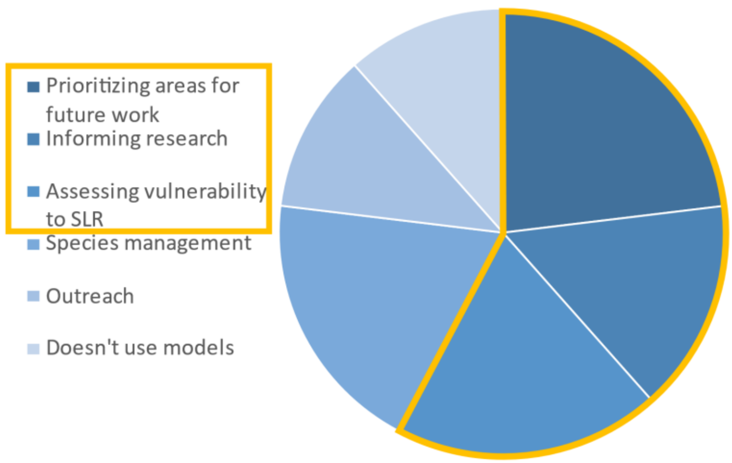
Results

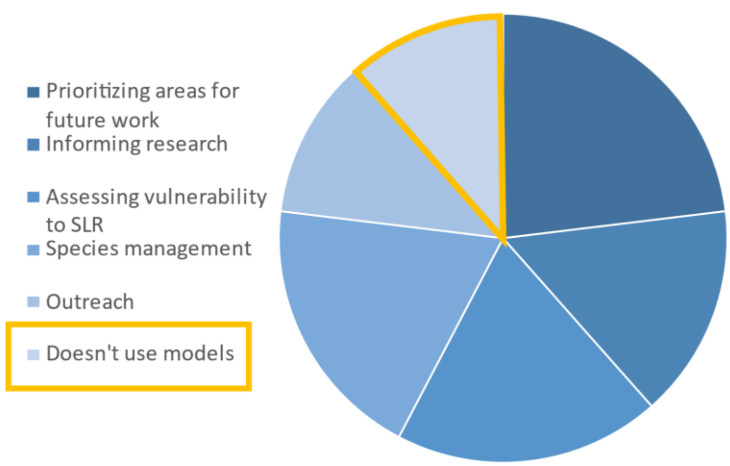
How do stakeholders use marsh models?



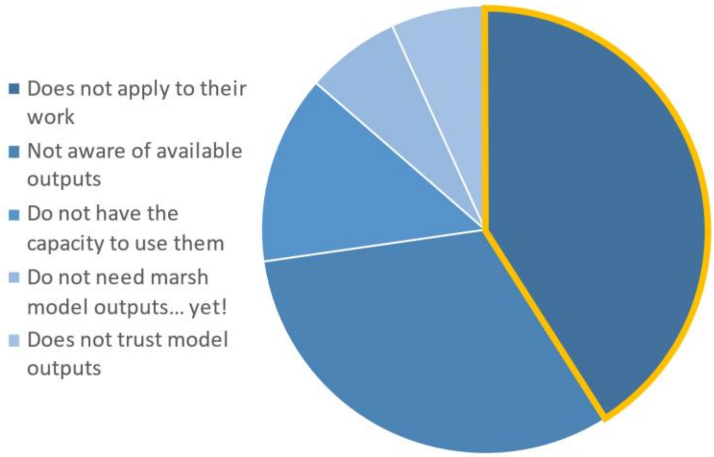
How do stakeholders use marsh models?



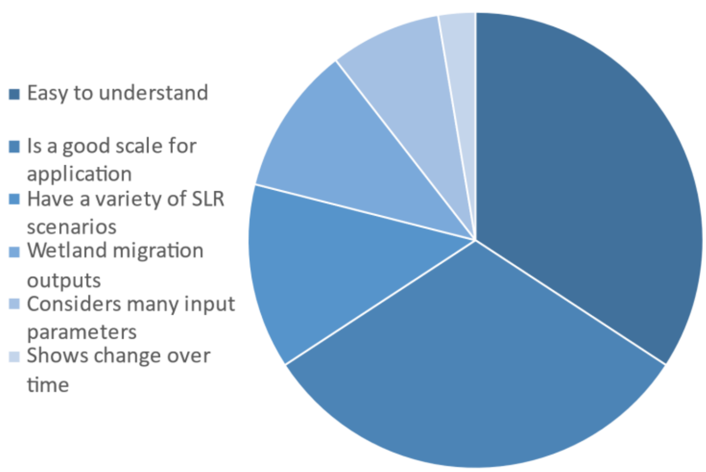
How do stakeholders use marsh models?



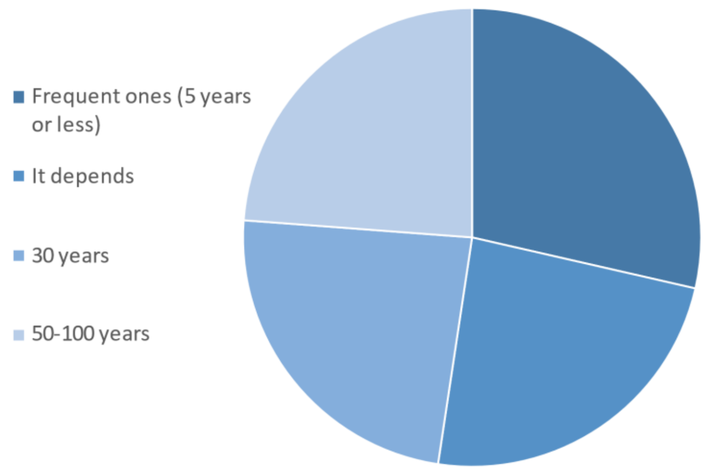
Why aren't stakeholders using marsh models?



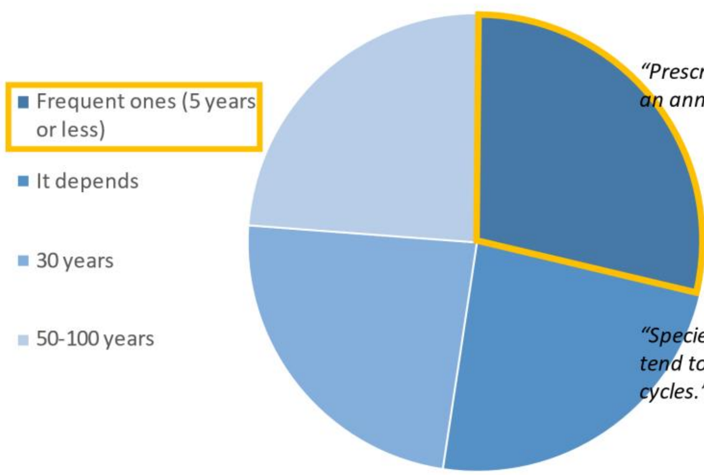
What works well in marsh model outputs?



What time steps are most useful to stakeholders?



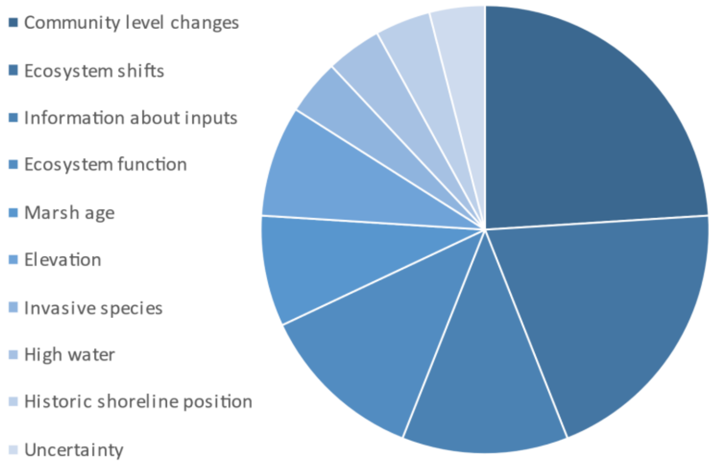
What time steps are most useful to stakeholders?



"Prescribed fire can be informed on an annual basis"

"Species recovery action reviews tend to be on two to five year cycles."

What kinds of outputs, other than marsh presence/absence, woul most useful to stakeholders?



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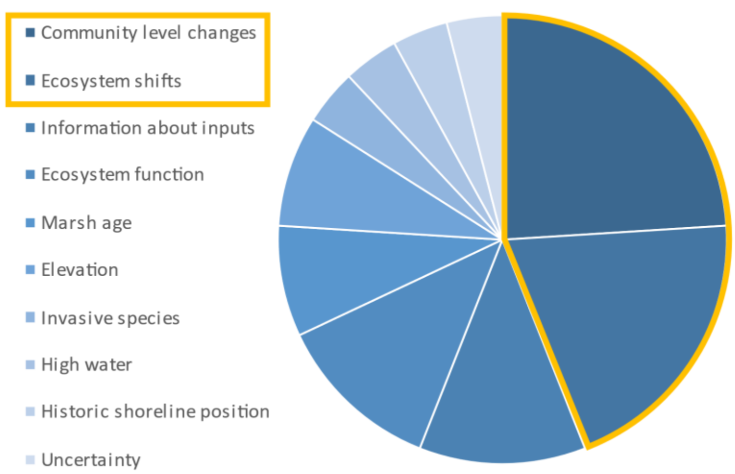
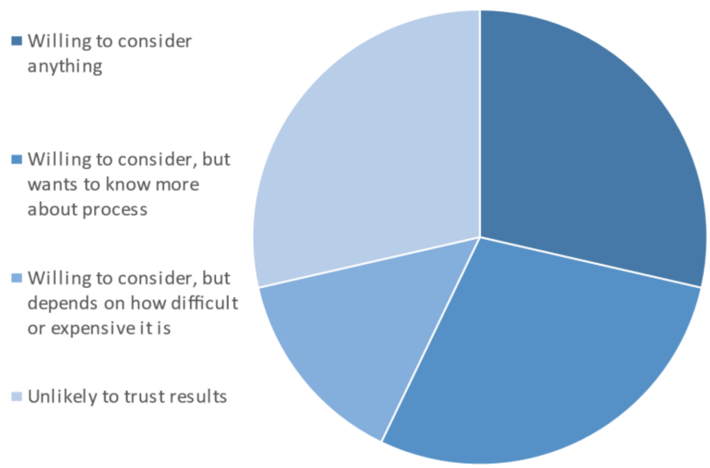


How likely are stakeholders to trust the results of the retrospecti



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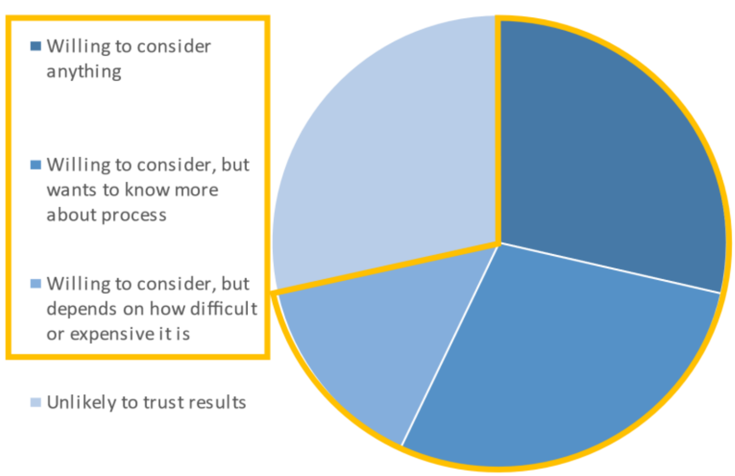

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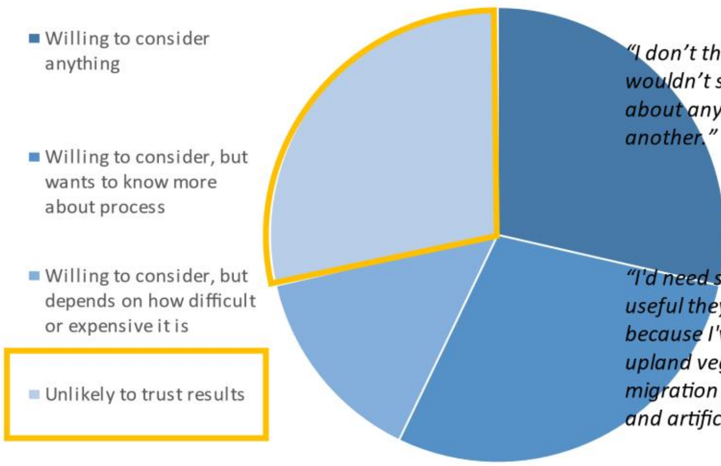


"I don't think I trust any models. I wouldn't say that I know enough about any of them to trust one over another."

"I'd need some convincing on how useful they are - I'm skeptical a bit because I've seen strong evidence of upland veg really inhibiting migration even when slope is good and artificial barriers are absent."

Key takeaways from the conversations with stakeholders

Key takeaways from the conversations with stakeholders

While most stakeholders do use models in their decision making, there is a segment that do not.

Key takeaways from the conversations with stakeholders

The more outputs and scenarios a model considers increases its useability for stakeholders, especially if it can be applied cheaply and easily for their managed lands.

Key takeaways from the conversations with stakeholders

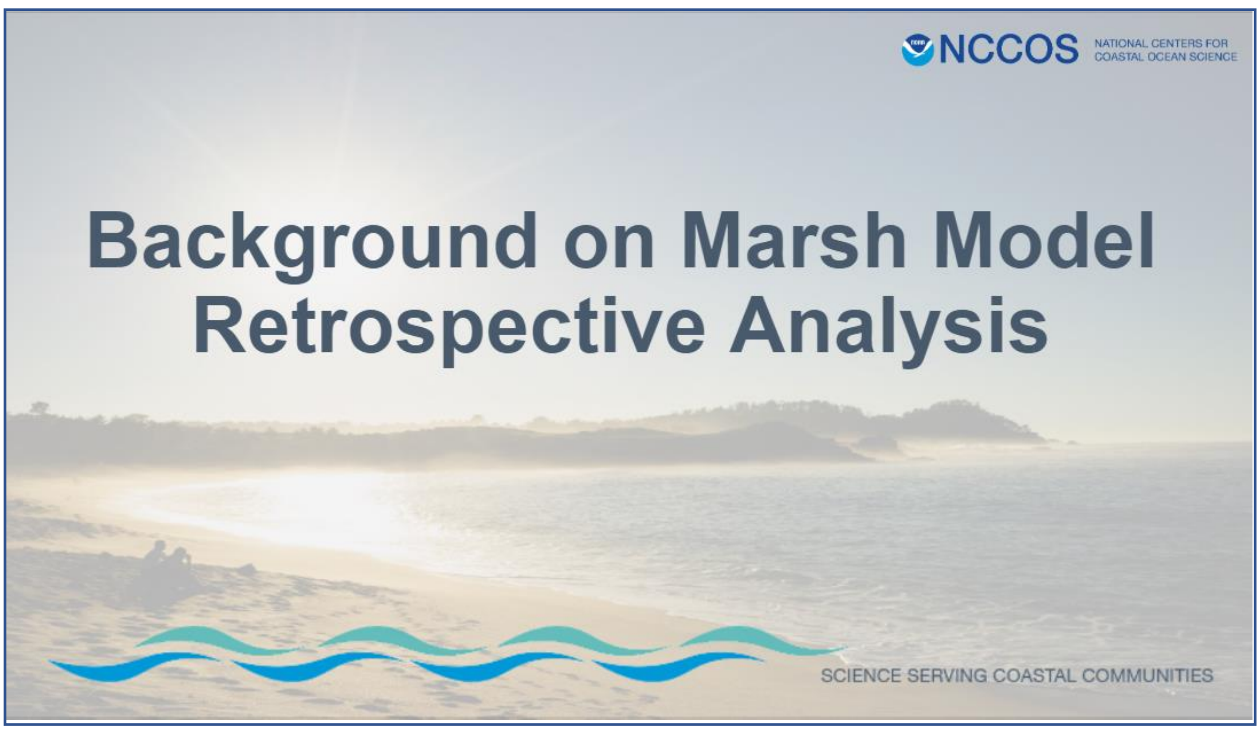
Many stakeholders expressed concerns about transparency in model processes and surrounding uncertainty in the outputs.

How does this apply to this workshop?

Example Application Questions

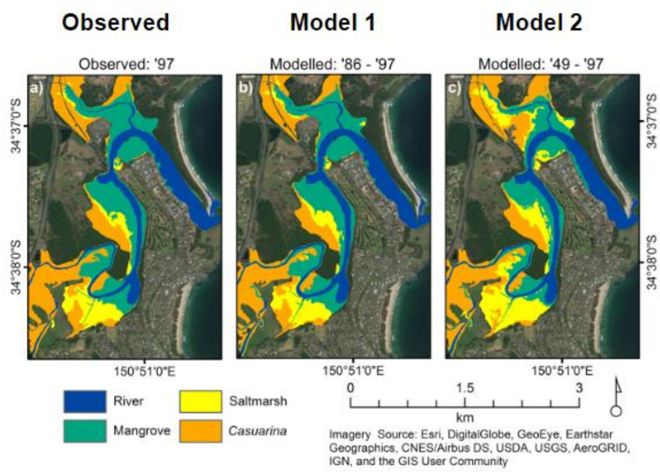
1. What model should I use for my marsh type?
2. What is the utility of different model output types for different management decisions?
3. How certain are the predictions and are there areas where we are more confident?

A3: Background on the Marsh Model Retrospective



NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Retrospective analysis uses historical data to predict known conditions

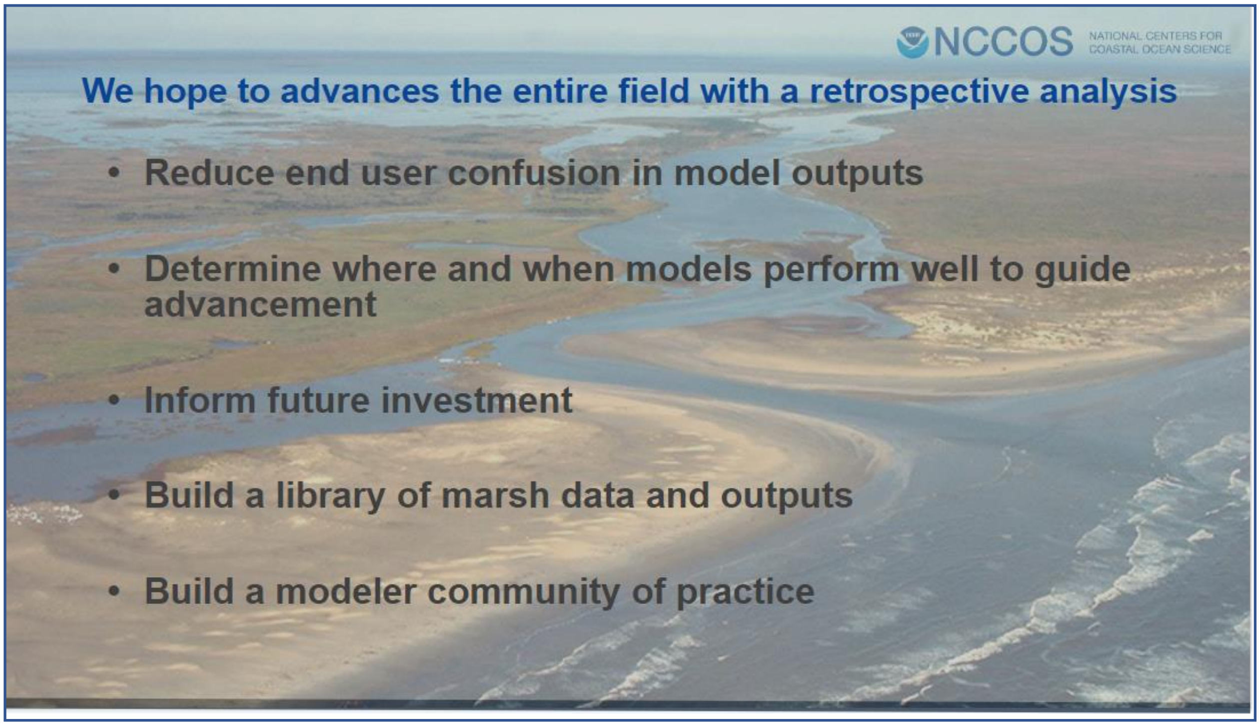


Mogensen and Rogers, 2018 | DOI:10.1038/s41598-018-19695-2

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

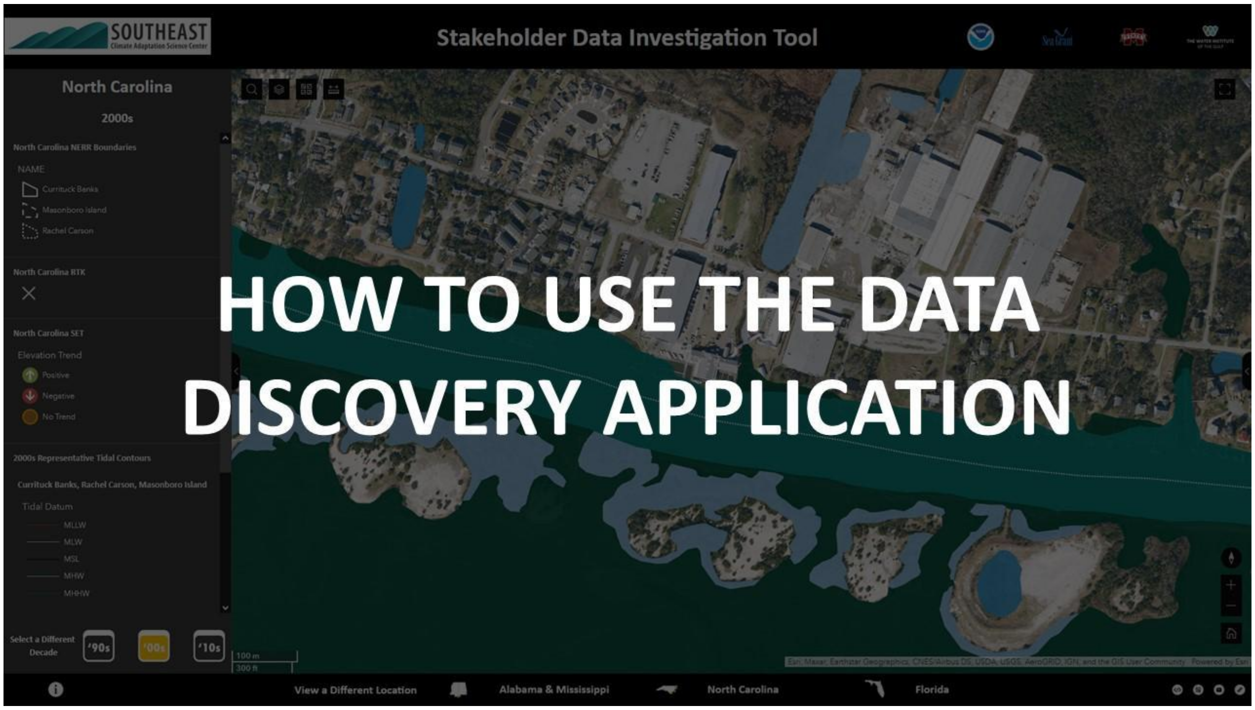
Marsh manager/planners have questions on application

