Louisiana Barrier Island Comprehensive Monitoring (BICM) Program (2022-2027)

1. Introduction

The Deepwater Horizon (DWH) oil spill settlement in 2016 provides the Natural Resource Damage Assessment (NRDA) Trustees (Trustees) up to $8.8 billion, distributed over 15 years, to restore natural resources and services injured by the spill. As described in the DWH oil spill Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement (PEIS) (DWH Trustees 2016), the Trustees selected a comprehensive, integrated ecosystem approach to restoration. The Final PDARP/PEIS considers programmatic alternatives, composed of Restoration Types, to restore natural resources, ecological services, and recreational use services injured or lost as a result of the DWH oil spill incident. As shown in the PDARP/PEIS, the injuries caused by the DWH oil spill affected such a wide array of linked resources over such an enormous area that the effects must be described as constituting an ecosystem-level injury. The PDARP/PEIS and information on the settlement with British Petroleum Exploration and Production Inc. (called the Consent Decree) are available at the Gulf Spill Restoration website.

Given the unprecedented temporal, spatial, and funding scales associated with the DWH oil spill restoration effort, the Trustees recognized the need for robust Monitoring and Adaptive Management (MAM) to support restoration planning and implementation. As such, the following proposed monitoring program will provide essential data towards the programmatic goals established in the PDARP/PEIS to "Provide for Monitoring, Adaptive Management, and Administrative Oversight to Support Restoration Implementation" to ensure that the portfolio of restoration projects provides long-term benefits to natural resources and services injured by the spill (Appendix 5.E of the PDARP/PEIS). This framework allows the Trustees to evaluate restoration effectiveness, address potential uncertainties related to restoration planning and implementation, and provide feedback to inform future restoration decisions. The integrated restoration portfolio emphasizes the broad ecosystem benefits that can be realized through coastal habitat restoration in combination with resource-specific restoration in the ecologically interconnected northern Gulf of Mexico ecosystem (DWH Trustees 2016). Most of the planned restoration projects identified in the integrated restoration portfolio (DWH Trustees 2016) are concentrated in coastal Louisiana and in conjunction with the Louisiana Coastal Master Plan (CPRA 2017a). The monitoring program efforts proposed below allows for the continuation and expansion of barrier island/headland data collection in order to establish a proper baseline condition as large-scale restoration projects proceed.

2. Purpose of this document

This MAM Activities Implementation Plan (MAIP) describes the MAM activity, "Louisiana *Barrier Island Comprehensive Monitoring (BICM) Program (2022-2027)*" to address restoration assessment priorities described in the PDARP/PEIS. This MAM activity is intended to support evaluation of regional restoration outcomes within the Louisiana Restoration Area; perform data aggregation and data management; resolve critical information gaps and uncertainties for restoration planning, inform restoration decision-making; and perform monitoring to inform the design and implementation of future restoration projects. This document provides information about the activities to be implemented and the data gaps and uncertainties they will address; describes their applicability to the PDARP/PEIS; describes

their consistency with the programmatic alternative selected by the DWH Trustees in the PDARP/PEIS, OPA, and compliance with NEPA.

This MAM activity is consistent with the DWH Final PDARP/PEIS. The Louisiana Trustee Implementation Group (LA TIG) can use the data provided by this effort to assess changes in the barrier shoreline ecosystem allowing for assessment of the influence of the comprehensive, integrated portfolio of restoration projects at a coast-wide or sub-region within Louisiana and relative to other drivers and long-term trends.

3. Monitoring and Adaptive Management: Barrier Island Comprehensive Monitoring (BICM) Program

This MAM Activities Implementation Plan (MAIP) describes MAM Activity for barrier island comprehensive monitoring (BICM) program to address the following priorities of various restoration types described in the PDARP/PEIS:

- Wetlands, Coastal, and Nearshore (Section 5.5.2 in PDARP/PEIS)
  - Goals Addressed:
    - Restore a variety of interspersed and ecologically connected coastal habitats in each of the five Gulf states to maintain ecosystem diversity, with particular focus on maximizing ecological functions for the range of resources injured by the spill, such as oysters, estuarine-dependent fish species, birds, marine mammals, and nearshore benthic communities.
    - Restore for injuries to habitats in the geographic areas where the injuries occurred, while considering approaches that provide resiliency and sustainability.
  - Rationale
    - The BICM Program will be used as monitoring and assessment for large-scale restoration.
    - The BICM is in Louisiana where most of the DWH injury occurred.
- Monitoring and Adaptive Management (Section 5.5.15 in PDARP/PEIS)
  - Goals Addressed:
    - Increase the likelihood of successful restoration
    - Provide feed-back for management decisions
  - Rationale
    - The BICM will be used as baseline monitoring for ecosystem restoration and continue after projects are in operation in order assess project impact on land loss and habitat change. BICM data and assessments will allow for adaptive management decisions for future restoration efforts. The BICM program will also serve as baseline and post- project monitoring for coastal restoration projects in the Louisiana Coastal Master Plan (CPRA 2017a).