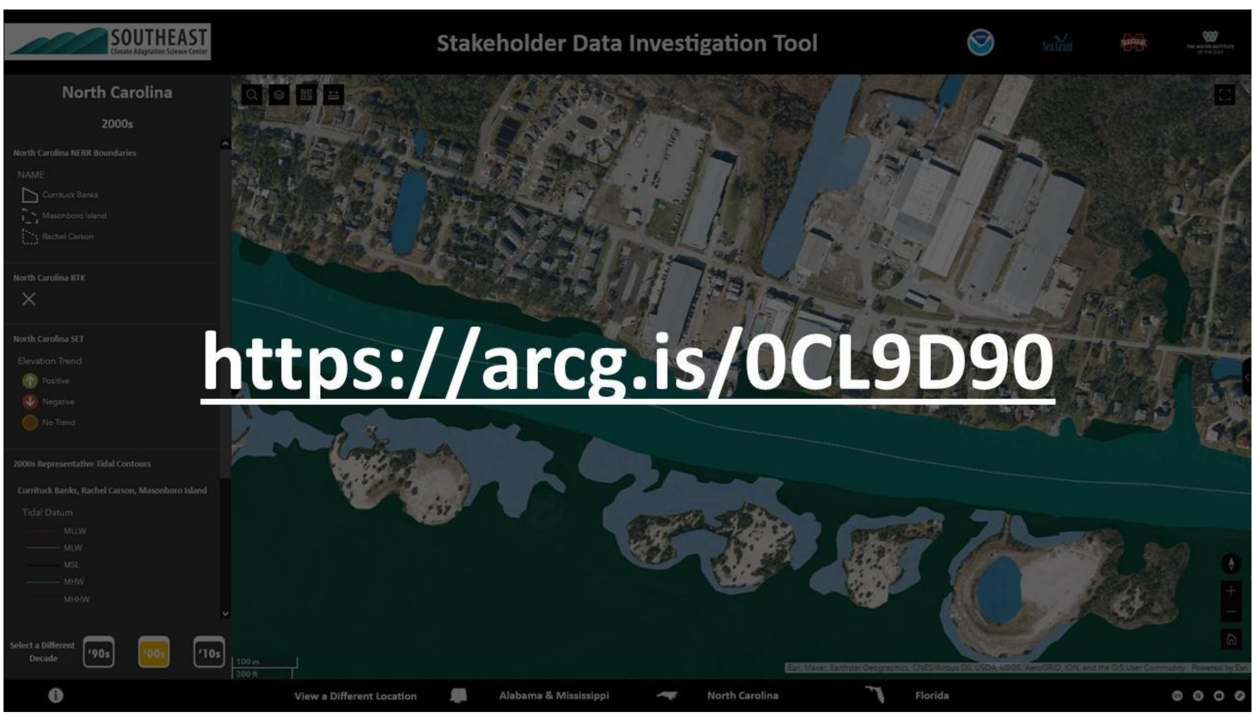
- Where should we acquire land or protect land (policy) or how should realign coastal infrastructure to ensure marshes exist in the future?
- How will management actions actions affect my marsh?
  - Controlled burn
  - Fronting structure to protect against erosion
  - Changing land elevation through placement of sediment
  - Estuary mouth opening (or allow to remain closed)
- These application questions have led to questions on what model should I use for my marsh and how accurate (certain) are the results?

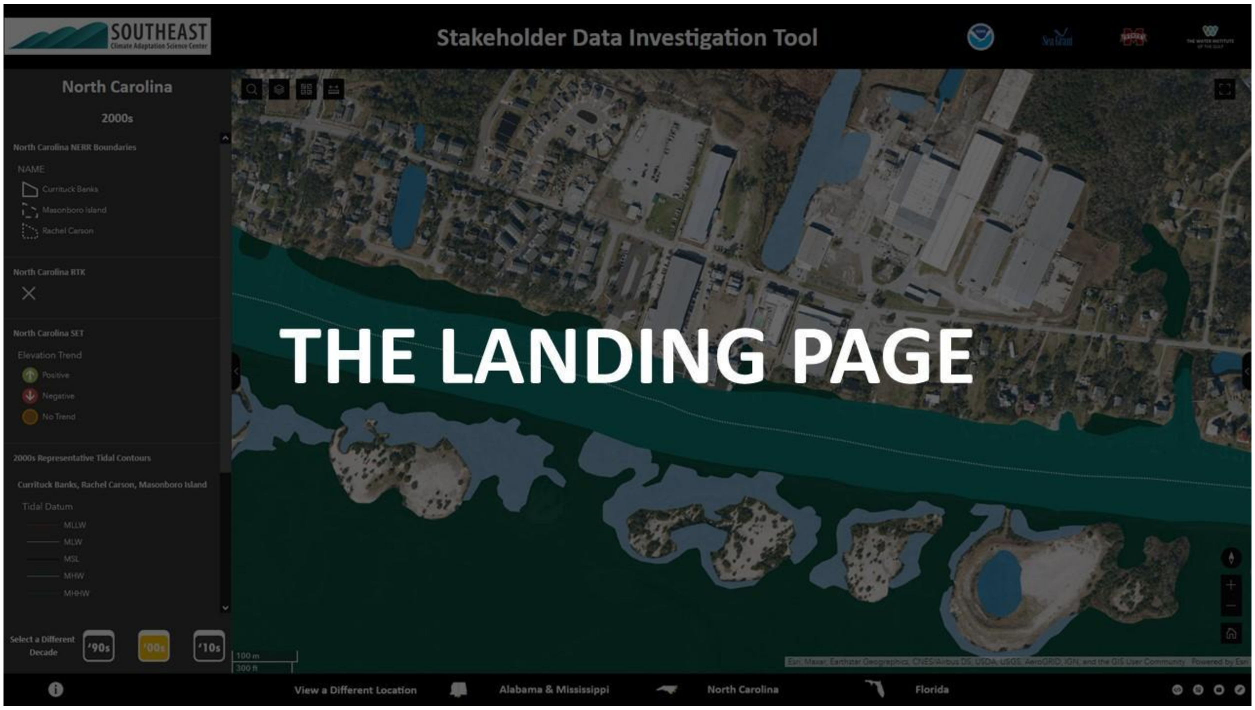

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE
We hope to advances the entire field with a retrospective analysis
• Reduce end user confusion in model outputs
• Determine where and when models perform well to guide advancement
• Inform future investment
• Build a library of marsh data and outputs
• Build a modeler community of practice

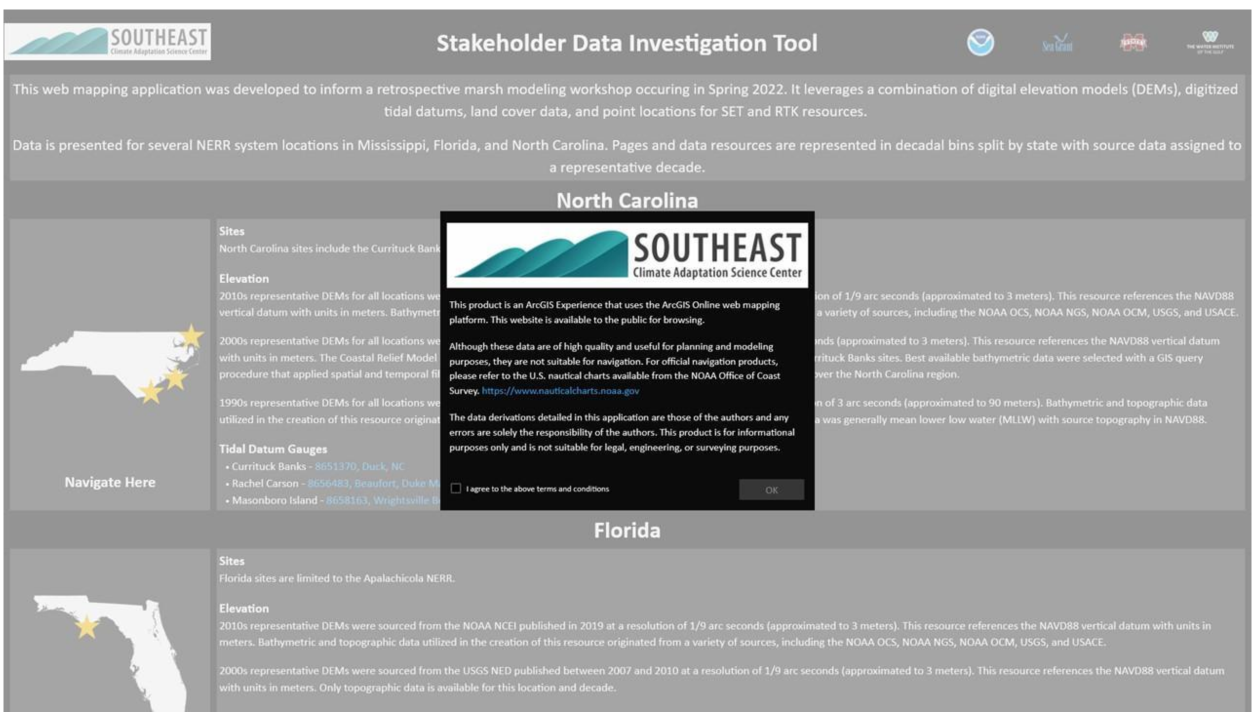

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE
Questions

A4: Introduction to Data Exploration






SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
North Carolina
2000s
North Carolina NERR Boundaries
North Carolina RTK
North Carolina SET
Elevation Trend
Positive
Negative
No Trend
2000s Representative Tidal Contours
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
THE LANDING PAGE
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
This web mapping application was developed to inform a retrospective marsh modeling workshop occuring in Spring 2022. It leverages a combination of digital elevation models (DEMs), digitized tidal datums, land cover data, and point locations for SET and RTK resources.
Data is presented for several NERR system locations in Mississippi, Florida, and North Carolina. Pages and data resources are represented in decadal bins split by state with source data assigned to a representative decade.
North Carolina
Sites
Elevation
Tidal Datum Gauges
Navigate Here
This product is an ArcGIS Experience that uses the ArcGIS Online web mapping platform. This website is available to the public for browsing.
Although these data are of high quality and useful for planning and modeling purposes, they are not suitable for navigation. For official navigation products, please refer to the U.S. nautical charts available from the NOAA Office of Coast Survey. https://www.nauticalcharts.noaa.gov
The data derivations detailed in this application are those of the authors and any errors are solely the responsibility of the authors. This product is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.
I agree to the above terms and conditions
OK
Florida
Sites
Florida sites are limited to the Apalachicola NERR.
Elevation
2010s representative DEMs were sourced from the NOAA NCEI published in 2019 at a resolution of 1/9 arc seconds (approximated to 3 meters). This resource references the NAVD88 vertical datum with units in meters. Bathymetric and topographic data utilized in the creation of this resource originated from a variety of sources, including the NOAA OCS, NOAA NGS, NOAA OCM, USGS, and USACE.
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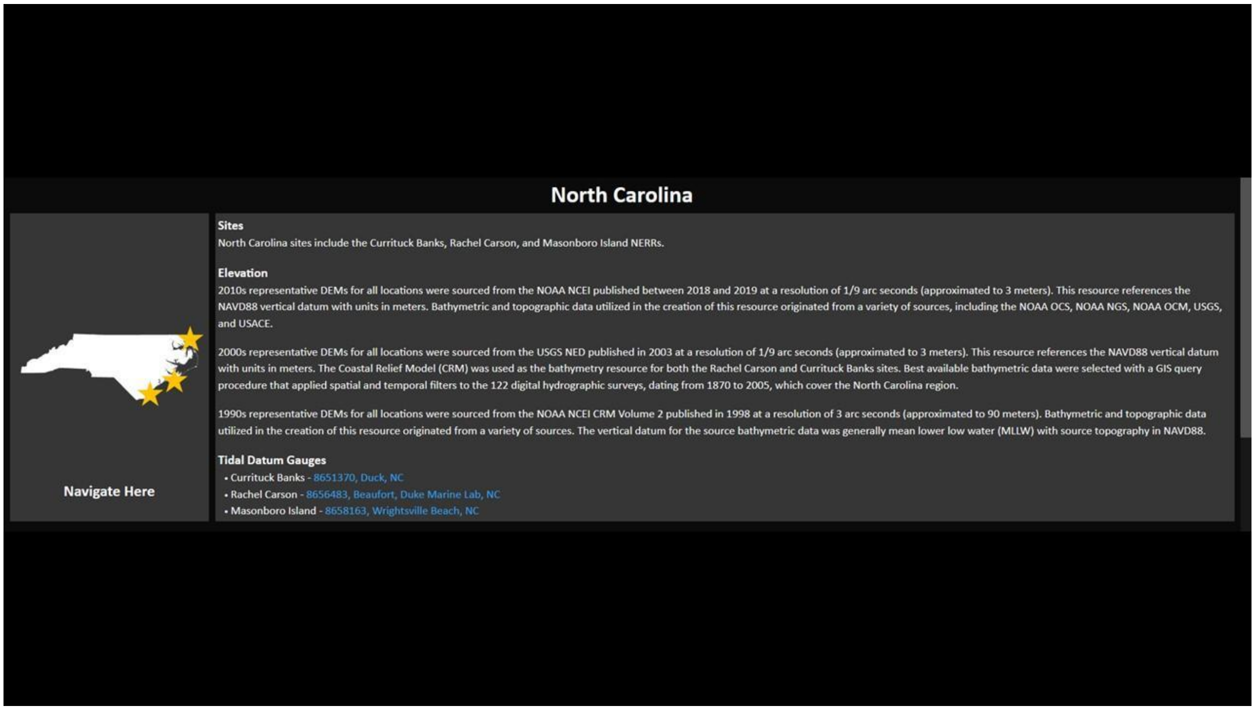
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North Carolina sites include the Currituck Banks, Rachel Carson, and Masonboro Island NERRs.
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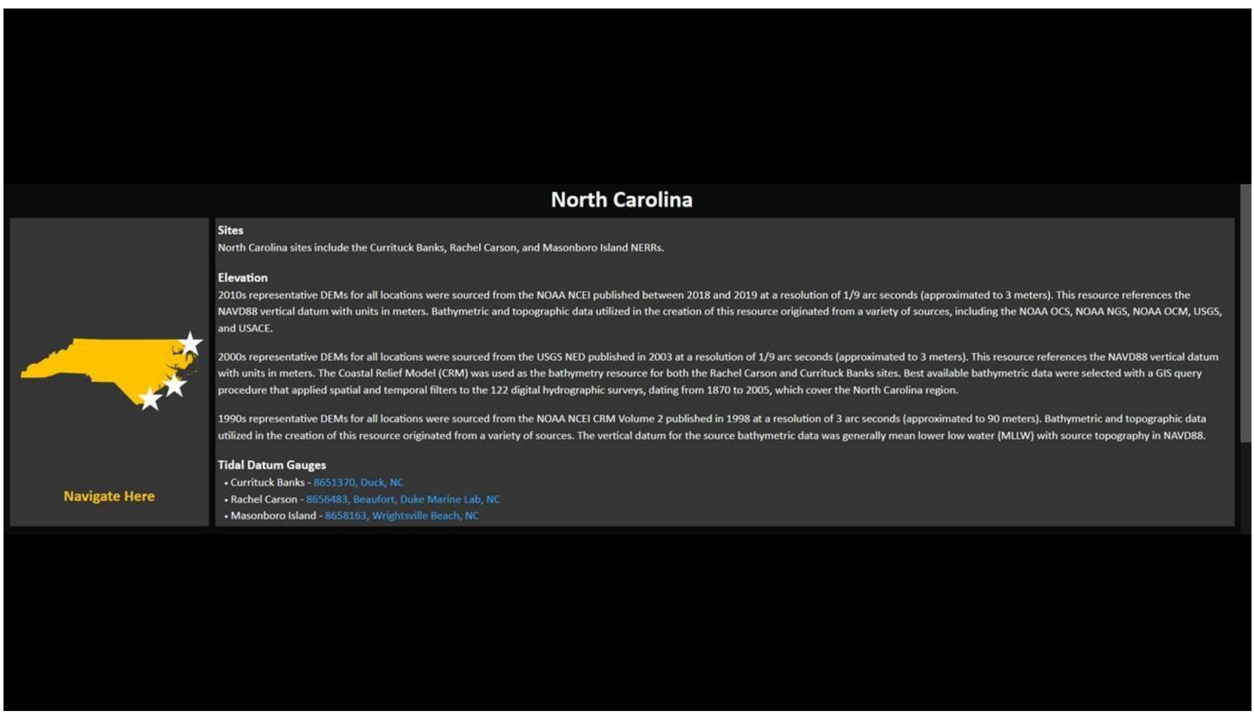
Tidal Datum Gauges
• Currituck Banks - 8651370, Duck, NC
• Rachel Carson - 8656483, Beaufort, Duke Marine Lab, NC
• Masonboro Island - 8658163, Wrightsville Beach, NC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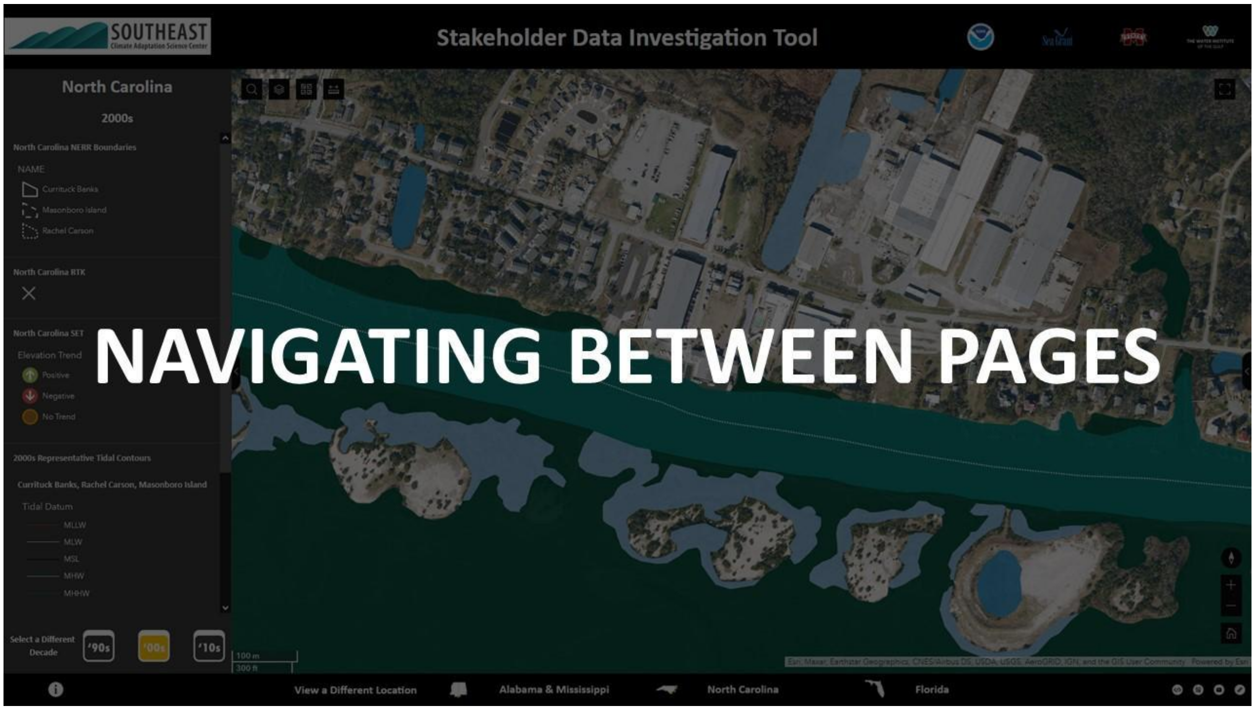
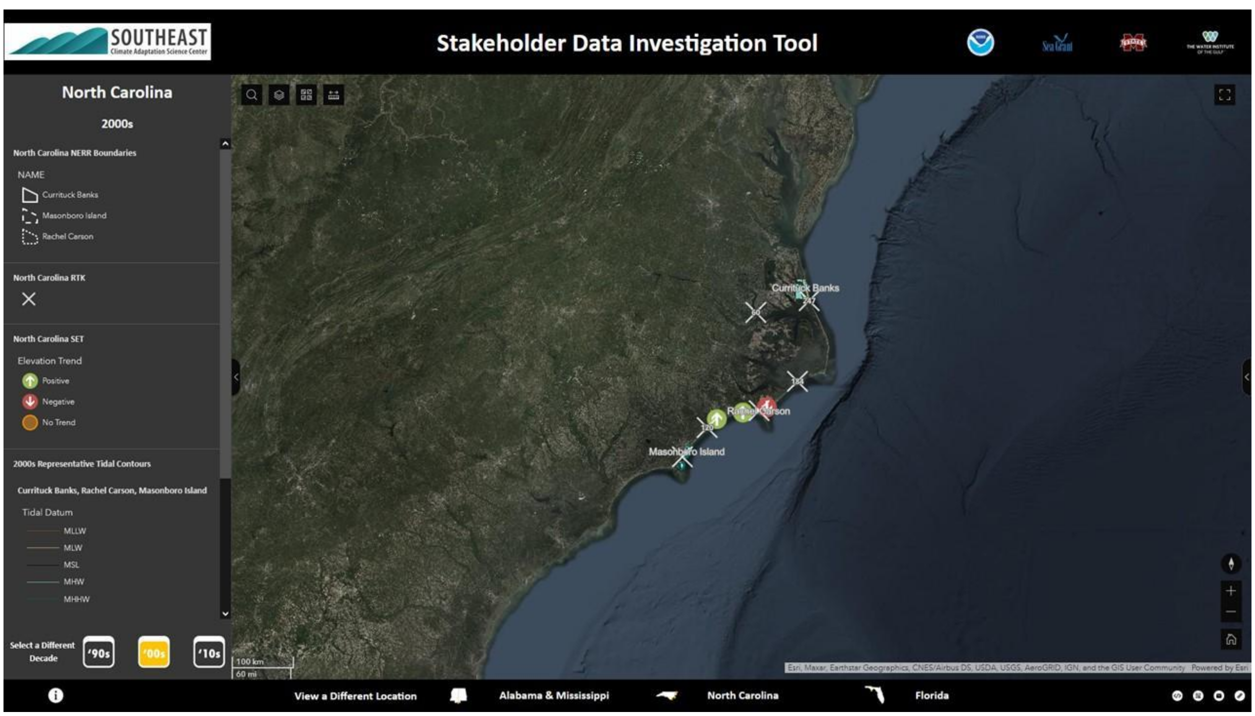
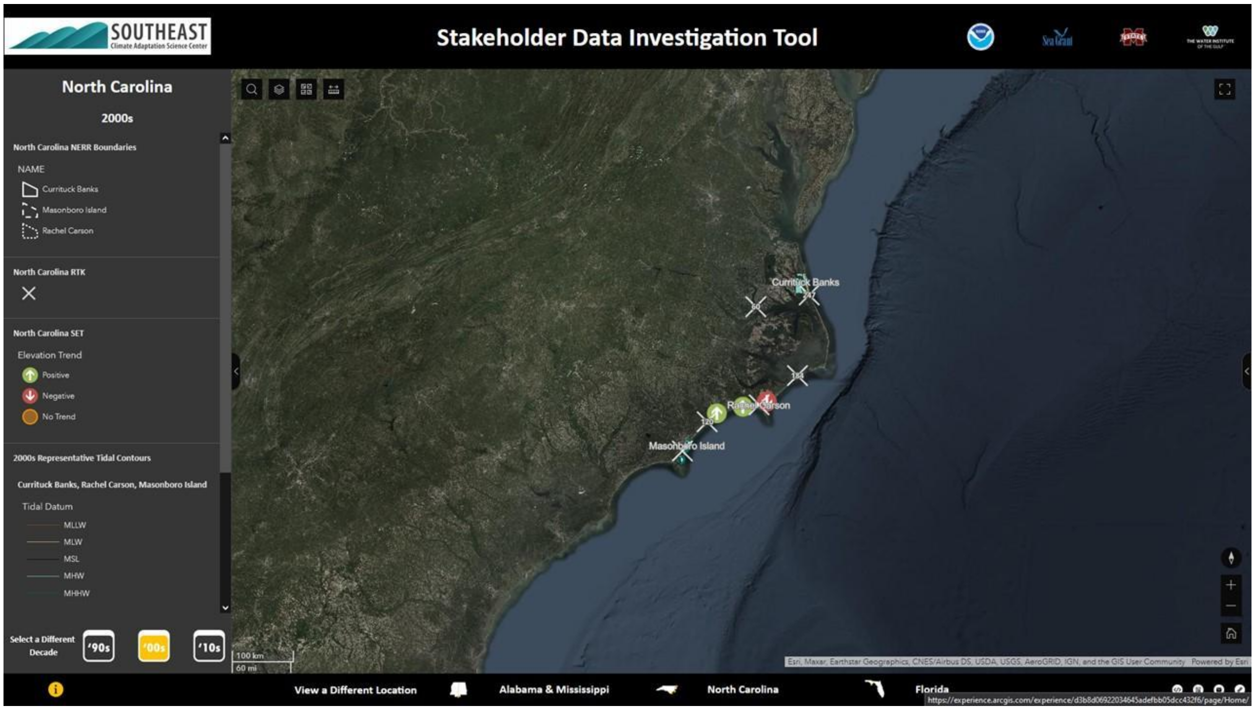