3.1. MAM Activity Description

3.1.1. Background

The BICM Program provides valuable data for the nearshore habitats and their dependent resources targeted for NRDA restoration, including coastal beaches, dunes, wetlands, and threatened and/or endangered species such as the Piping Plover, Red Knot, and sea turtles among many other injured resources. The LA TIG can use the existing data as well as new data provided through the BICM Program to assess changes in their associated habitats along the Gulf of Mexico shoreline over time, allowing for assessment of the influence of the comprehensive, integrated portfolio of restoration projects at a coast-

wide or regional-scale within the Gulf of Mexico (GOM) and relative to other drivers and long-term trends in the basins. Currently, data collection activities occur within every deltaic region along the Gulf shoreline and includes recently acquired as well as historic dataset compilations which are available to NRDA.

3.1.1.1. History of Barrier Island Comprehensive Monitoring Program

Development of a comprehensive program to evaluate the State's barrier shoreline was initiated by a Louisiana Department of Natural Resources – Coastal Restoration Division (LDNR - CRD) workgroup in 2002 (now Coastal Protection and Restoration Authority [CPRA]). This workgroup developed a monitoring framework to assess shoreline processes and resulting geomorphic features and associated habitats, along with the changes in these ecosystems over time. The initiation of BICM in 2005, post-Katrina and Rita, was conducted through CPRA in a partnership between the University of New Orleans (UNO) and the U.S. Geological Survey (USGS). Initiation was funded by the Louisiana Coastal Area Science and Technology (LCA S&T) Office. Currently, CPRA continues the program through the second cycle with funding provided by National Fish and Wildlife Foundation (NFWF) through the Gulf Environmental Benefits Fund (GEBF). The first phase of BICM was completed in 2012, culminating with a workshop on program successes, the initial development process, and lessons learned from data collection and analysis and a summary report (Kindinger et al. 2013). The second phase is nearing completion with data and reporting for individual tasks complete and development of a final summary report expected in early 2022.

The advantage of the BICM Program over project-specific monitoring is the ability to provide integrated long-term data on all Louisiana shorelines, instead of just those areas with constructed projects. As a result, large amounts of long-term data are available to evaluate constructed projects, facilitate planning and design of future barrier shoreline projects, support operations and maintenance activities, determine storm impacts, and provide coast-wide baseline conditions necessary for assessing system evolution. BICM encompasses a wide variety of datasets and analysis that include: 1) shoreline assessment photography and period comparisons, 2) coast-wide shoreline delineation and change analysis, 3) topography data and elevation change, 4) bathymetry data and elevation change, 5) habitat delineation with habitat and land/water changes, and 6) surficial sediment composition and change.

BICM Program development continues as needs are identified. Additional datasets, such as subsidence, post-storm over wash and recovery, and vegetation composition are being developed and scoped for potential future implementation based on needs identified, user inputs for the State's Master Plan activities. Additionally, BICM is coordinating and integrating with other CPRA comprehensive monitoring programs, as a part of CPRA's System-wide Assessment and Monitoring Program (SWAMP) to insure cost-effective and integrated data and analysis.

3.1.2. Objectives

The goal of the BICM Program is to provide long-term data sets and assessment of Louisiana's barrier shoreline for planning, designing, evaluating, and maintaining current and future barrier shoreline projects and programs.

Objectives:

1. Determine the elevation, longevity, and conservation mass of the barrier islands.
2. Determine major habitat types and the distribution and quantity of each habitat over time on the barrier islands.

3. Determine geotechnical properties of sediments on the barrier shoreline to evaluate nourishment fill performance through assessment of sediment composition and movement.

4. Relate available data on environmental forces that affect the ecology and morphology of the barrier islands to other BICM data sets.

5. Determine species composition and diversity of vegetation within major habitat types on the barrier islands.

Below, the MAIP is divided into the tasks carried out within the nine BICM regions of Louisiana (Figure 1) which were divided to reflect deltaic conditions. Currently, the BICM Program is operating based on a semi-decadal (5 yr) cycle.