Stakeholder Data Investigation Tool
SOUTHEAST
Climate Adaptation Science Center
North Carolina
2000s
NAVIGATING BETWEEN PAGES
Select a Different Decade
'90s
'00s
'10s
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
North Carolina
2000s
North Carolina NERR Boundaries
NAME
Currituck Banks
Masonboro Island
Rachel Carson
North Carolina RTK
North Carolina SET
Elevation Trend
Positive
Negative
No Trend
2000s Representative Tidal Contours
Currituck Banks, Rachel Carson, Masonboro Island
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Currituck Banks
Rachel Carson
Masonboro Island
100 km
60 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida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MLW
MSL
MHW
MHHW
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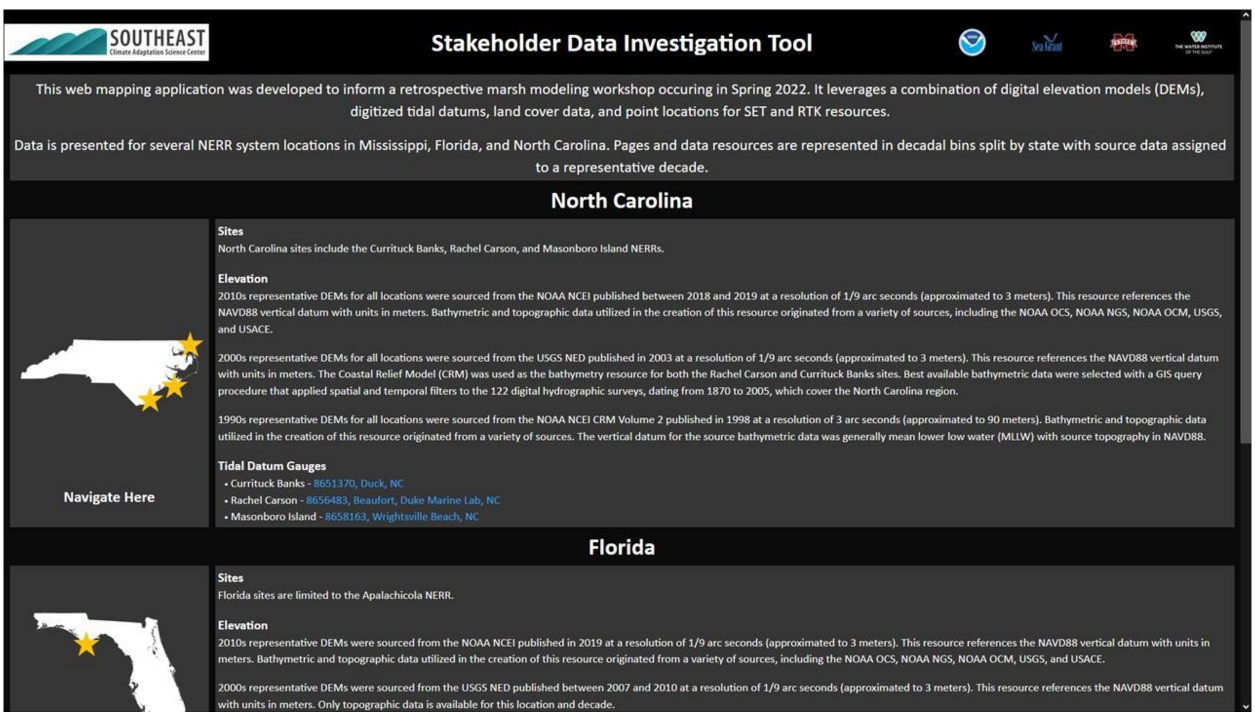
Currituck Banks
Rachel Carson
Masonboro Island
100 km
60 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida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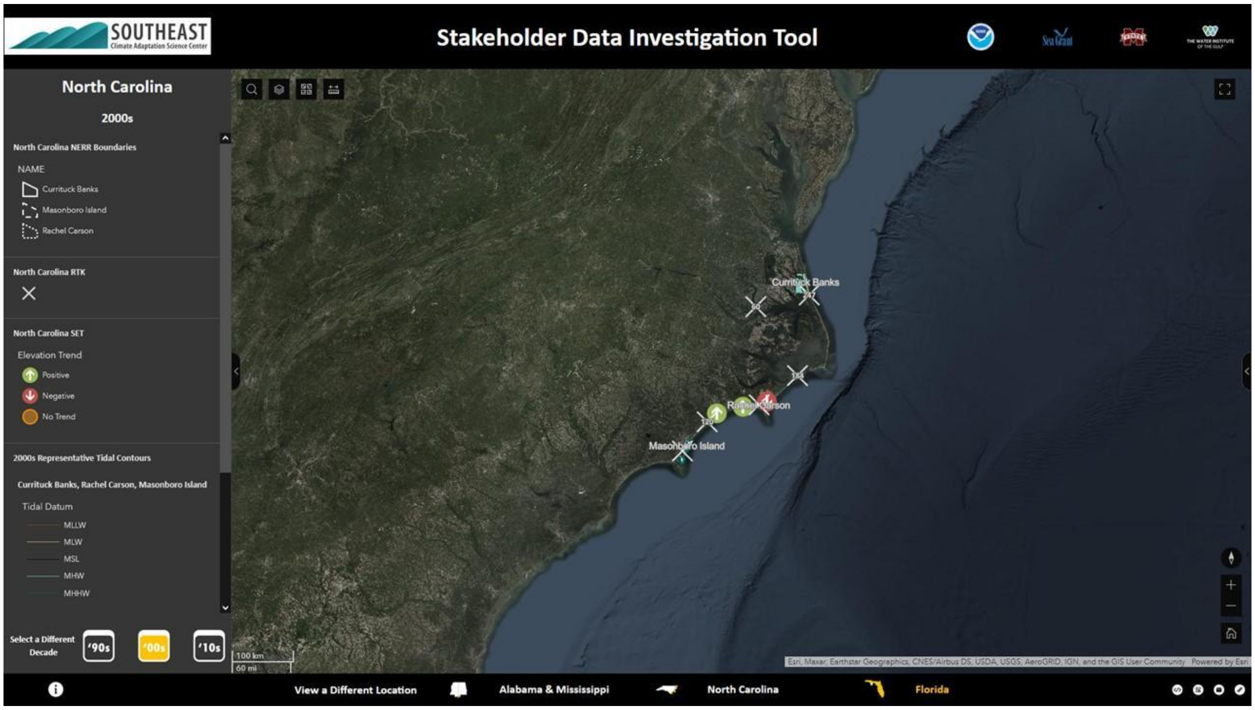
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2000s
North Carolina NERR Boundaries
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Masonboro Island
Rachel Carson
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North Carolina SET
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No Trend
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Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
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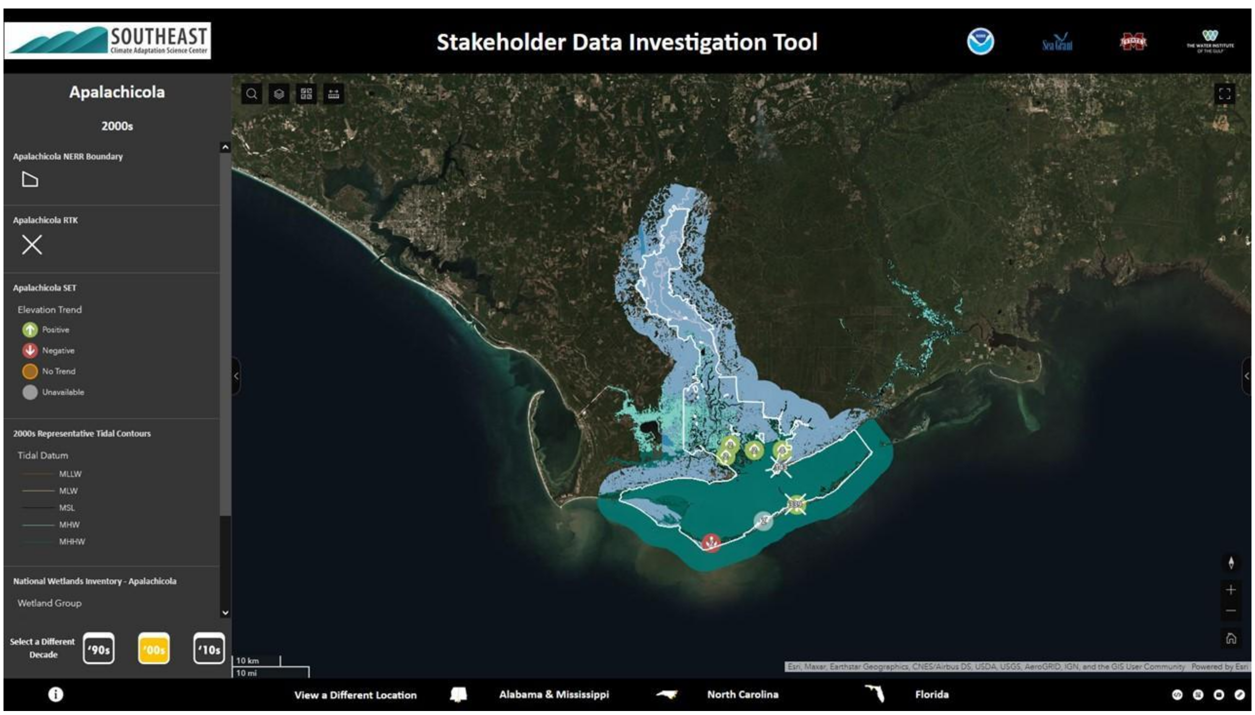
Currituck Banks
Rachel Carson
Masonboro Island
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
Apalachicola
2000s
Apalachicola NERR Boundary
Apalachicola RTK
Apalachicola SET
Elevation Trend
Positive
Negative
No Trend
Unavailable
2000s Representative Tidal Contours
Tidal Datum
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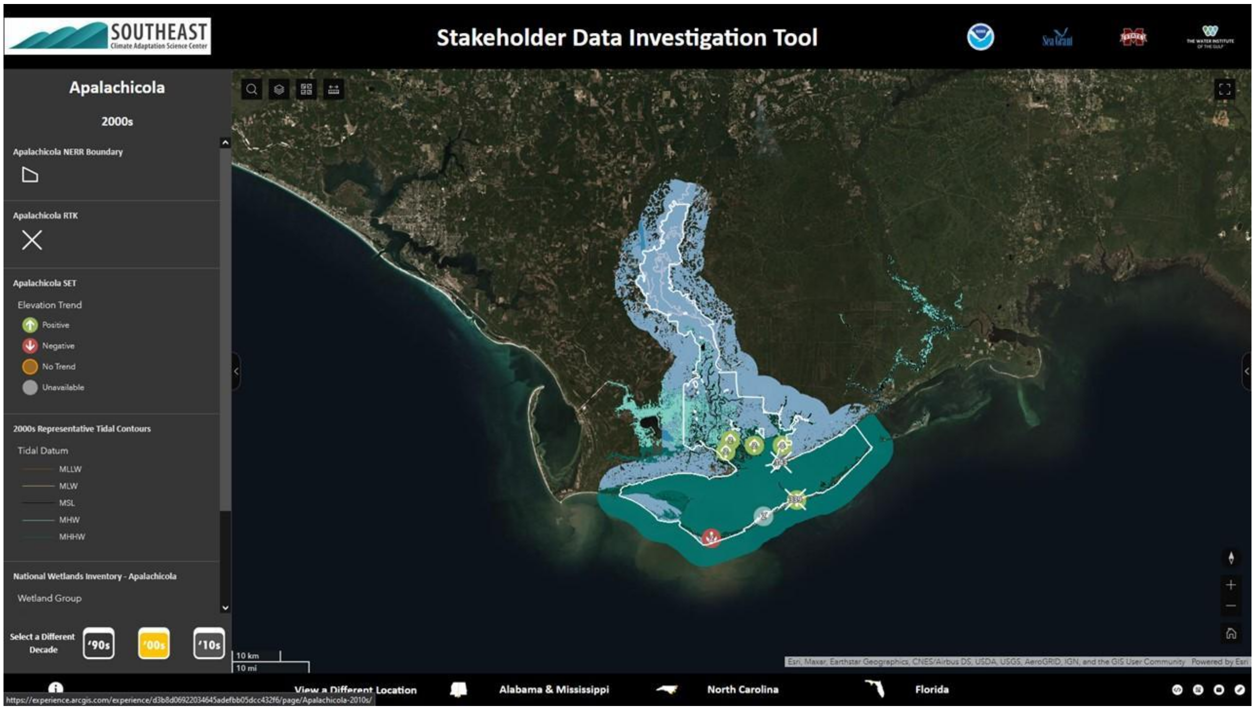
MHHW
National Wetlands Inventory - Apalachicola
Wetland Group
Select a Different Decade
'90s
'00s
'10s
10 km
10 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida



SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
Apalachicola
2000s
Apalachicola NERR Boundary
Apalachicola RTK
Apalachicola SET
Elevation Trend
Positive
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No Trend
Unavailable
2000s Representative Tidal Contours
Tidal Datum
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National Wetlands Inventory - Apalachicola
Wetland Group
Select a Different Decade
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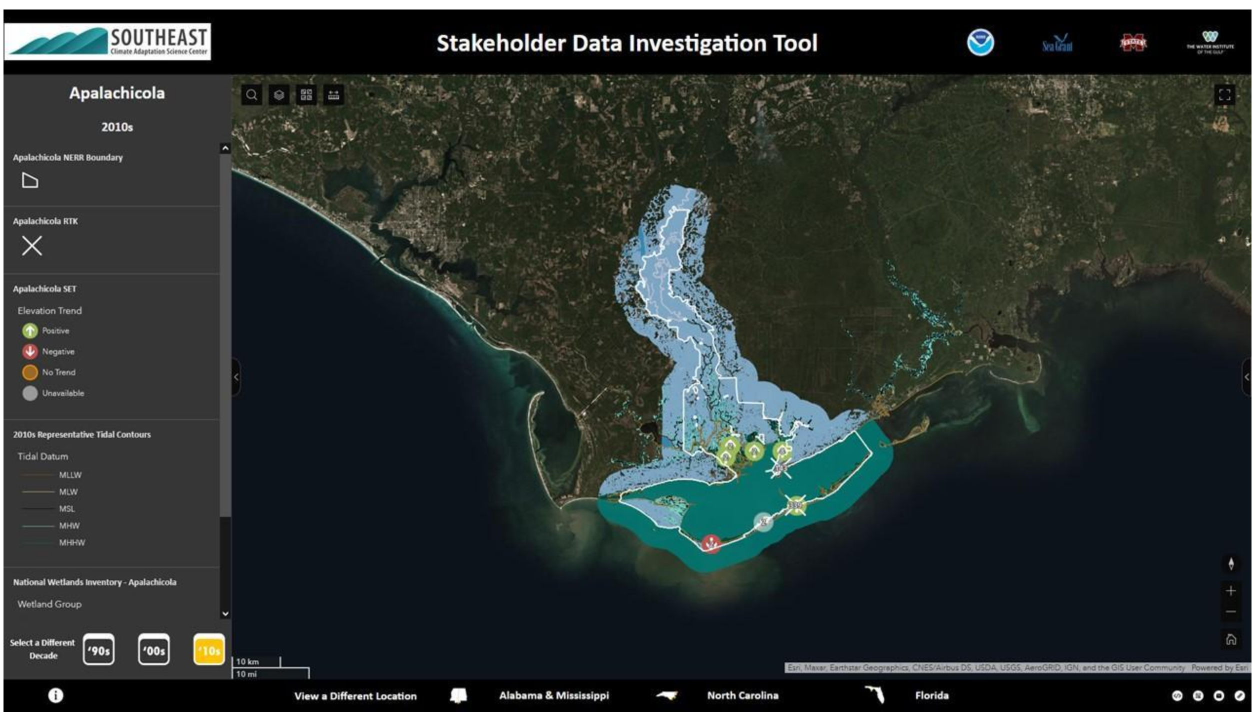
'10s
10 km
10 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida



SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
Apalachicola
2010s
Apalachicola NERR Boundary
Apalachicola RTK
Apalachicola SET
Elevation Trend
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Tidal Datum
MLLW
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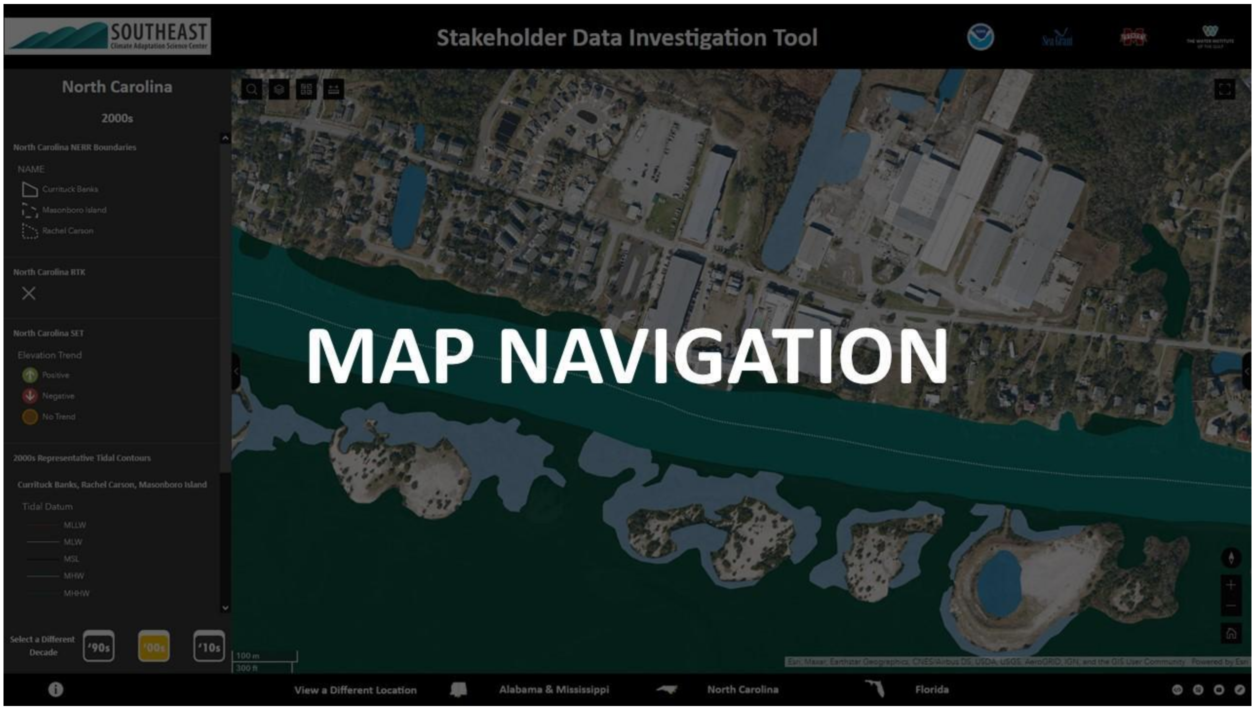
MHW
MHHW
National Wetlands Inventory - Apalachicola
Wetland Group
Select a Different Decade
'90s
'00s
'10s
10 km
10 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
North Carolina
2000s
MAP NAVIGATION
Select a Different Decade
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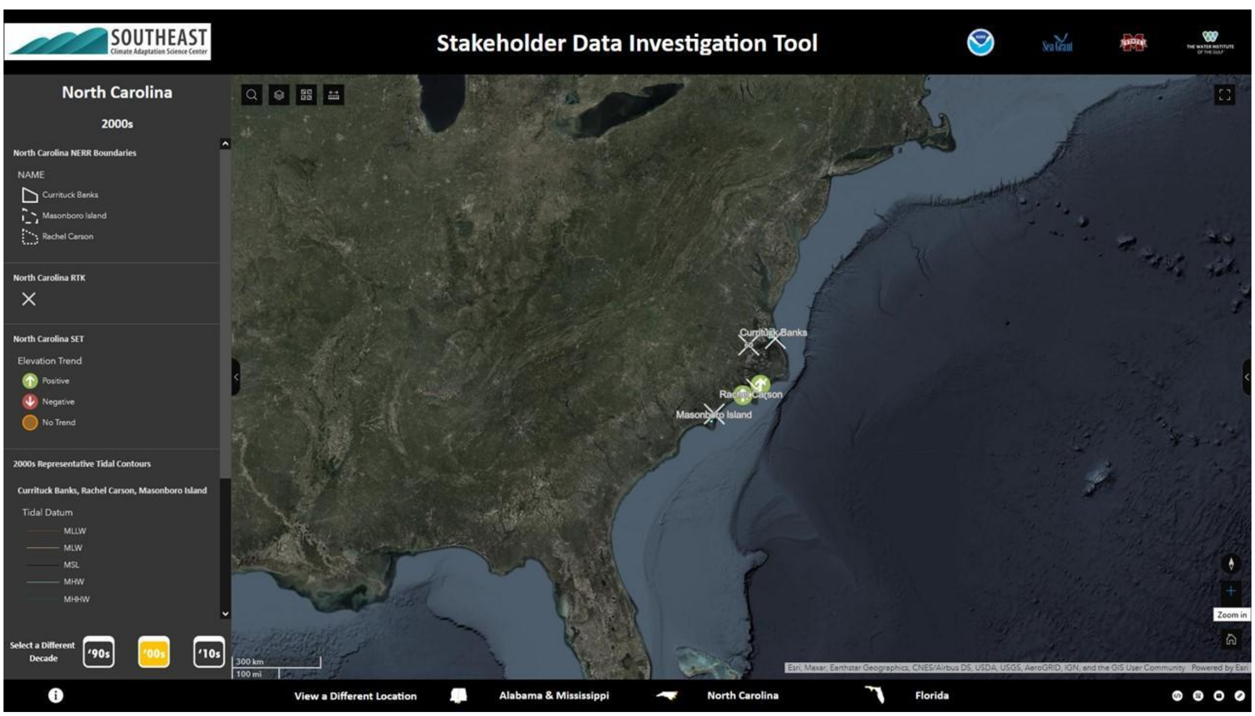
'00s
'10s
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
North Carolina
2000s
North Carolina NERR Boundaries
NAME
Currituck Banks
Masonboro Island
Rachel Carson
North Carolina RTK
North Carolina SET
Elevation Trend
Positive
Negative
No Trend
2000s Representative Tidal Contours
Currituck Banks, Rachel Carson, Masonboro Island
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Currituck Banks
Rachel Carson
Masonboro Island
Zoom in
300 km
100 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida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Tidal Datum
MLLW
MLW
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MHHW
Select a Different Decade
'90s
'00s
'10s
Search
Beaufort, NC
Beaufort, NC, USA
Beaufort County, NC, USA
Beaufort Inlet, NC, USA
Beaufort Meadows, NC, USA
Beaufort Pointe, NC, USA
NC-101, Beaufort, NC, 28516, USA
Currituck Banks
Rachel Carson
Masonboro Island
300 km
100 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida


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Tidal Datum
MLLW
MLW
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MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Search
Beaufort, NC
Search result
Beaufort, North Carolina
Show more results
Zoom to
Rachel Carson
1 km
0.4 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida


SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
North Carolina
2000s
North Carolina NERR Boundaries
NAME
Currituck Banks
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Rachel Carson
North Carolina RTK
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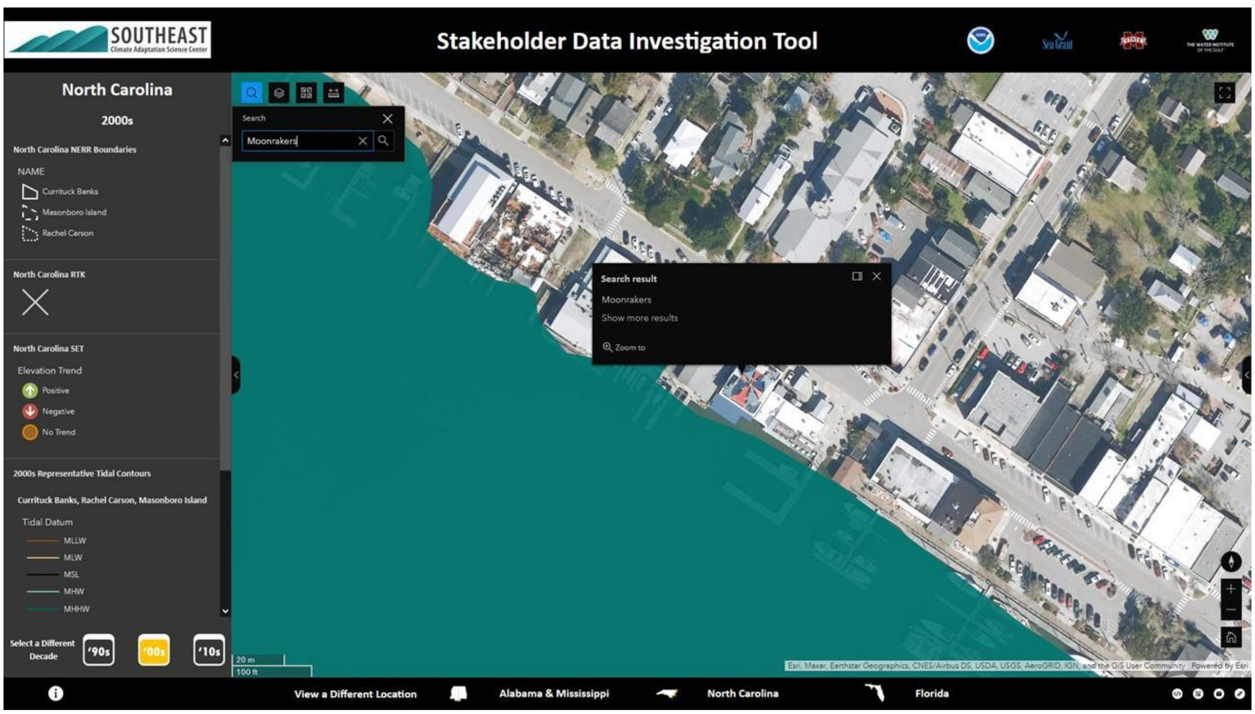
2000s Representative Tidal Contours
Currituck Banks, Rachel Carson, Masonboro Island
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Search
Moonrakers
Moonrakers, 326 Front St, Beaufort, NC, 28516, USA
Moonrakers, 126 E Washington St, Iowa City, IA, 52240, USA
Moonrakers, 29 Nursteed Road, Devizes, Wiltshire, England, SN10 3, GBR
Moonrakers, 57 High Street, Pewsey, Wiltshire, England, SN9 5, GBR
Moonrakers, High Street, Alfriston, Polegate, East Sussex, England, BN26 5, GBR
Rachel Carson
1 km
0.4 mi
View a Different Location
Alabama & Mississippi
North Carolina
Florida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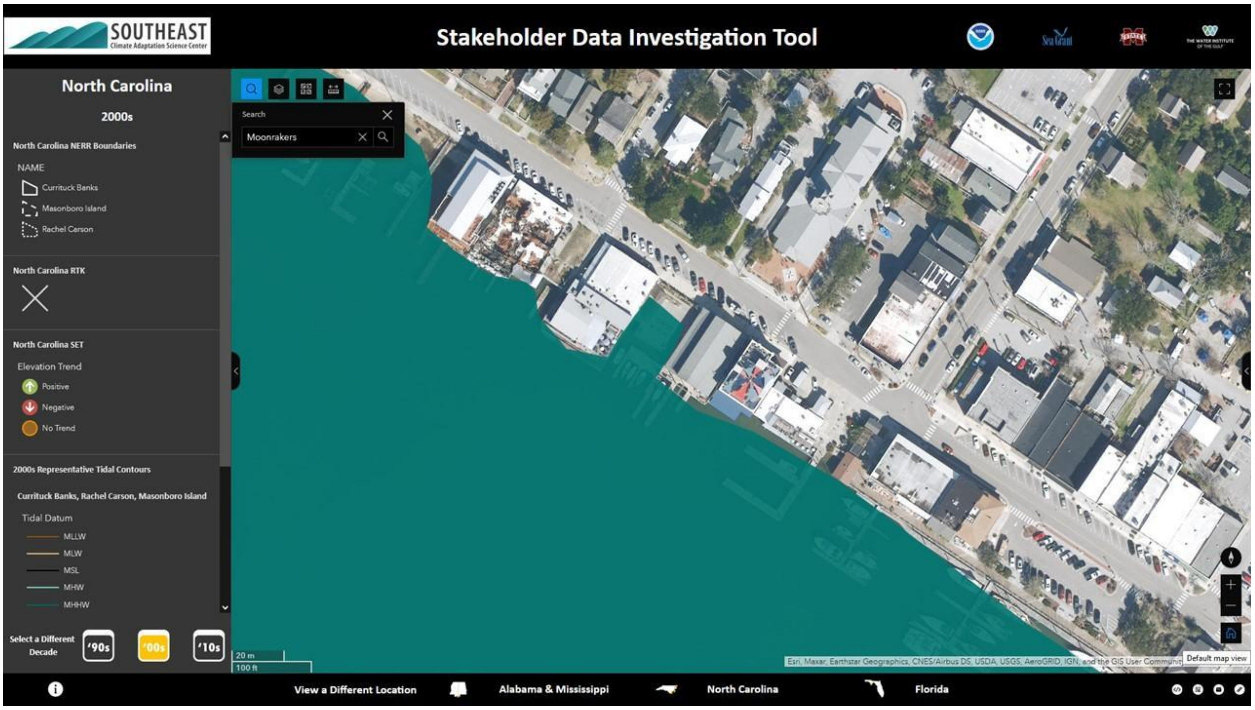
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Search
Moonrakers
Search result
Moonrakers
Show more results
Zoom to
20 m
100 ft
View a Different Location
Alabama & Mississippi
North Carolina
Florida



Stakeholder Data Investigation Tool
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Tidal Datum
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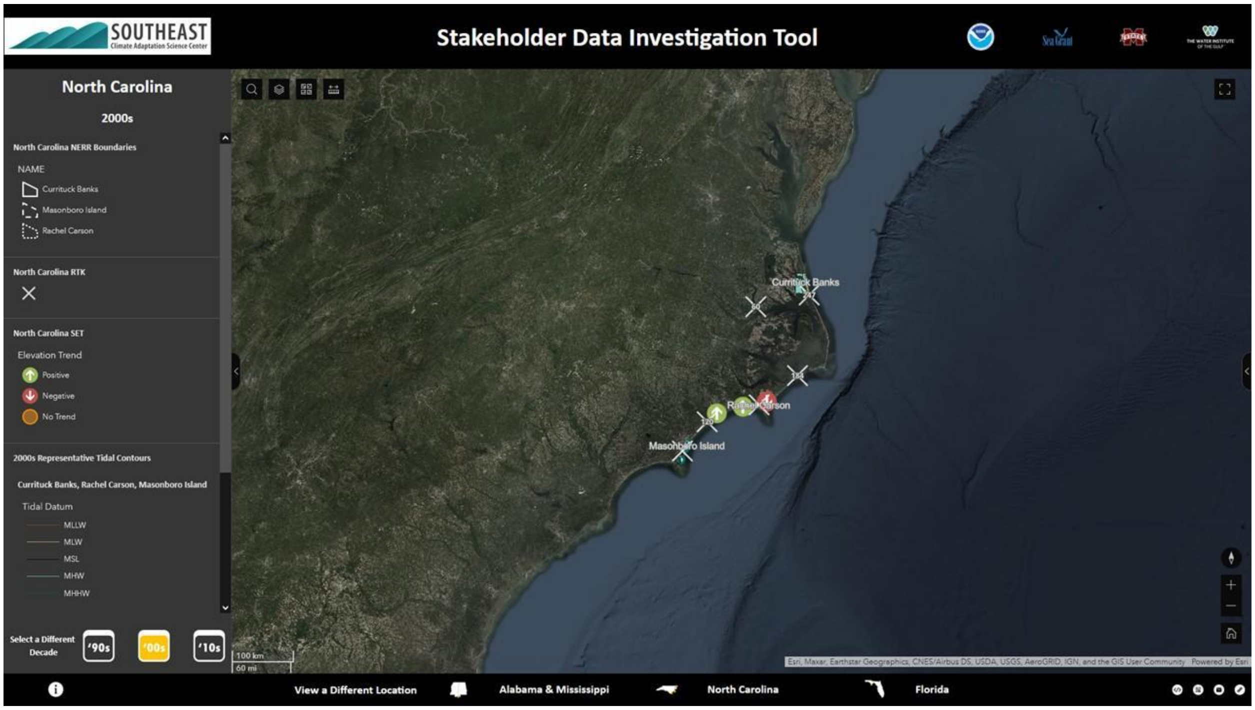
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Search
Moonrakers
View a Different Location
Alabama & Mississippi
North Carolina
Florida