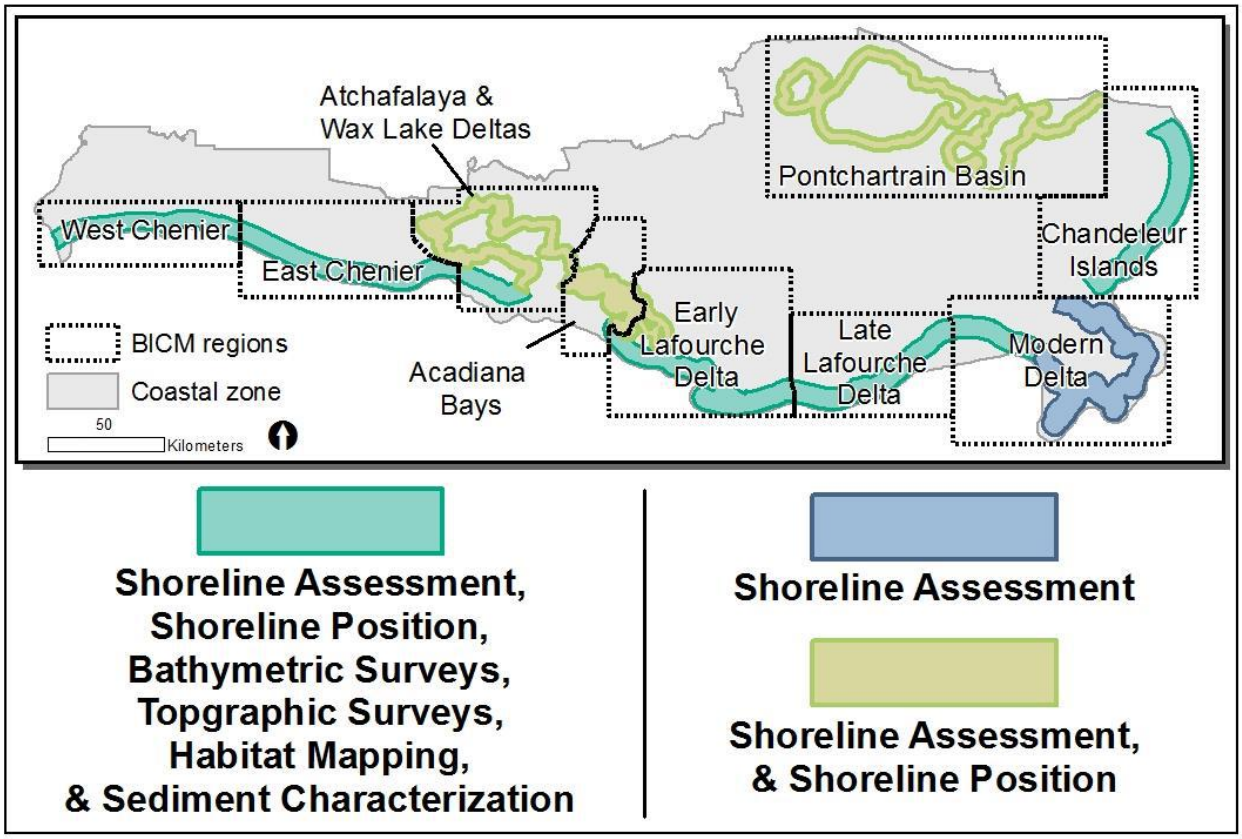

Figure 1: BICM Program deltaic regions with current data collection efforts and extents.

3.1.3. Tasks

The proposed MAIP BICM project will complete the third BICM cycle providing additional datasets and analysis of current status and long-term impacts of restoration on the gulf shoreline. This BICM cycle 3 will provide a wide variety of datasets and analysis that include: , utilizing airplane flights, and photo period comparisons; 2) coast-wide shoreline delineation and change analysis utilizing digitization of existing CIR aerial photography; 3) topography data collection utilizing LiDAR and RTK surveying, with elevation change analysis; 4) bathymetry data collections

from 2KM inshore to 5KM offshore, utilizing a variety of small vessels, with elevation change analysis; 5) habitat delineation from existing CIR aerial photography, with habitat and land/water change analysis; 6) surficial sediment petite ponar or hand scoop grab sample data collections, with composition/change analysis; 7) vegetation composition data collection utilizing ocular estimations of cover with vegetation characterization analysis; 8) subsidence monitoring utilizing RTK of existing survey monuments, with change analysis; and 9) Focused shoreface overwash and recovery assessments utilizing similar field methods as components above including bathymetry, topography, sediment, and vegetation sampling; and 10) a final summary report. These tasks will include the continued maintenance and development of BICM program data delivery and formatting for all tasks. Representatives from TIG Trustee agencies will collaborate to identify the various synthesis products needed to inform DWH NRDA restoration and MAM, including development of a final report. The proposed program schedule is outlined below (Figure 2).