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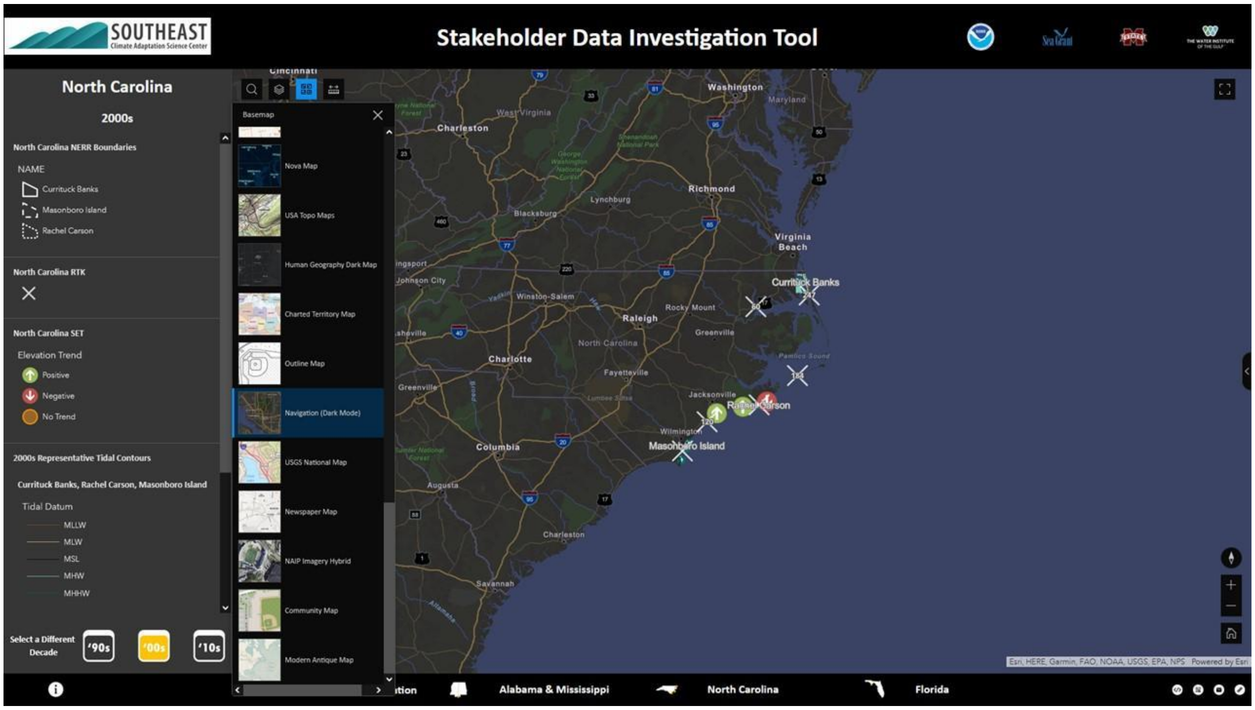
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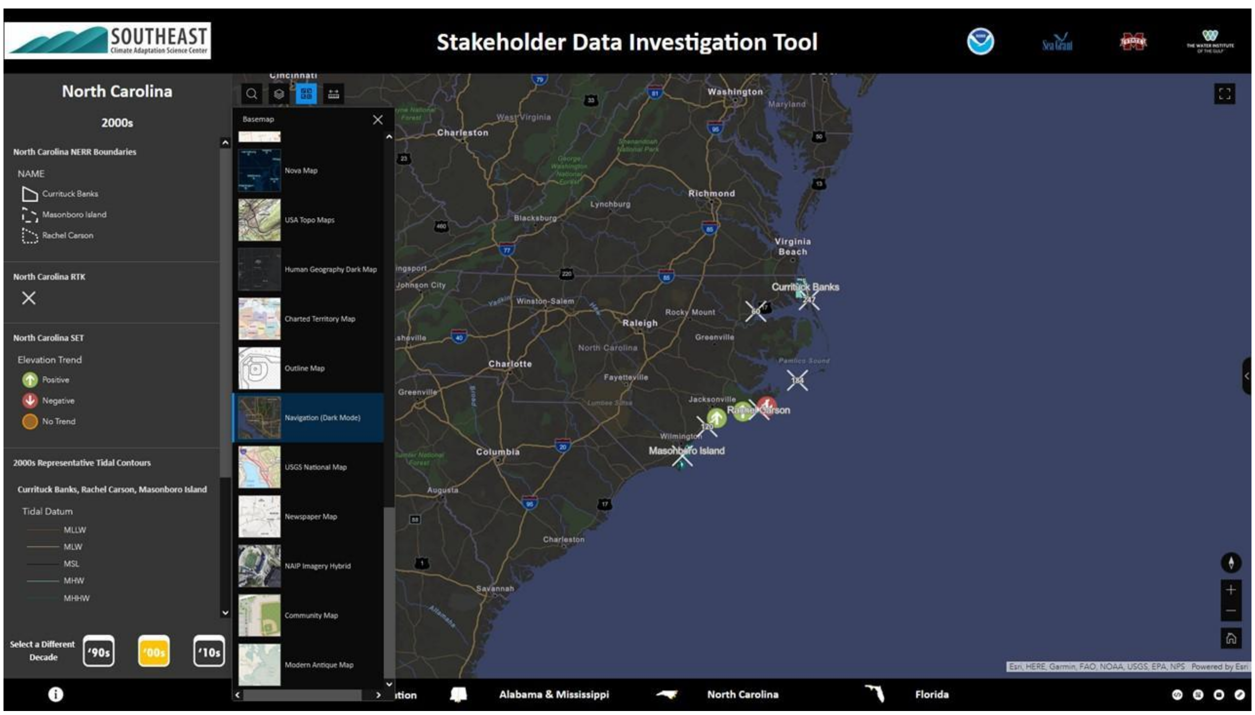
MLW
MSL
MHW
MHHW
Select a Different Decade
'90s
'00s
'10s
Basemap
Nova Map
USA Topo Maps
Human Geography Dark Map
Charted Territory Map
Outline Map
Navigation (Dark Mode)
USGS National Map
Newspaper Map
NAIP Imagery Hybrid
Community Map
Modern Antique Map
Alabama & Mississippi
North Carolina
Florida
Currituck Banks
Rachel Carson
Masonboro Island
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS Powered by Esri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Nova Map
USA Topo Maps
Human Geography Dark Map
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Outline Map
Navigation (Dark Mode)
USGS National Map
Newspaper Map
NAIP Imagery Hybrid
Community Map
Modern Antique Map
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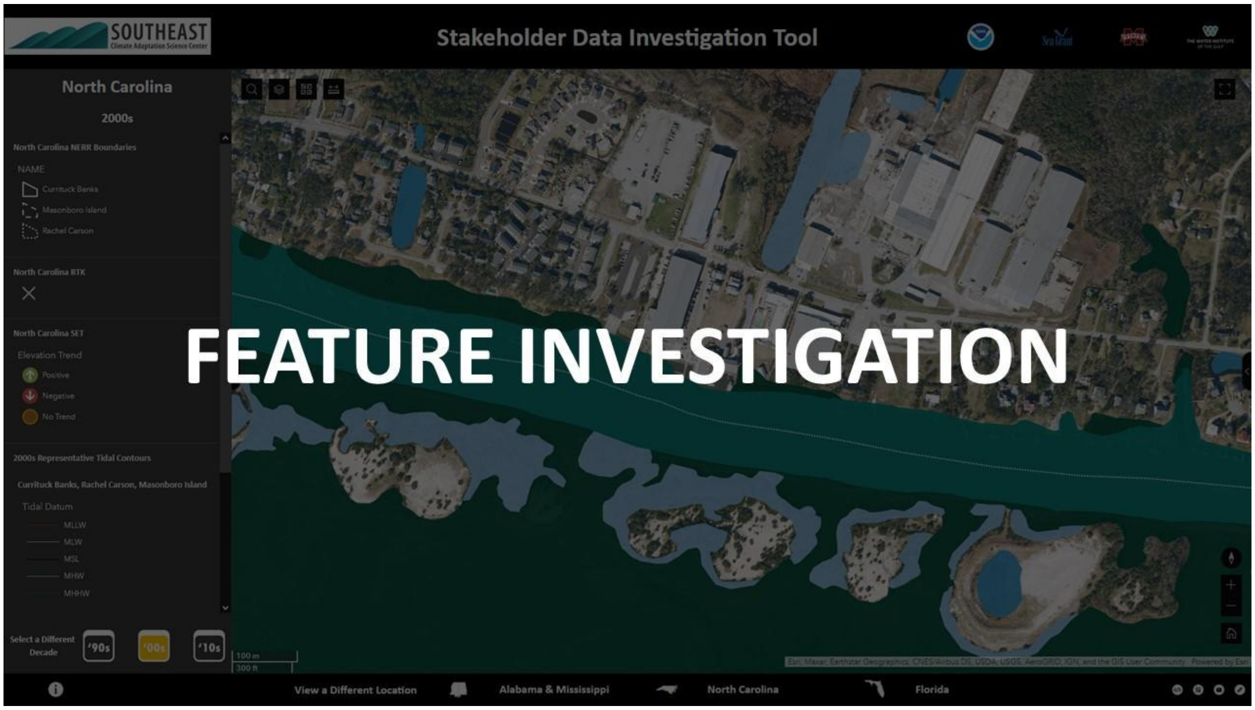
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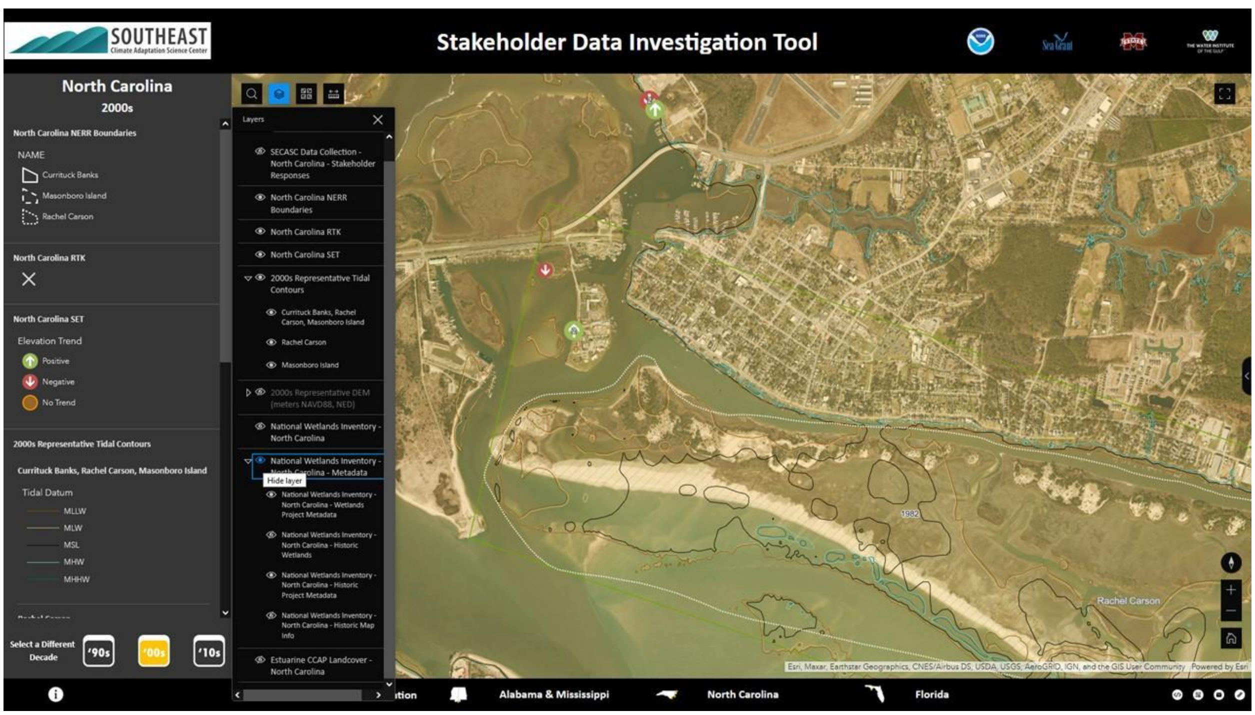
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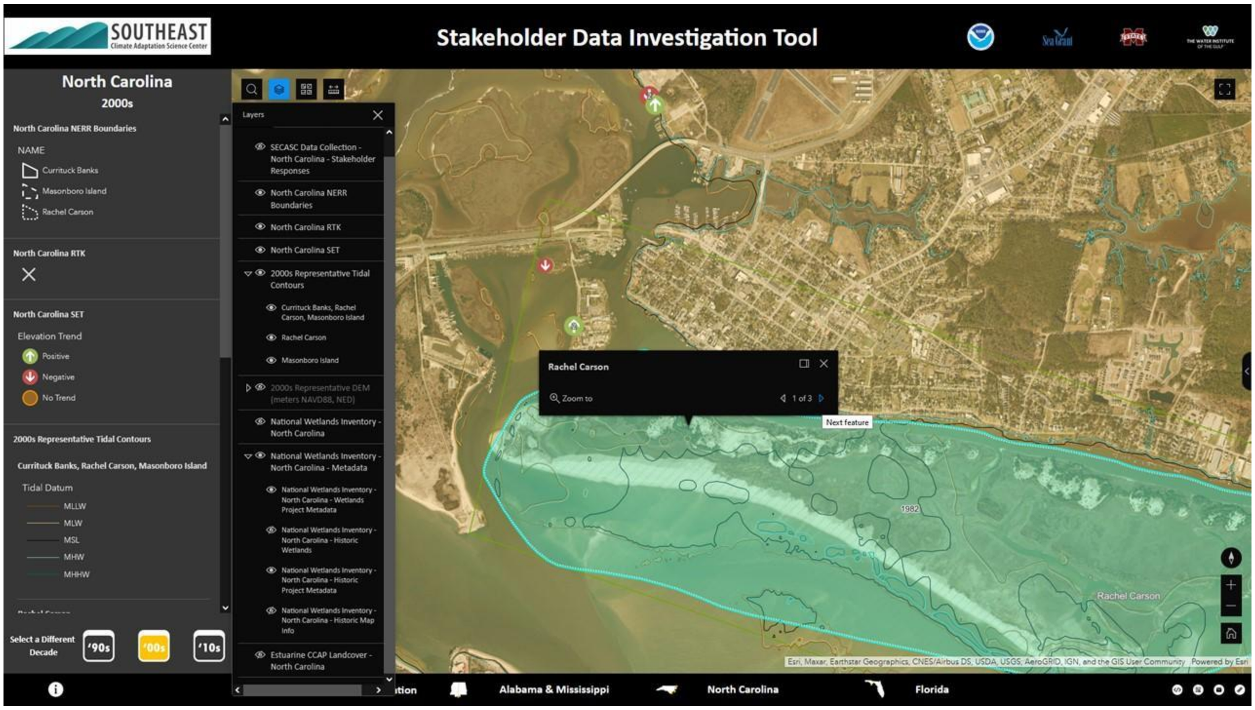
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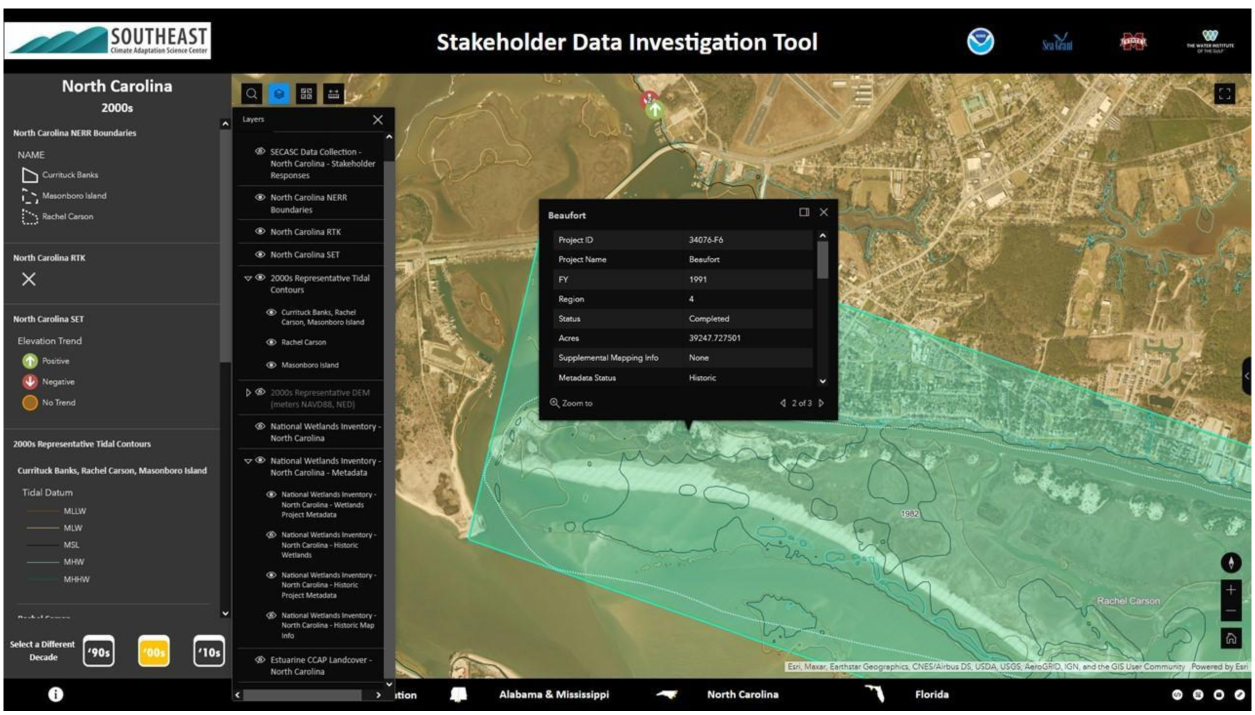
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Project Name
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Supplemental Mapping Info
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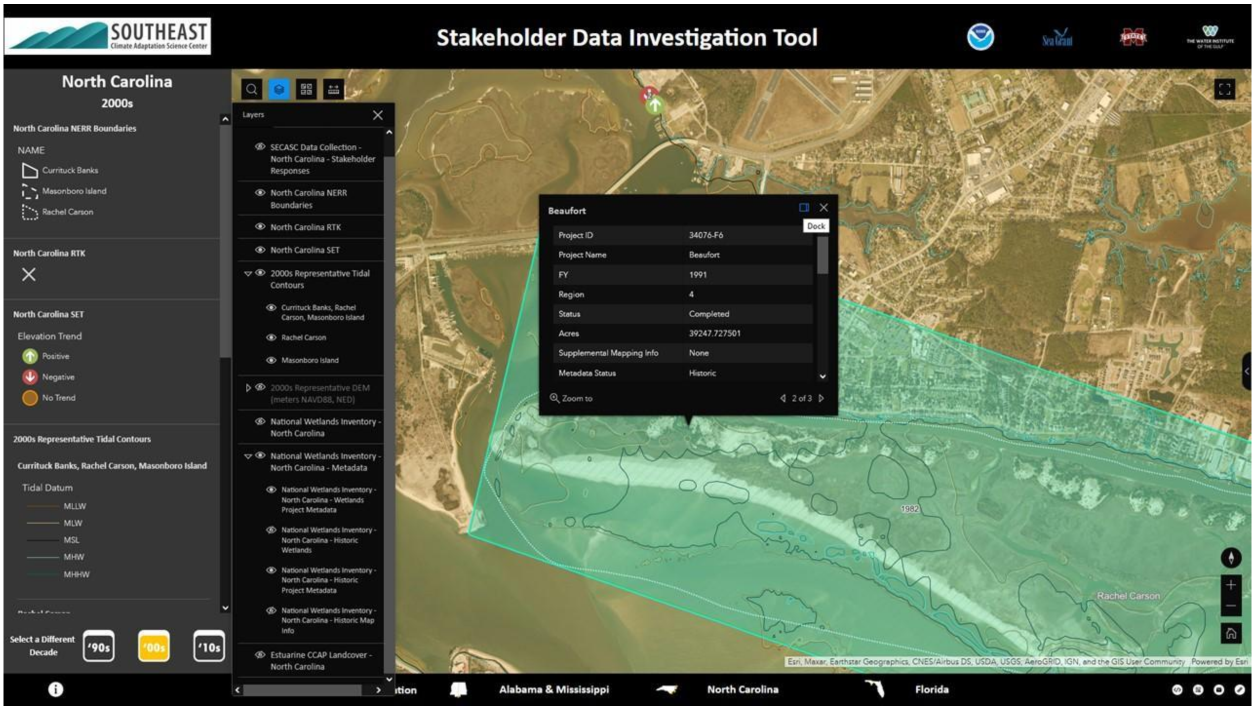
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Project Name Beaufort
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Status Completed
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Metadata Status Historic
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Powered by Esri
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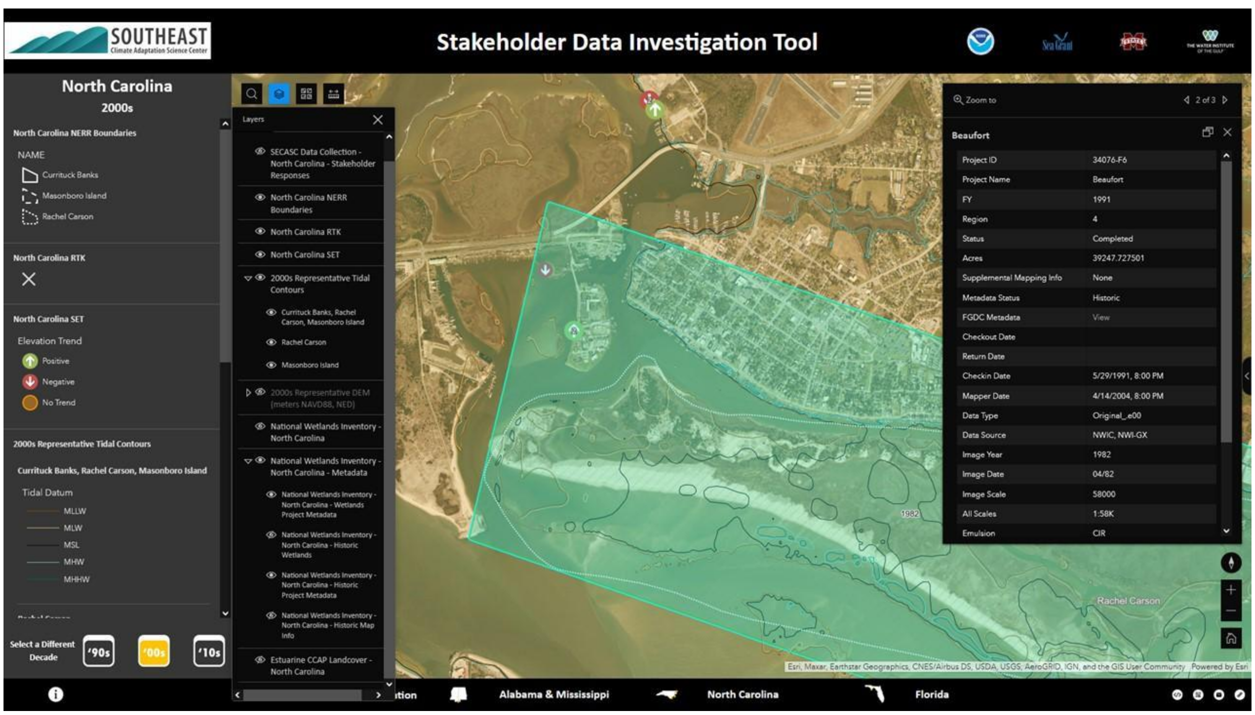
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Data Source NWIC, NWI-GX
Image Year 1982
Image Date 04/82
Image Scale 58000
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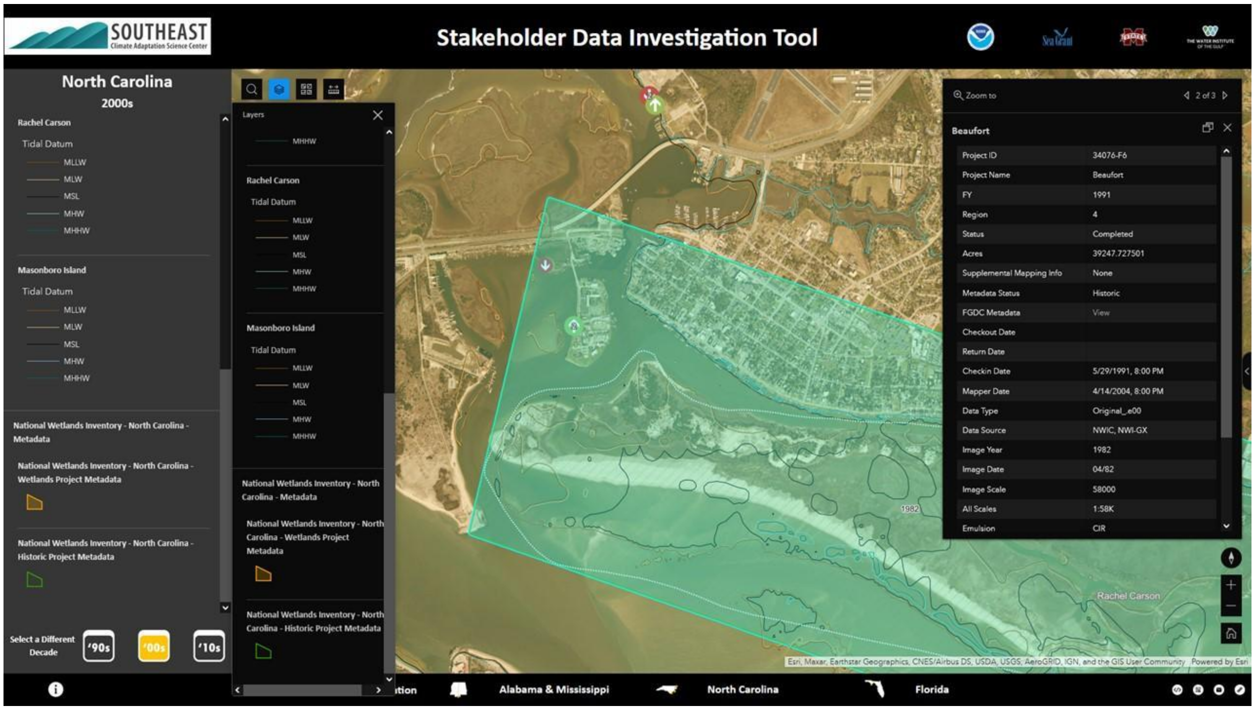
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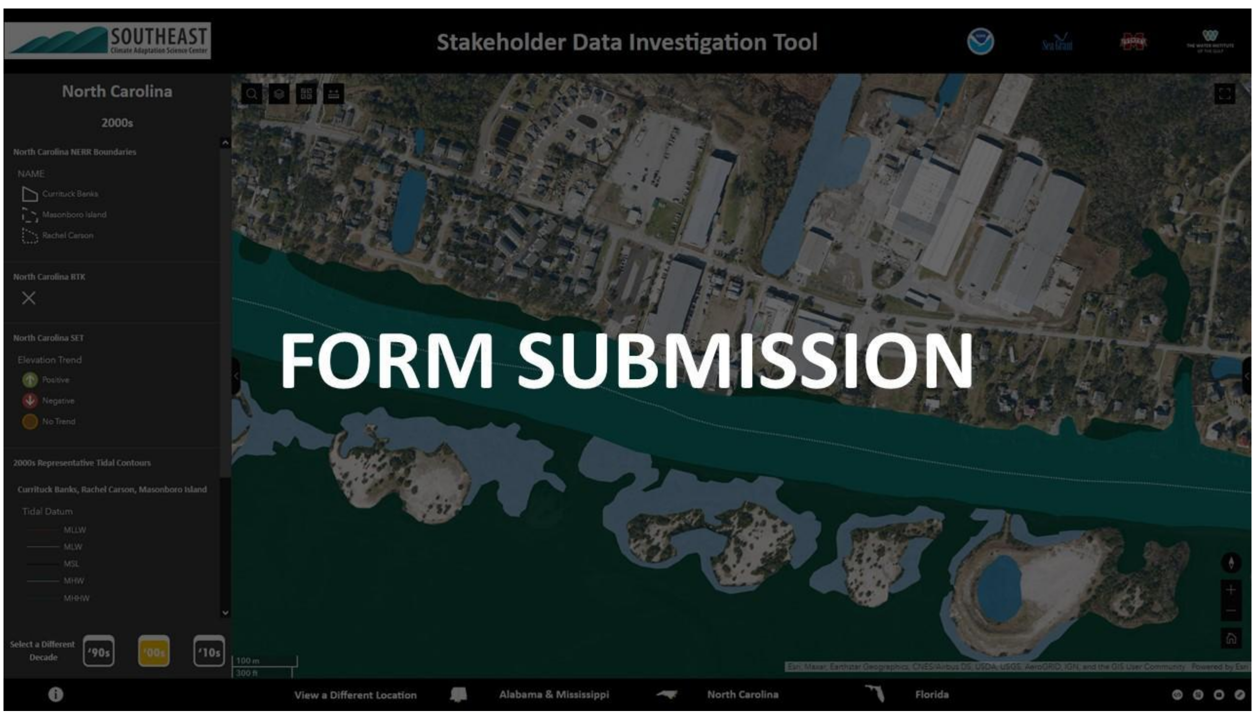
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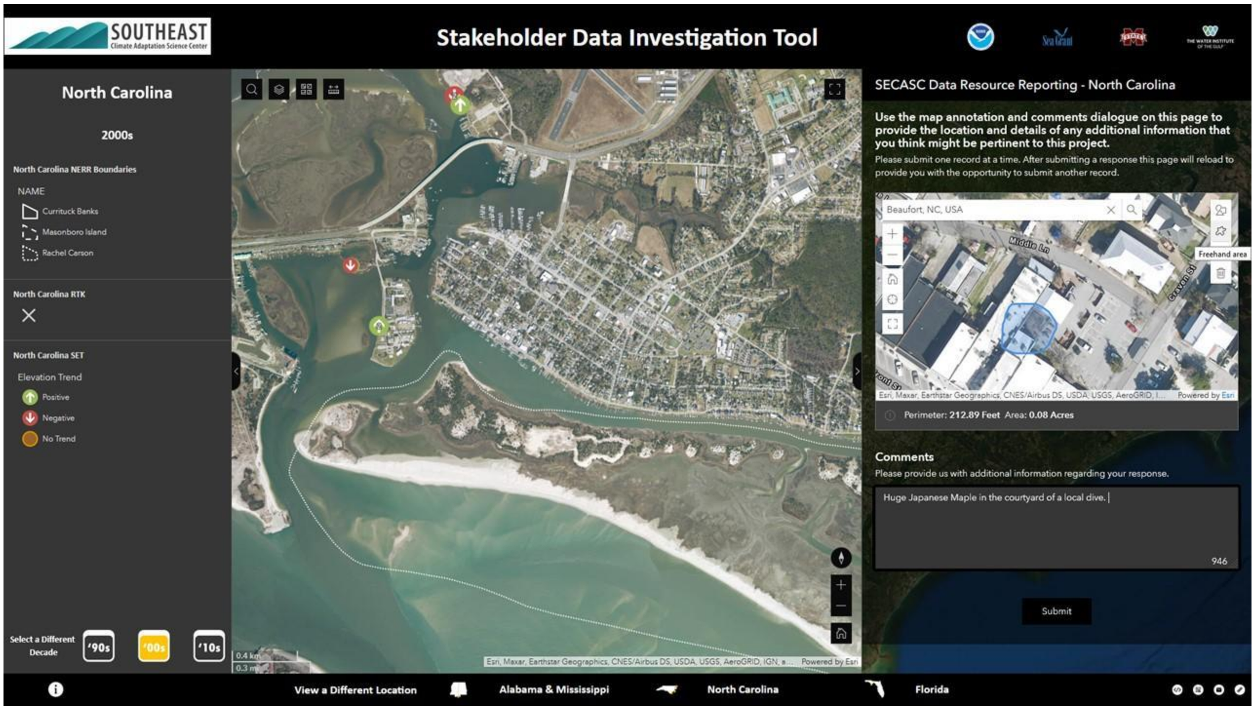
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Use the map annotation and comments dialogue on this page to provide the location and details of any additional information that you think might be pertinent to this project.
Please submit one record at a time. After submitting a response this page will reload to provide you with the opportunity to submit another record.
Beaufort, NC, USA
Freehand area
Perimeter: 212.89 Feet Area: 0.08 Acres
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Please provide us with additional information regarding your response.
Huge Japanese Maple in the courtyard of a local dive.
946
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View a Different Location
Alabama & Mississippi
North Carolina
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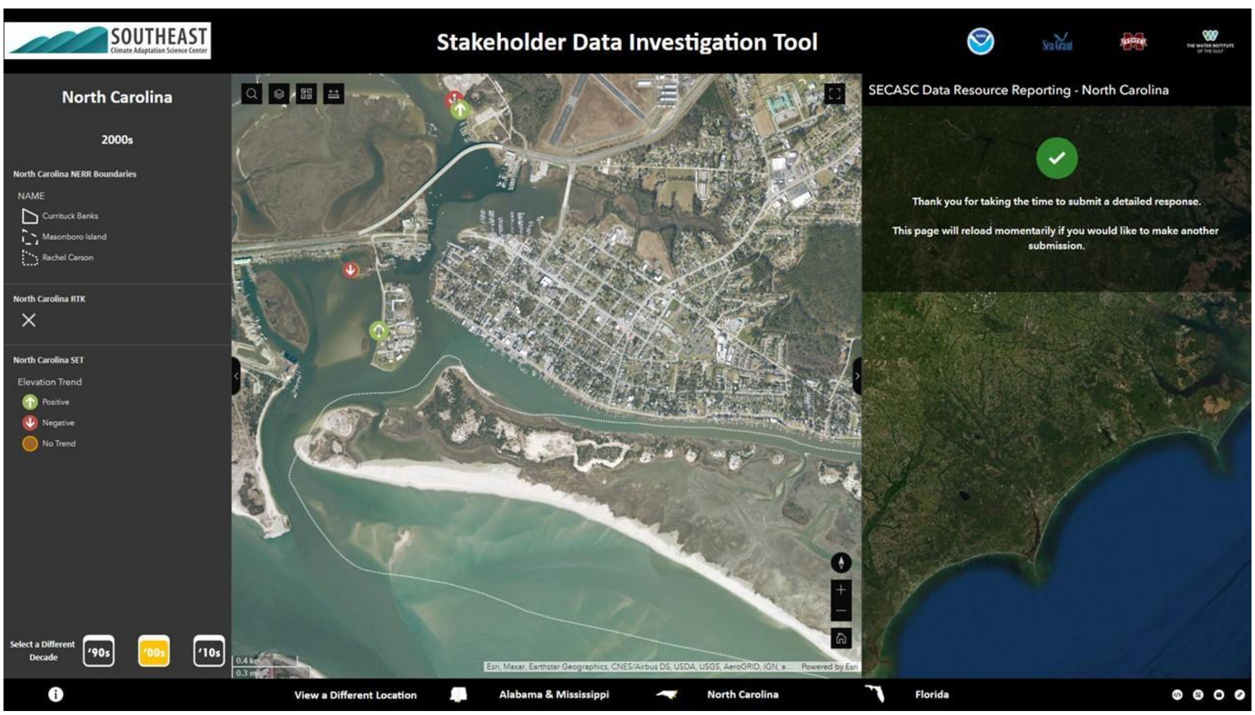
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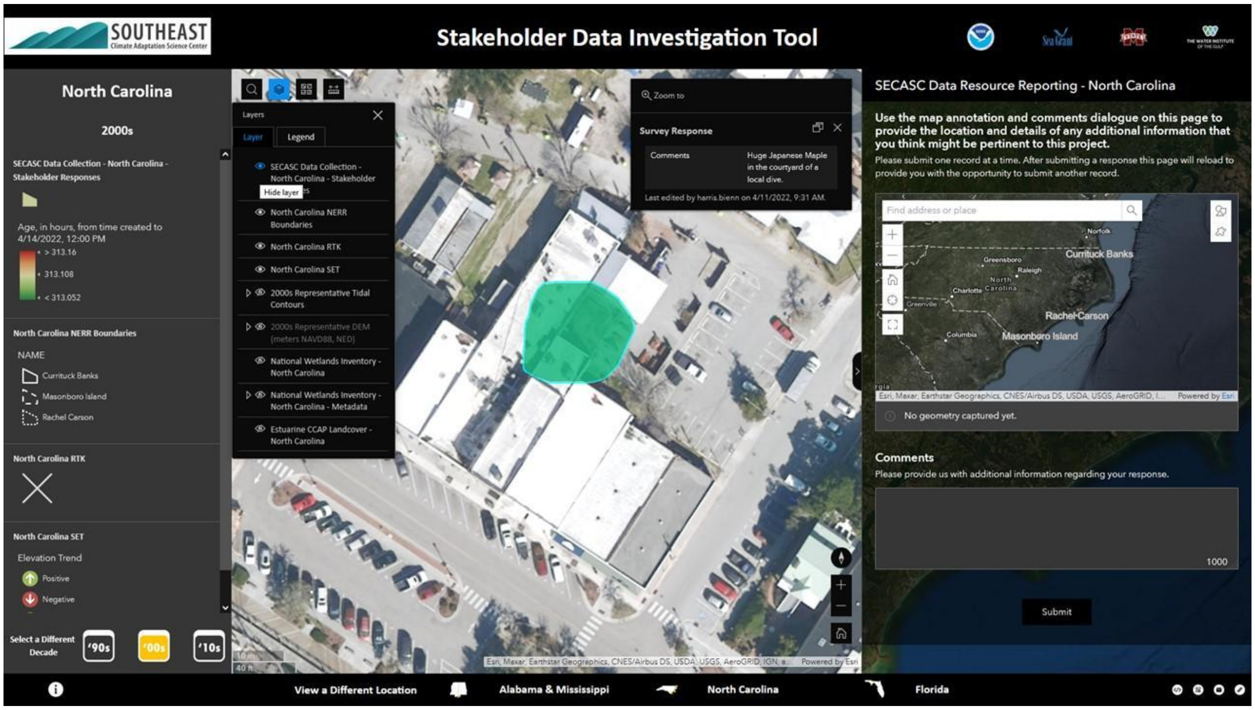
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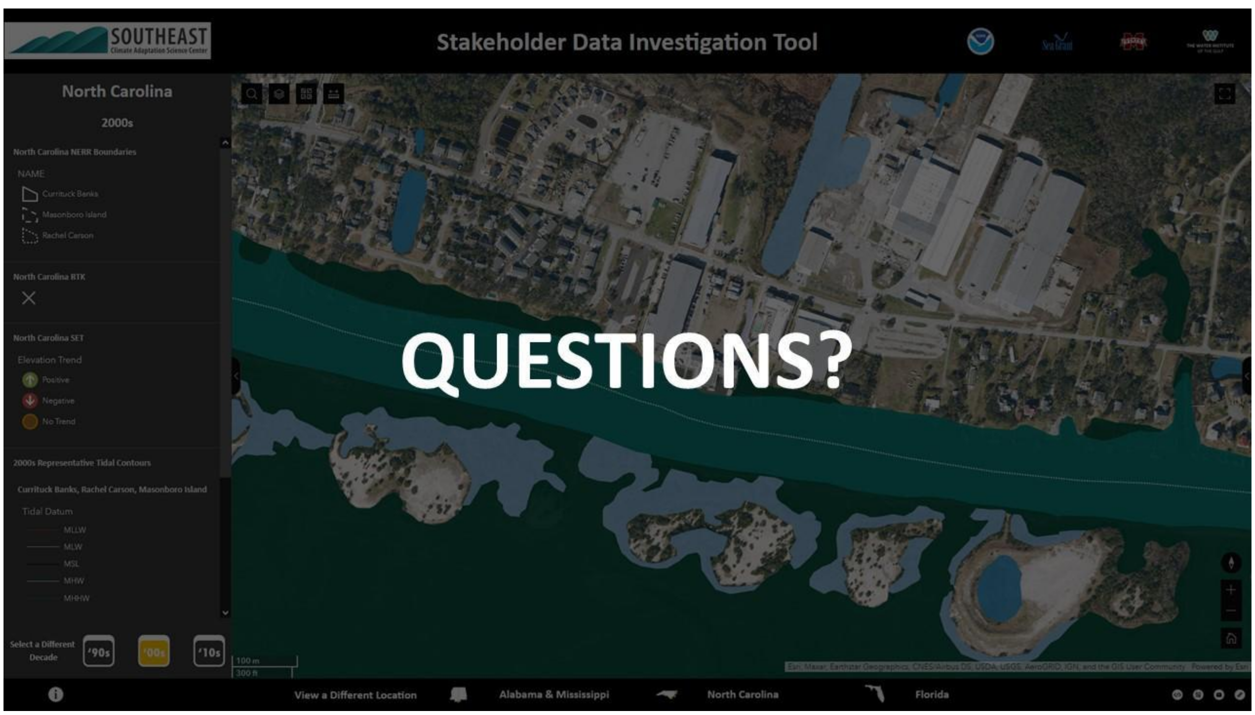
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A5: Marsh Model Retrospective Framework

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

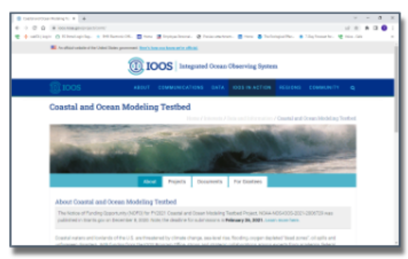
Reviewing Framework on the Marsh Model Retrospective Analysis

SCIENCE SERVING COASTAL COMMUNITIES

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NOAA's COMT as an example

- NOAA's Coastal and Ocean Modeling Testbed (COMT) offers a general framework for how we could collaborate
- COMT creates a dataset for evaluating models to better understand them for operational running of models
- We may even be able to use their platform.



https://ioos.noaa.gov/project/comt/

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Our testbed will focus on improving application

Our Goal is to run a test bed that fosters organized model advancement and sharing and does not crown an "operationally" superior model.

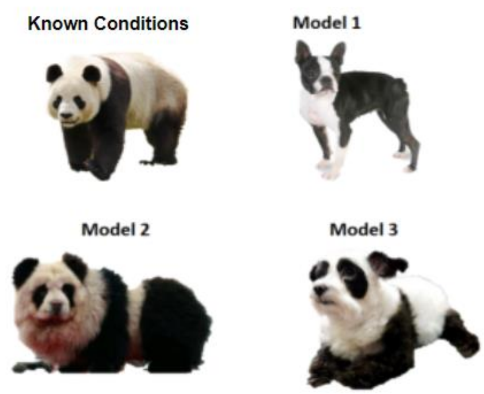
Marsh modeling is not ready for operations and will never involve model runs as regularly as the models COMT has considered.

We expect modelers to all be involved in running models and hope to design the retrospective analysis in a way to benefit modelers.

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

We are going to ask for input across two areas

- **Scoping questions** to inform the approach to accomplishing the analysis
- **Technical details** on data needs that will inform how we scope the analysis.



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Questions for scoping the retrospective analysis:

- What site specific variables do we need to evaluate for their influence on model performance?
  - Estuary type and characteristics to consider?
  - Data quality of data inputs to consider?

- How do we evaluate marsh model performance?
  - What outputs do we compare?

- Do we have enough data to run a retrospective right now?

- Are there other scoping aspects to consider?

Appendix B: Handouts

B1: Participant Agenda

Marsh Model Retrospective Workshop Day 1

April 11-12, 2022 | The Beaufort Hotel | Beaufort, North Carolina

12:00 pm	**Lunch** Grab some lunch provided by 34◦ North
1:00 pm	**Welcome and Introductions** Get to know everyone
1:20 pm	**Introduction to the Day** Establish ground rules, go over the agenda for the day, and review the reasons for performing a marsh model retrospective analysis
1:45 pm	**Stakeholder Perceptions on Marsh Models** Learn why stakeholders use marsh model outputs
2:05 pm	**Big Picture Questions for the Marsh Model Retrospective** Review the questions that the retrospective will seek to answer
2:20 pm	**Break** With snacks!
2:35 pm	**The Work So Far** Review the data that has been accumulated so far
2:50 pm	**Data Exploration and Discussion** Explore the data using this link: https://arcg.is/0CL9D90
3:45 pm	**The Marsh Model Retrospective Framework** Revisit the Big Questions again
4:15 pm	**Wrap-up** Review the accomplishments of the day and prepare for Day 2
4:25 pm	**Adjourn**

5:30 pm	**Dinner at Moonrakers**

Marsh Model Retrospective Workshop Day 2

April 11-12, 2022 | The Beaufort Hotel | Beaufort, North Carolina

9:00 am	**Welcome & Introduction to Day 2** Review the agenda for Day 2 of the workshop and get everyone on the same page before diving into the details
9:35 am	**Details of the Marsh Model Retrospective (Part 1)** Dig into the details of when, where, and how to run the analysis
10:15 am	**Break** With snacks!
10:30 am	**Details of the Marsh Model Retrospective (Part 2)** More discussion of details for the retrospective analysis
11:15 am	**Return to the Big Picture Questions** Now that we discussed the details, how do you feel about the Big Questions?
11:30 am	**Putting All of the Pieces Together** Determine what the Marsh Model Retrospective will look like
12:00 pm	**Working Lunch** Next steps for the Marsh Model Retrospective
12:50 pm	**Workshop Wrap-Up** Recap and review what has been accomplished and next steps
1:00 pm	**End of Workshop** Thank you for your input and hard work!
2:00 pm	**Field Trip to the Rachel Carson Reserve** Meet at the docks across from Beaufort Hotel for a tour by the reserve staff

B2: Questions for Marsh Model Retrospective

Questions for the Marsh Model Retrospective

Example Application Questions – These are examples of questions that we hope to answer by performing a marsh model retrospective. These questions will inform the framing of much of the discussion throughout the workshop.

1. What model should I use for my marsh type?
2. What is the utility of different model output types for different types of management decisions?
3. How certain are the predictions and are there areas we are more confident?

Scoping Questions – These questions will inform the approach to accomplishing the analysis.

1. What site specific variables do we need to evaluate for their influence on model performance?
    a. Estuary type and characteristics
    b. Quality of data inputs
2. How do we evaluate marsh model performance? What outputs do we compare?
3. Do we have enough data and the right data to perform the retrospective analysis and to answer the research questions right now?
4. Are there any other scoping questions that we need to consider?

B3: Data Inventory

Data Inventory
NORTH CAROLINA

DEMS

Note: Rows shaded in orange indicate no bathymetry, yellow shading indicates that the vertical datum was something other than NAVD 88 for bathymetry.

Masonboro Island

Source	Resolution	Tidal Datum	Relative Tidal Datum	Vertical Datum	Vertical Units	Date Published	Decade Represented	Notes
NOAA NCEI	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2019	2010s	Topobathy. Site mosaicked from 2 individual 15 minute x 15 minute rasters. Bathymetric and topographic data utilized for DEM creation originate from a variety of sources, including the NOAA OCS, NOAA NGS, NOAA OCM, USGS, and USACE. DEMs are referenced vertically to NAVD 88 with vertical units in meters.
USGS NED	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2003	2000s	Topography only. Site mosaicked from 2 individual rasters. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure.
NOAA NCEI CRM Vol. 2 (THREDDS)	~90m - 3 arc second MLLW (EPSG: 5866)	MLLW (EPSG: 5866	MSL	NAVD88 for topography	Meters	1998	1990s	Topobathy. The vertical datum for the source bathymetric data was generally mean lower low water (MLLW). Source topographic data were in NAVD 88. The differences between these datums are less than the vertical accuracy of the CRM, so you can assign MSL to the CRM if you like, just recognize that the elevation values may not be as accurate as you might like or need. Assume a vertical accuracy no better than 1 meter for any elevation values in the CRM.

Rachel Carson Reserve

Source	Resolution	Tidal Datum	Relative Tidal Datum	Vertical Datum	Vertical Units	Date Published	Decade Represented	Notes
NOAA NCEI	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2019	2010s	Topobathy. Site mosaicked from 2 individual 15 minute x 15 minute rasters. Bathymetric and topographic data utilized for DEM creation originate from a variety of sources, including the NOAA OCS, NOAA NGS, NOAA OCM, USGS, and USACE. DEMs are referenced vertically to NAVD 88 with vertical units in meters.
USGS NED	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2003	2000s	Topobathy, bathymetry from CRM. Site mosaicked from 2 individual 15 minute x 15 minute rasters. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. Best available bathymetric data were selected with a GIS query procedure that applied spatial and temporal filters to the 122 digital hydrographic surveys, dating from 1870 to 2005, which cover the North Carolina region.
NOAA NCEI CRM Vol. 2 (THREDDS)	~90m - 3 arc second MLLW (EPSG: 5866)	MLLW (EPSG: 5866	MSL	NAVD88 for topography	Meters	1998	1990s	Topobathy. The vertical datum for the source bathymetric data was generally mean lower low water (MLLW). Source topographic data were in NAVD 88. The differences between these datums are less than the vertical accuracy of the CRM, so you can assign MSL to the CRM if you like, just recognize that the elevation values may not be as accurate as you might like or need. Assume a vertical accuracy no better than 1 meter for any elevation values in the CRM.

Currituck Banks

Source	Resolution	Tidal Datum	Relative Tidal Datum	Vertical Datum	Vertical Units	Date Published	Decade Represented	Notes
NOAA NCEI	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2019	2010s	Topobathy. Site mosaicked from 2 individual 15 minute x 15 minute rasters. Bathymetric and topographic data utilized for DEM creation originate from a variety of sources, including the NOAA OCS, NOAA NGS, NOAA OCM, USGS, and USACE. DEMs are referenced vertically to NAVD 88 with vertical units in meters.
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DEM CORRECTIONS

Data for RTK surveys conducted by Brandon Phuckett available for the following locations and dates:

Location	Date
Carrot Island	09/2018-08/2019
Beaufort (site: middle marsh)	2008, 2012, 2015, 2017
Wilmington (site: Zeke's Island)	2013, 2016, 2017, 2019, 2021

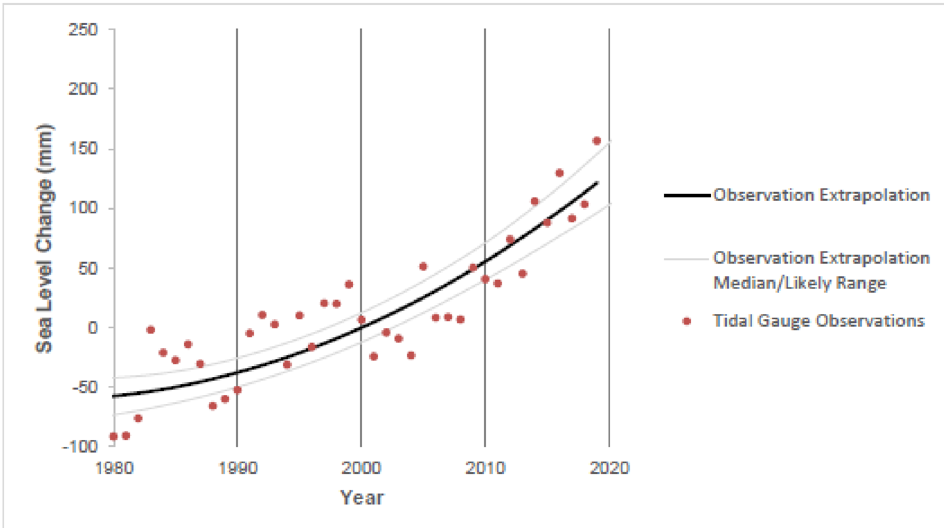
ECOLOGICAL DATA

Ecological Data is also available from the National Wetlands Inventory

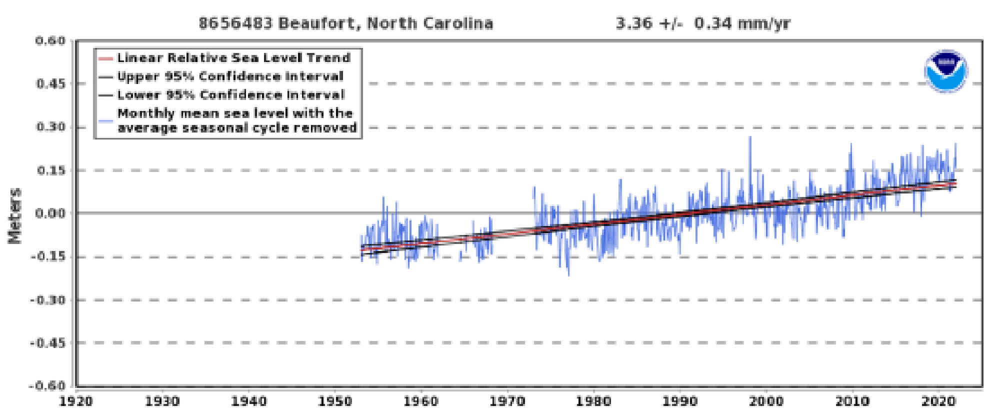
Location	Type	Date	Source
Beaufort, NC	Point Salinity Dominant Plan Communitieis and Vegetation Community Types	2015-2020	NOAA / NCCOS-Beaufort
Theodore Roosevelt Natural Area	Point Salinity Dominant Plan Communitieis and Vegetation Community Types	2016	UNC / Voss
Cedar Island NWR	Point Salinity Dominant Plan Communitieis and Vegetation Community Types	2016	UNC / Voss

SEA LEVEL TRENDS

Nonlinear trends for Beaufort, NC
Created using data from the Interagency Sea Level Rise Scenario Tool:
https://sealevel.nasa.gov/task-force-scenario-tool?psmsl_id=2295
Technical Report available:
https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report-sections.html



Relative Sea Level (linear) trends for Beaufort, NC
From NOAA: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8656483`



GAUGE DATA

Currituck Banks

	Datum	Elevations on NAVD88	Elevations on Mean Lower Low Water	Elevations on Mean Sea Level
Present Installation Start: 27-Jul-88				
Station Home Page: 8651370, Duck, NC	MHHW	0.457	1.124	0.585
Station Datum Definitions: 8651370, Duck, NC	MHW	0.36	1.027	0.488
	MSL	-0.128	0.539	0
RSLR: 8651370, Duck, NC	MLW	-0.623	0.044	-0.496
	MLLW	-0.667	0	-0.539

Rachel Carson Reserve

	Datum	Elevations on NAVD88	Elevations on Mean Lower Low Water	Elevations on Mean Sea Level
Present Installation Start: 27-Jul-88				
Station Home Page: 8656483, Beaufort, Duke Marine Lab, NC	MHHW	0.455	1.078	0.557
Station Datum Definitions: 8656483, Beaufort, Duke Marine Lab, NC	MHW	0.358	1.991	0.47
	MSL	-0.122	0.521	0
	MLW	-0.59	0.043	-0.478
RSLR: 8656483, Beaufort, Duke Marine Lab, NC	MLLW	-0.633	0	-0.521

Masonboro Island

	Datum	Elevations on NAVD88	Elevations on Mean Lower Low Water	Elevations on Mean Sea Level
Present Installation Start: 26-Apr-04				
Station Home Page: 8658163, Wrightsville Beach, NC	MHHW	0.526	1.367	0.709
Station Datum Definitions: 8658163, Wrightsville Beach, NC	MHW	0.421	1.262	0.604
	MSL	-0.183	0.658	0
	MLW	-0.793	0.048	-0.61
RSLR: N/A	MLLW	-0.641	0	-0.658

Data Inventory
APALACHICOLA, FL

DEMS
Note: Rows shaded in orange indicate no bathymetry, yellow shading indicates that the vertical datum was something other than NAVD 88 for bathymetry.

Source	Resolution	Tidal Datum	Relative Tidal Datum	Vertical Datum	Vertical Units	Date Published	Decade Represented	Notes
NOAA NCEI	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2019	2010s	Topobathy. Site mosaicked from 2 individual 15 minute x 15 minute rasters. Bathymetric and topographic data utilized for DEM creation originate from a variety of sources, including the NOAA OCS, NOAA NGS, NOAA OCM, USGS, and USACE. DEMs are referenced vertically to NAVD 88 with vertical units in meters.
USGS NED	~3m - 1/9 arc second	N/A	N/A	NAVD88	Meters	2007-2010	2000s	Topography only. Site mosaicked from 9 individual 15 minute x 15 minute rasters. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure.
NOAA NCEI CRM Vol. 2 (THREDDS)	~90m - 3 arc second	MLLW (EPSG: 5866)	MSL	NAVD88 for topography	Meters	2001	1990s	Topobathy. The vertical datum for the source bathymetric data was generally mean lower low water (MLLW). Source topographic data were in NAVD 88. The differences between these datums are less than the vertical accuracy of the CRM, so you can assign MSL to the CRM if you like, just recognize that the elevation values may not be as accurate as you might like or need. Assume a vertical accuracy no better than 1 meter for any elevation values in the CRM.

DEM CORRECTIONS
Data for RTK surveys conducted by Michael Starek available for the following locations and dates:

Location	Date
Cat Point	05/26/21; 09/22/21
East Bay	05/27/21
Unit 4	03/18/16; 03/25/17; 07/11/18; 05/24/19; 09/22/20; 05/27/21

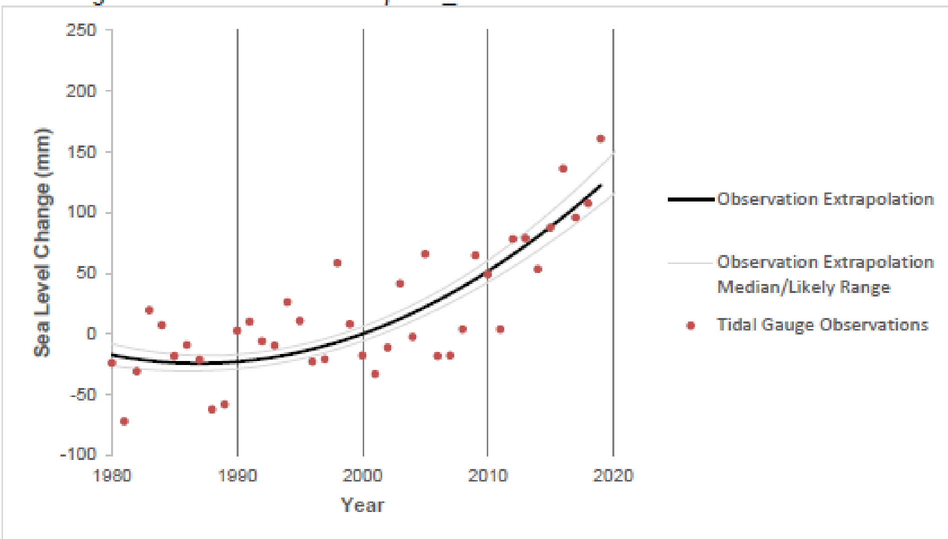
ECOLOGICAL DATA
See note below tables for details regarding the Apalachicola NERR Vegetation Survey

Location	Type	Date	Source
Apalcchicola NERR	Point Salinity from SET	2020	Apalachicola NERR
Apalachicola NERR	Point Salinity	2021	http://cdmo.baruch.sc.edu/
Apalachicola NERR	Vegetation Survey	2015 - 2020	Florida DEP

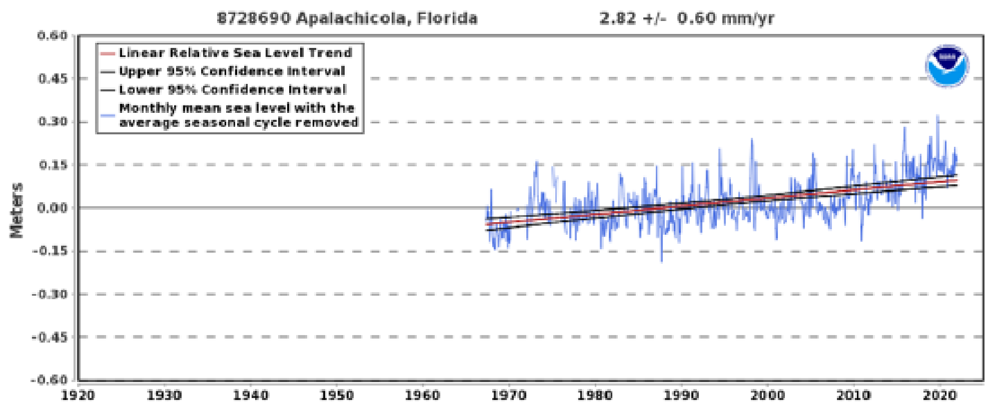
"The objectives of the APA NERR monitoring program are consistent with the objectives outlined in the NERRS technical report on Long-term Monitoring of Estuarine Submersed and Emergent Vegetation (Moore 2013) with some adaptations specific to the APA NERR. Specifically, the objectives of the APA NERR emergent vegetation protocol are: 1. Quantify vegetation patterns and their change over time and space; 2. Be consistent with other monitoring programs used worldwide, especially those used at other NERRS; 3. Be consistently applicable over a wide range of estuarine sites and habitats, including mangrove forests and seagrass meadows; 4. Quantify relationships among the various edaphic factors and the processes that are regulating the patterns of distribution and abundance in marsh communities; 5. Provide detailed information that can supplement comprehensive remotely sensed mapping of vegetation communities and other NERRS System Wide Monitoring Program data collection, as well as NERRS/NOAA education, stewardship, and restoration efforts."

SEA LEVEL TRENDS

Nonlinear trends for Apalachicola, FL
Created using data from the Interagency Sea Level Rise Scenario Tool
https://sealevel.nasa.gov/task-force-scenario-tool?psmsl_id=1193



Relative Sea Level (linear) trends for Apalachicola, FL
From NOAA: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8728690



25-year linear rate of SLR from 1995-2020 for Apalachicola, FL
5.84 mm/yr with a 95% CI of 1.65

GAUGE DATA

Present Installation Start: 22-Sep-89 Station Home Page: 8728690, Apalachicola, FL Station Datum Definitions: 8728690, Apalachicola, FL RSLR: 8728690, Apalachicola, FL	Datum	Elevations on NAVD88	Elevations on Mean Lower Low Water	Elevations on Mean Sea Level
	MHHW	0.26	0.492	0.215
	MHW	0.228	0.46	0.183
	MSL	-0.045	0.277	0
	MLW	-0.11	0.122	-0.155
	MLLW	-0.232	0	-0.277

Data Inventory
GRAND BAY, MS

DEMS
Note: Rows shaded in orange indicate no bathymetry, yellow shading indicates that the vertical datum was something other than NAVD 88 for bathymetry.

Source	Resolution	Tidal Datum	Relative Tidal Datum	Vertical Datum	Vertical Units	Date Published	Decade Represented	Notes
MARIS/ MDEQ	Varies	N/A	N/A	NAVD88	Meters (Convert-ed)	2019	2010s	Mosaic of Lidar Projects spanning 10 years in Mississippi. State-wide Mosaic reports all elevations in US Feet. Orignial elevations were mixed between Meters and Feet.
USACE NCMP	1m	N/A	N/A	NAVD88	Meters	2018	2010s	Rasterized topobathy lidar elevations generated from data col-lected by the Coastal Zone Mapping and Imaging Lidar (CZMIL) system.CZMIL integrates a lidar sensor with simultaneous topographic and bathymetric capabilities, a digital camera and a hyperspectral imager on a single remote sensing platform for use in coastal mapping and charting activities.
USGS NED	~3m 1/9 arc second	N/A	N/A	NAVD88	Meters	2012	2000s	NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. Best available bathymetric data were selected with a GIS query proce-dure that applied spatial and temporal filters digital hydrographic surveys which cover the central Gulf of Mexico region including Grand Bay.
USGS NED	~3m 1/9 arc second	N/A	N/A	NAVD88		2002	1990s	

DEM CORRECTIONS
Data for RTK surveys conducted by Jonathan Pitchford available for the following location and dates:

Location	Date
Grand Bay, MS	2013 and 2018
Available for download at Digital Coast: https://bit.ly/3JAXj1T	

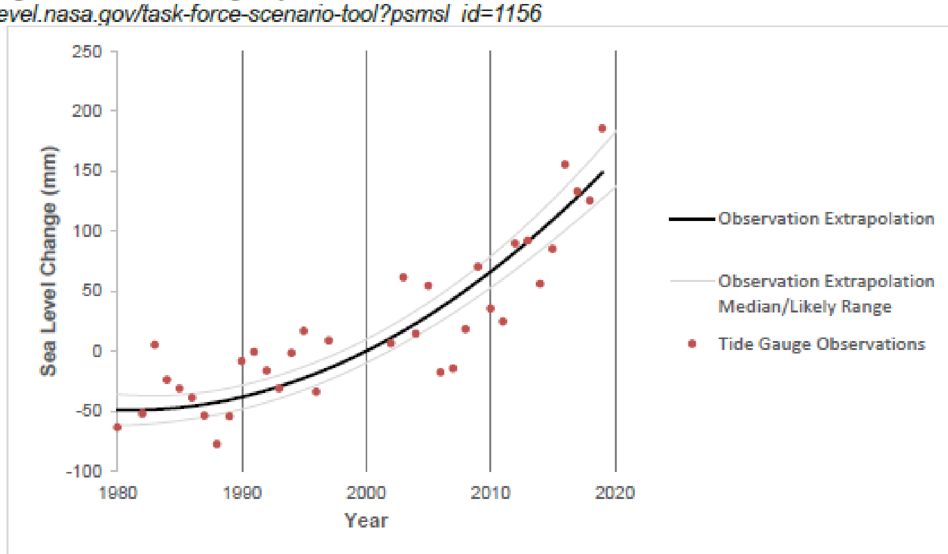
ECOLOGICAL DATA
All NERR Point Salinity data are available from http://grandbaynerr.org/data-downloads/

Location	Type	Date	Source
Grand Bay, MS	Point Salinity and Dominant Vegetation	2020	Jonathan Pitchford
Bayou Cumbest	Point Salinity	2004 - present	NERR
Bayou Heron	Point Salinity	2004 - present	NERR
Bangs Lake	Point Salinity	2004 - present	NERR
Crooked Bayou	Point Salinity	2004 - 2005	NERR
Point Aux Chenes Bay	Point Salinity	2005 - present	NERR

SEA LEVEL TRENDS

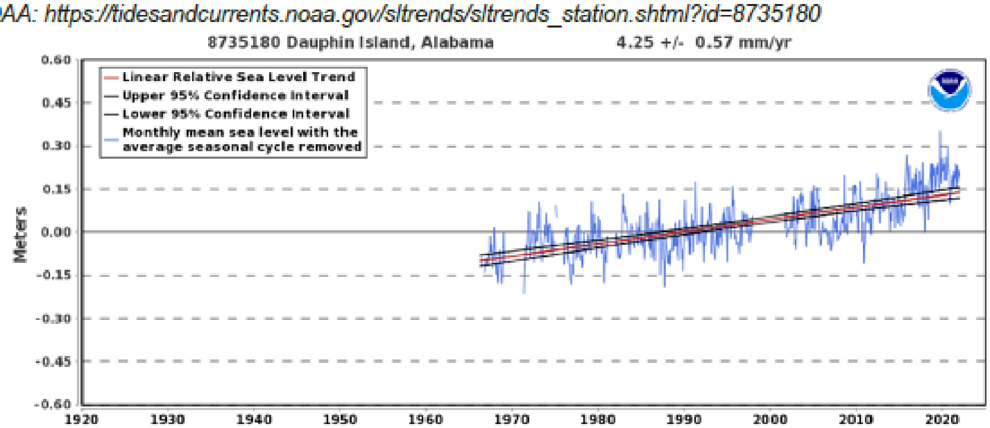
Nonlinear trends for Dauphin Island, AL

Created using data from the Interagency Sea Level Rise Scenario Tool
https://sealevel.nasa.gov/task-force-scenario-tool?psmsl_id=1156



Relative Sea Level (linear) trends for Dauphin Island, AL

From NOAA: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8735180



25-year linear rate of SLR from 1995-2020 for Daupihn Island, AL

7.01 mm/yr with a 95% CI of 1.84

GAUGE DATA

<table>
<tr><td rowspan="6">Present Installation Start: 25-May-10

Station Home Page:
8740166, Grand Bay NERR, Mississippi Sound MS

Station Datum Definitions:
8740166, Grand Bay NERR, Mississippi Sound MS

RSLR:
N/A</td><td>Datum</td><td>Elevations on NAVD88</td><td>Elevations on Mean Lower Low Water</td><td>Elevations on Mean Sea Level</td></tr>
<tr><td>MHHW</td><td>0.302</td><td>0.485</td><td>0.249</td></tr>
<tr><td>MHW</td><td>0.273</td><td>0.456</td><td>0.220</td></tr>
<tr><td>MSL</td><td>-0.053</td><td>0.236</td><td>0</td></tr>
<tr><td>MLW</td><td>-0.144</td><td>0.039</td><td>-0.197</td></tr>
<tr><td>MLLW</td><td>-0.183</td><td>0</td><td>-0.236</td></tr>
</table>

B4: Map Data Exploration Activity Sheet

Map Data Exploration Activity Sheet
Link to map: https://arcg.is/0CL9D90

1. How does the NWI land cover data differ from the CCAP land cover data in Apalachicola?

2. How many SETs show a negative elevation trend in Apalachicola?

3. In Apalachicola, there are a number of clusters of RTK readings near Cat Point Rd. What is the elevation of the RTK point named "Cat Point – GCP18"?

4. How do elevation trends (i.e., SET trends) in Alabama & Mississippi compare to those in Apalachicola?

5. What appears to be the most common CCAP land cover type, or types, in Alabama & Mississippi?

6. What is the name of the northernmost SET in North Carolina?

7. Which of the three locations had the most SET sites?

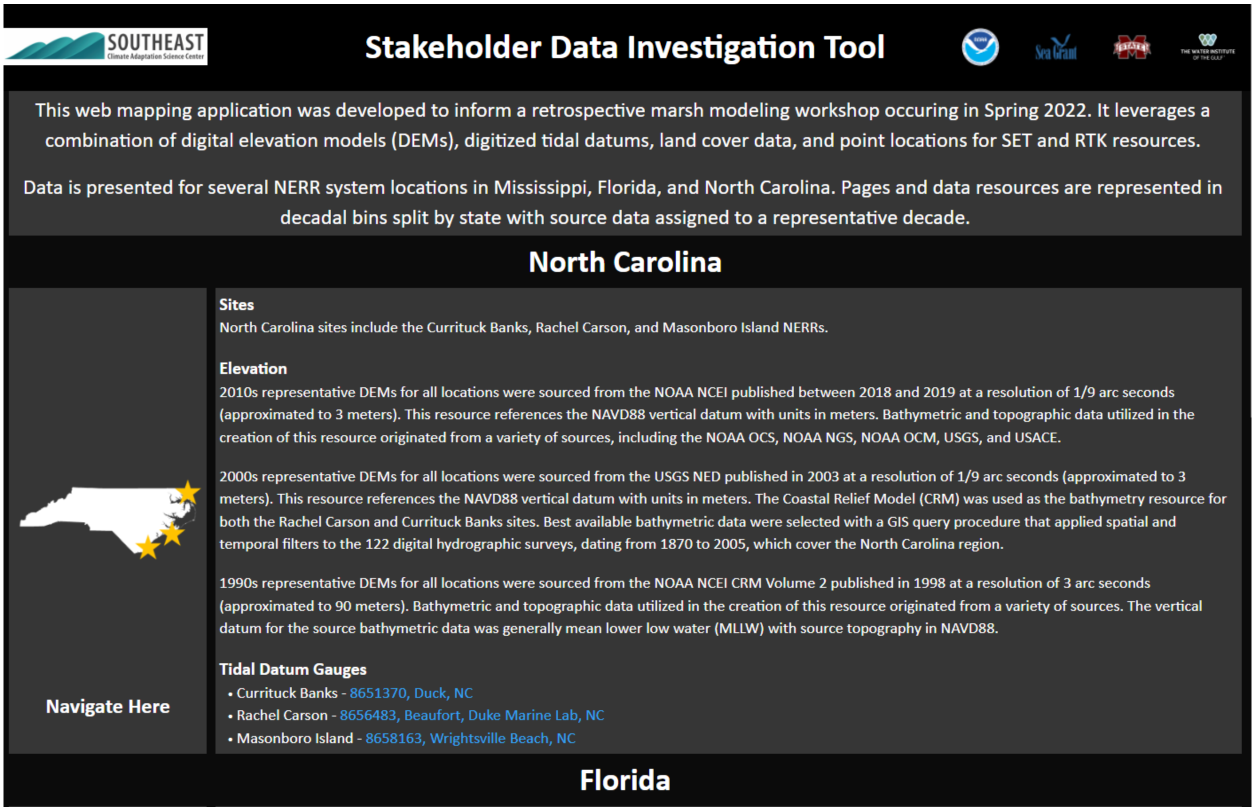
8. When looking at the DEM information layer, what colors represent the highest and lowest elevations?

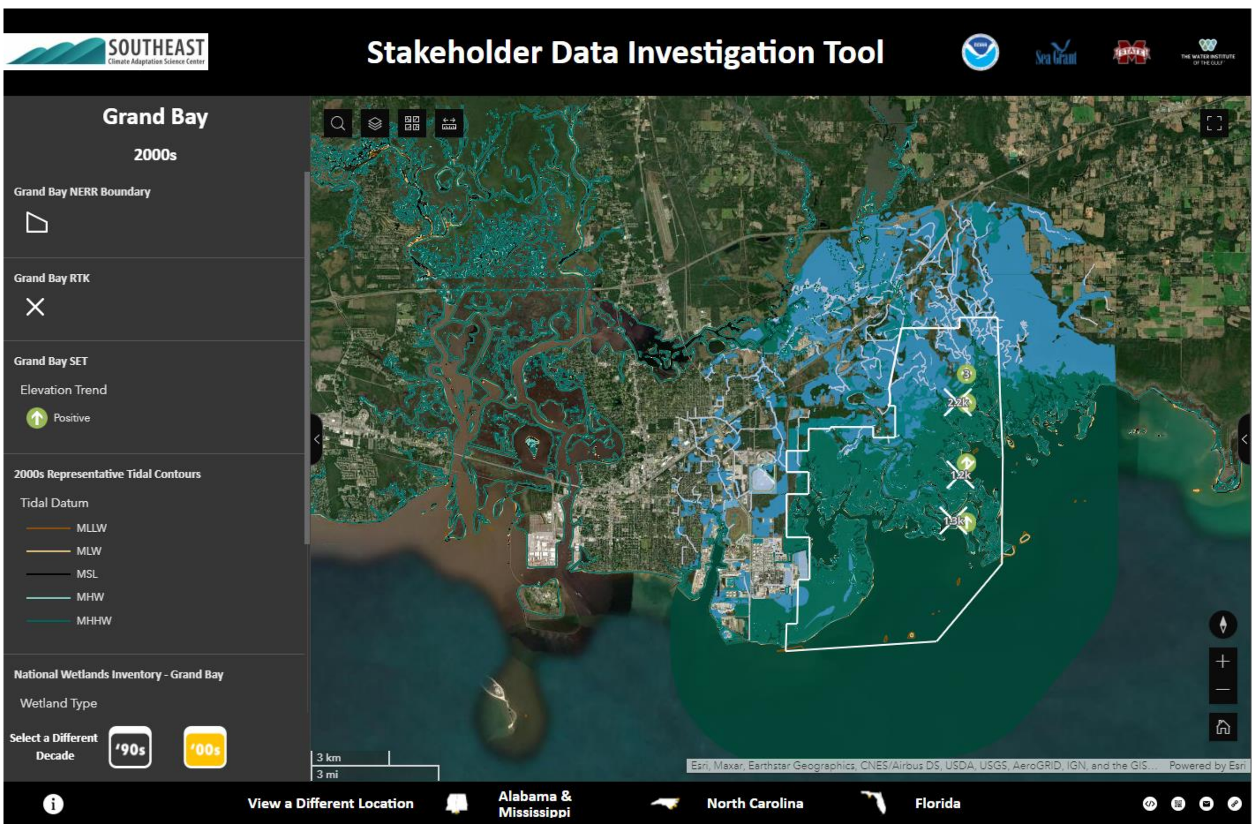
9. In the 2010s DEM for North Carolina, what does the elevation appear to be on Harker's Island?

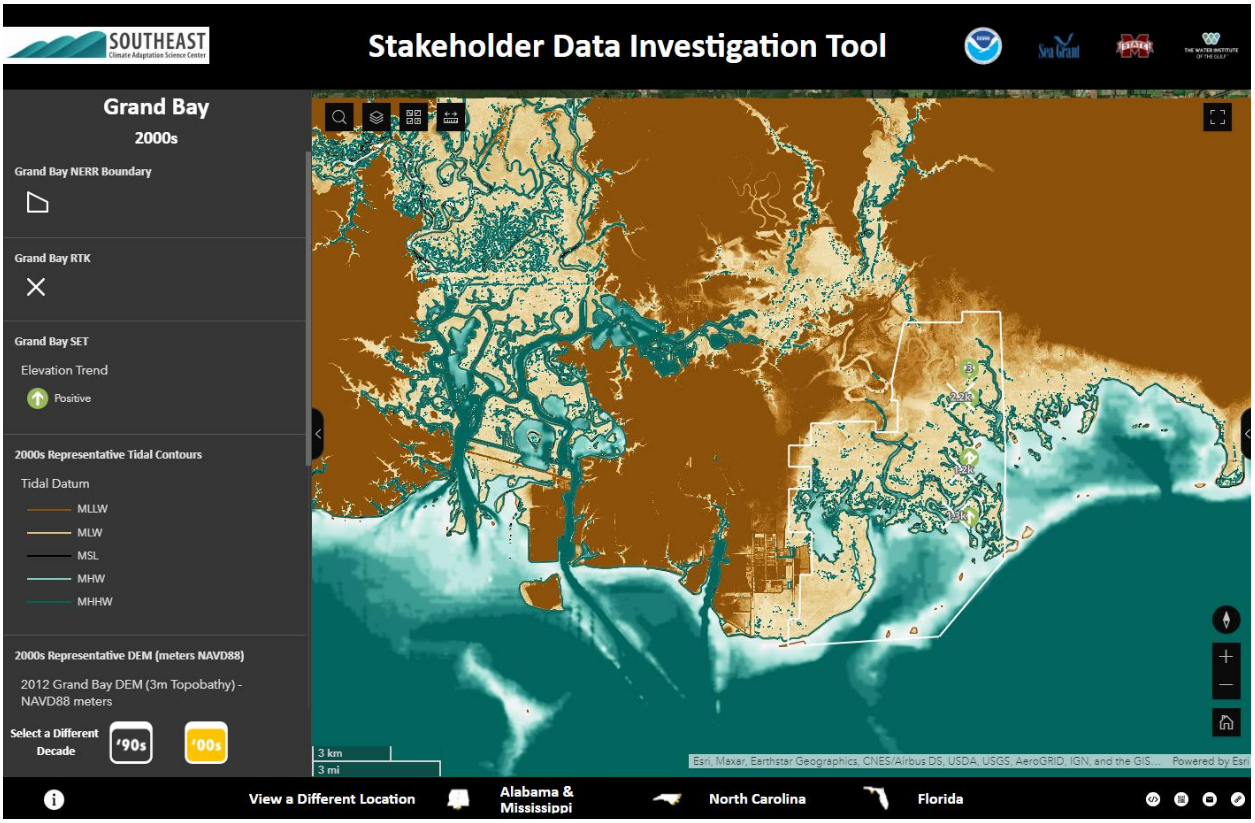
10. Does the DEM data differ across time in each location?

11. For the DEM data available in Alabama & Mississippi, what year(s) of DEM data are available?

Appendix C: Data Exploration Web Application Screenshots

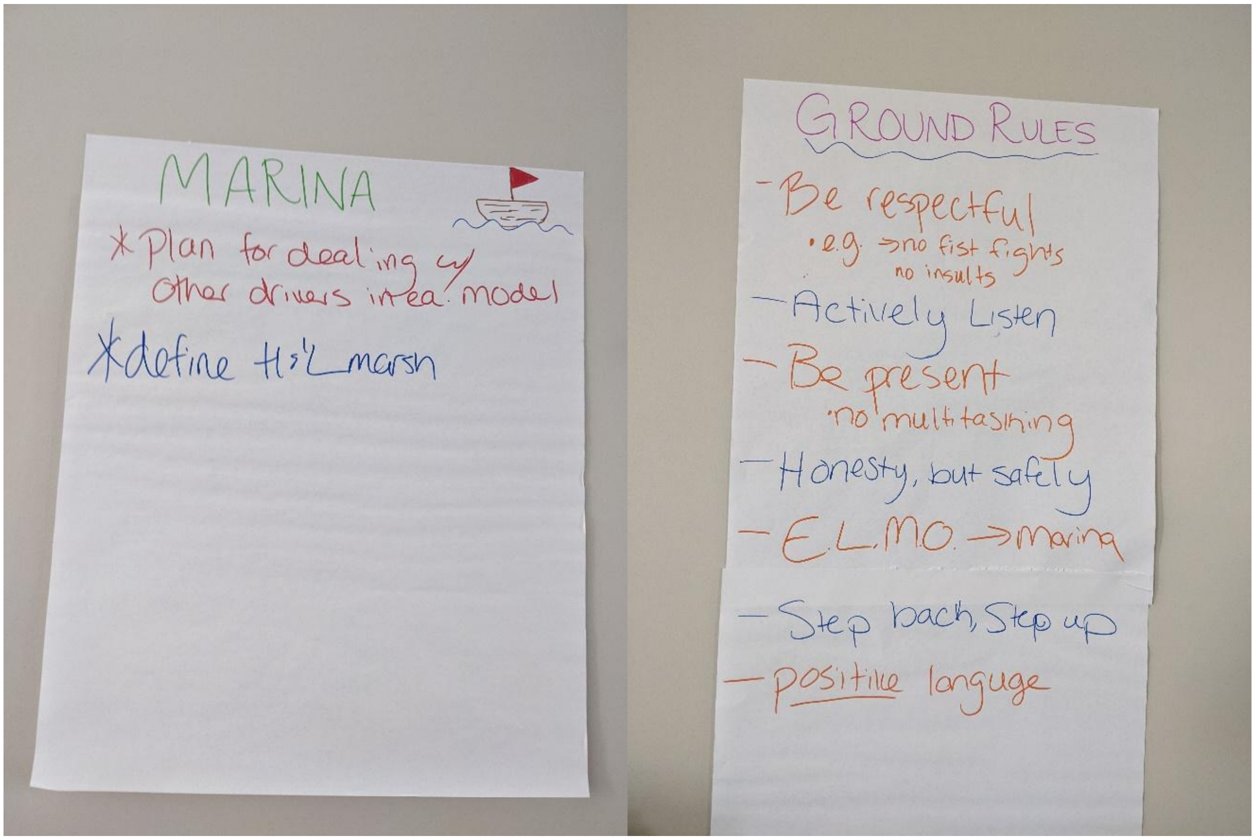




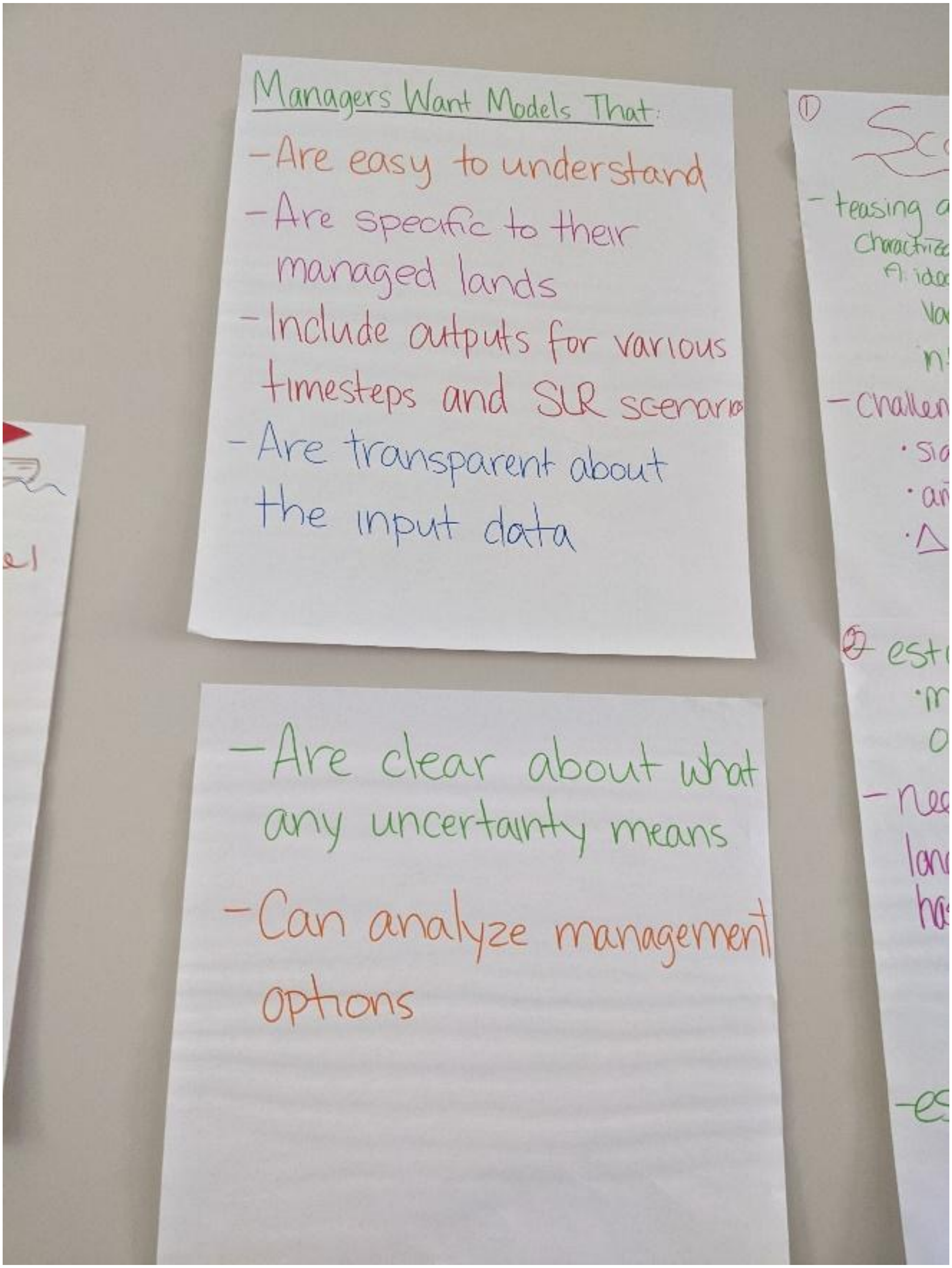

SOUTHEAST
Climate Adaptation Science Center
Stakeholder Data Investigation Tool
Grand Bay
2000s
Grand Bay NERR Boundary
Grand Bay RTK
Grand Bay SET
Elevation Trend
Positive
2000s Representative Tidal Contours
Tidal Datum
MLLW
MLW
MSL
MHW
MHHW
2000s Representative DEM (meters NAVD88)
2012 Grand Bay DEM (3m Topobathy) - NAVD88 meters
Select a Different Decade
'90s
'00s
3 km
3 mi
Esri, Maxar, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS... Powered by Esri
View a Different Location
Alabama & Mississippi
North Carolina
Florida

Appendix D: Workshop Flip Charts

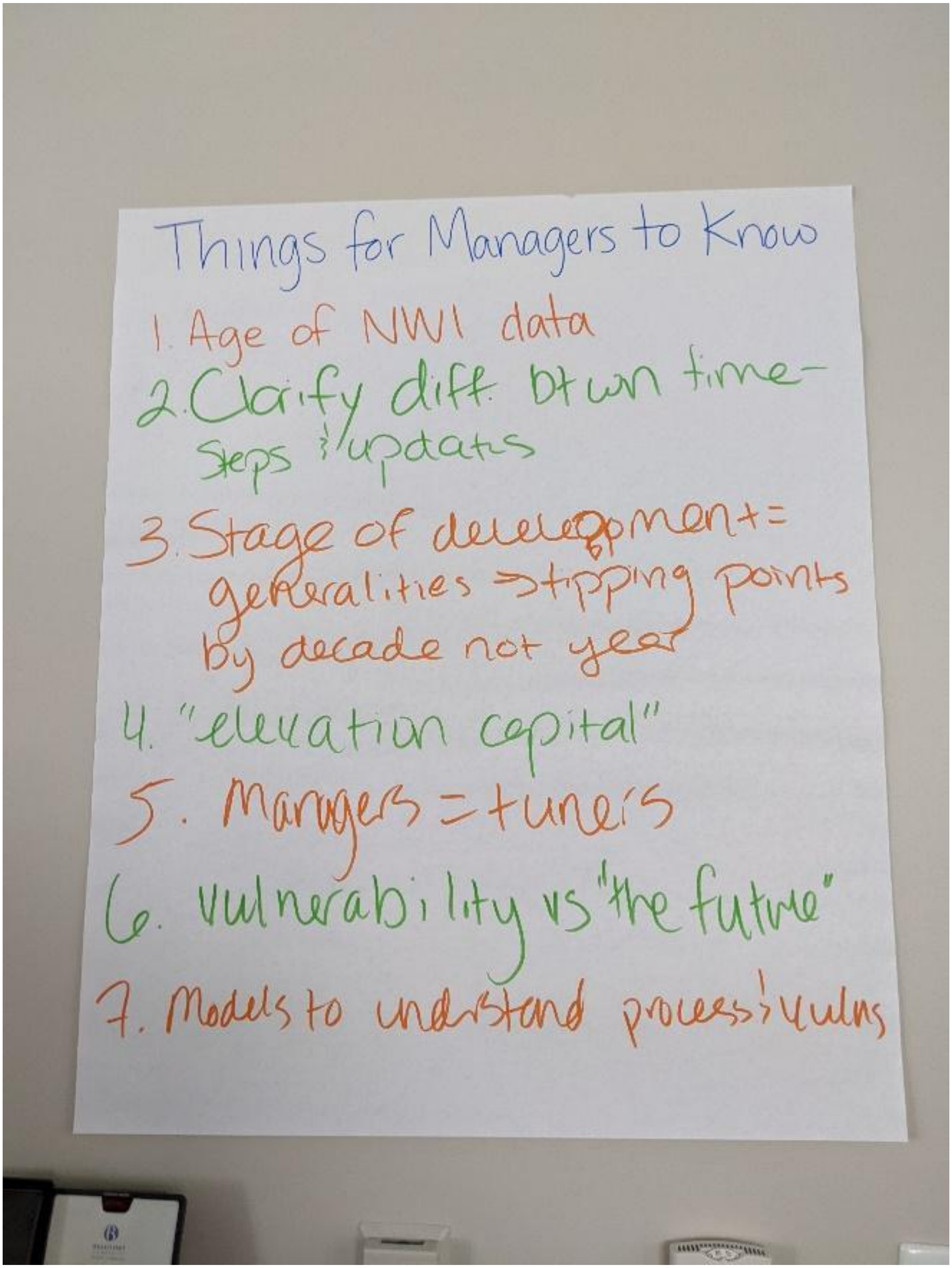
D1: Workshop Marina & Ground Rules



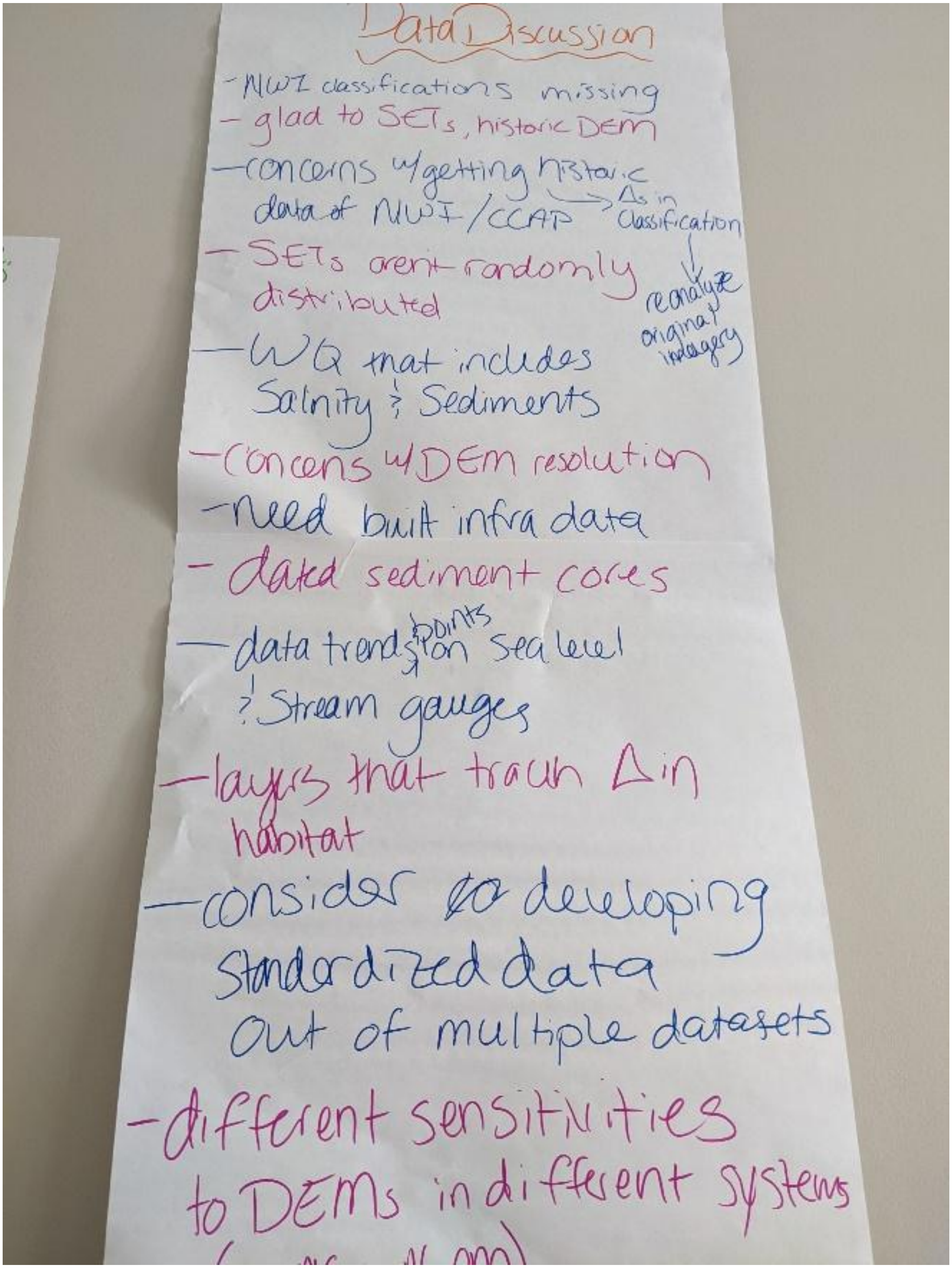
D2: Managers Want Modelers to Know



D3: Things for Managers to Know



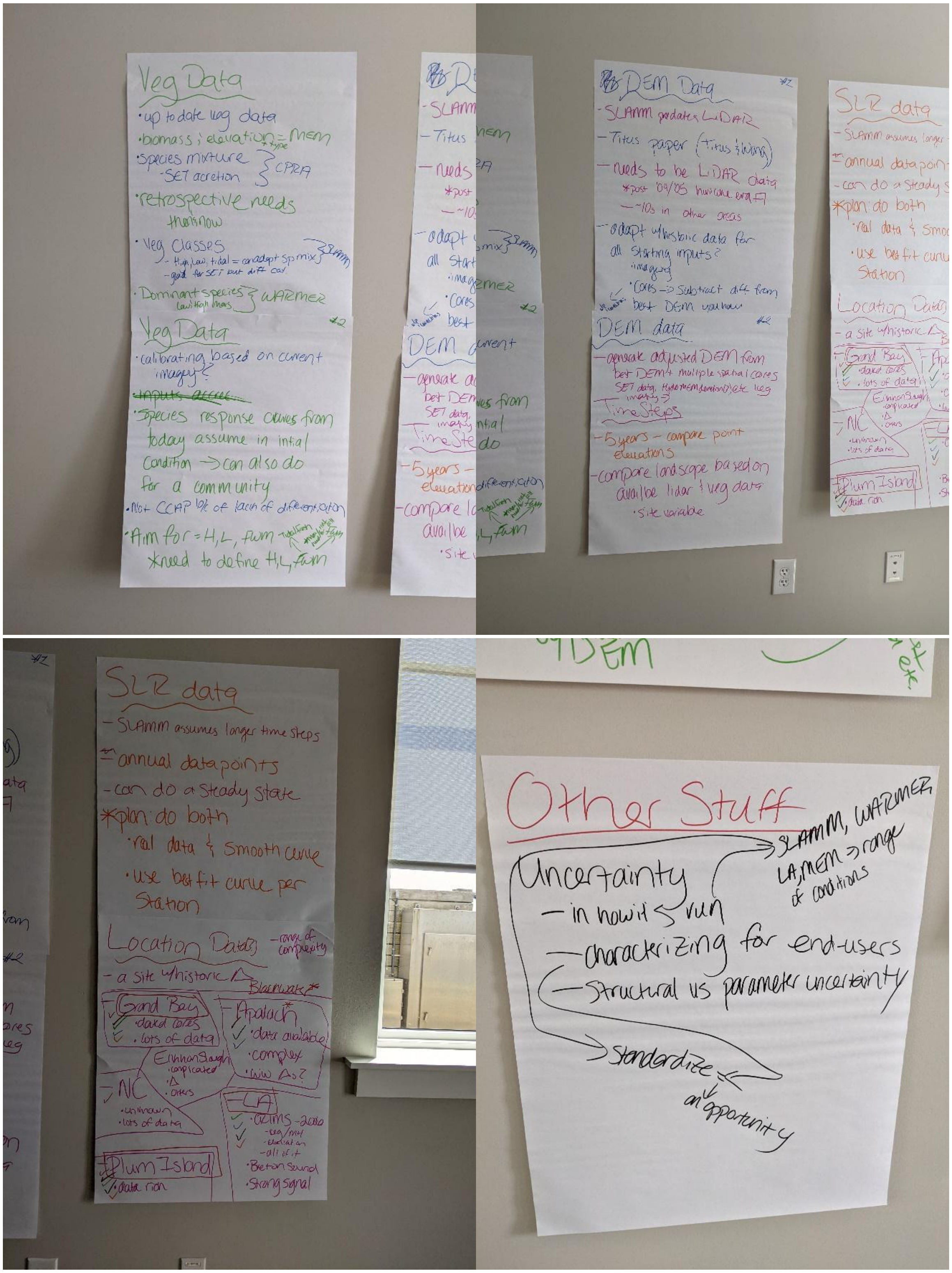
D4: Data Discussion



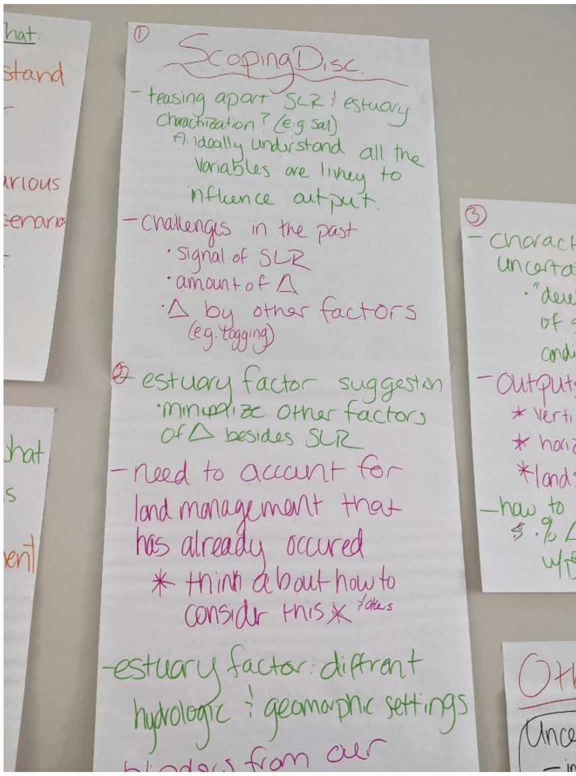
Data Discussion

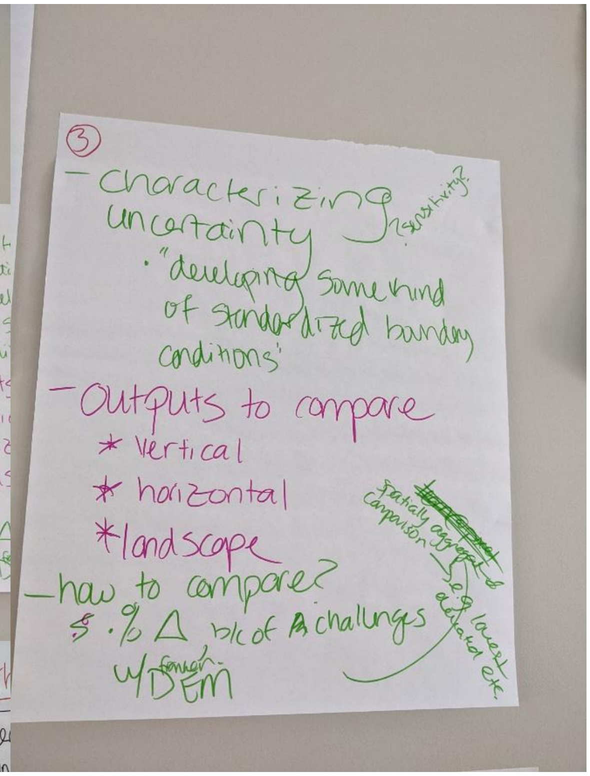
- NWI classifications missing
- glad to SETs, historic DEM
- concerns w/getting historic data of NWI/CCAP → Δs in classification → reanalyze original imagery
- SETs aren't randomly distributed
- WQ that includes Salinity & Sediments
- Concerns w/DEM resolution
- need built infra data
- dated sediment cores
- data trends/points on sea level & Stream gauges
- layers that track Δ in habitat
- consider ~~to~~ developing Standardized data out of multiple datasets
- different sensitivities to DEMs in different systems

D5: Details of the Retrospective



D6: Scoping Question Discussion





D7: Next Steps