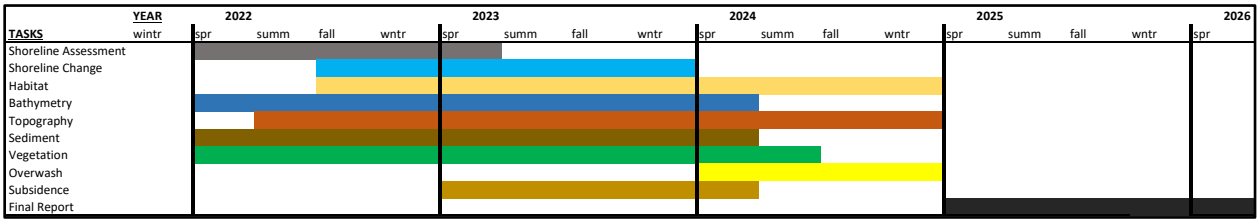

Figure 2: Initial BICM Program schedule to be updated upon final funding approvals.

3.1.3.1. Shoreline Assessment

Purpose

The Barrier Island Comprehensive Monitoring (BICM) Program acquires oblique imagery via airplane flights along the entire shoreline to document conditions at various times and provide supplemental information to managers and scientists to help interpret and explain barrier shoreline performance and processes in a readily understandable form. This effort produces geo-located images along the Louisiana coastline. Assessment of barrier shorelines through oblique aerial photography has long been a viable and vivid method for visualizing and explaining qualitative changes along coastal systems. To this day, such images remain important supplemental datasets, albeit qualitative in nature, that aid to better understand the processes that govern coastal change on beach and barrier systems. These images are important to managers and scientists to explain complex processes such as storm impacts, shoreline erosion, breaching, overwash, and habitat change in a simple manner that along with more quantitative data supports and explains adaptive decision making. For example NOAA and USGS commonly flight geo-referenced aerial imagery and oblique aerials post tropical event to document and explain storm impacts.

CPRA has worked with the UNO – PIES Aerial Video Survey slide archive, which includes imagery as early as 1984. Over many years of filming the coast, a standardized methodology produced imagery that facilitated comparison between time periods. Images that visually match from any two flights produce “Photo-pairs” to illustrate cumulative landscape changes for the selected time-periods. Imagery matched from more than two surveys are considered a “Time Series” and selected locations have documented shoreline conditions since 1984.

The initial BICM Program Shoreline Assessment was completed in 2009 and included the acquisition of images in 2005 and 2006-07 along with the development of Photo-pairs and Time series along the coast. BICM acquired additional imagery in 2008 and 2017 and has produced additional Photo-pairs comparing 2006-07 to 2017 conditions, along with updating and creating additional Time series.

The BICM Program provides individual, merged photo-pair, and cropped time series images, along with geo-referenced location data, metadata files, and methodology reports. Additionally, regional photo-pairs and time series location slide shows are available for download as PowerPoint or pdf files. (https://cims.coastal.louisiana.gov/Viewer/Map.aspx?guid=b4e2039f-5ca7-490d-ba30-8bf7f556592e)

Objectives

1. Provide geo-referenced oblique aerial imagery to document shoreline conditions and changes.
2. Provide qualitative comparisons of shoreline conditions over time by producing matched imagery Photo-pairs and Time series.

Methods

Following previous BICM efforts (Westphal 2018), oblique aerial photographs are typically acquired along the Gulf shoreline and major bays of Louisiana, from an open window on the right side of a small plane. The flight line generally follows a path counterclockwise in bays and east to west along the gulf shoreline. If GPS enabled cameras are not available, as in earlier years, GPS data are collected separately along the flight path to geo-locate the images in post processing and provide metadata. Images and associated data files are produced to BICM Program standards for distribution and long-term archiving.

Photo-pairs and time series are then produced by searching available photos for possible matches (Figure 3). The individual images were overlaid on a grid to match scales and crop as necessary to match compositions. Some images were digitally “stretched” or “skewed” to overcome the perspective produced by a difference in altitude or camera angle and to enhance the visual relationship. The processed photos were then arranged together on one figure, with the older image on the top and the newer image on the bottom. Red triangles were commonly used as a point of rotation or to identify common features to enhance the visual comparison. The date of each image was included, and a text line was added at the bottom to provide location information – at a minimum: latitude, longitude and direction of the view. Once images are matched, scaled, adjusted and cropped in Adobe PhotoShop, the images were individually “flattened” and saved as individual jpegs. These jpegs are used to produce slide shows for Photo-Pairs in a BICM region or a time series.

Figure 3. Example BICM photo-pairs (Westphal 2018).

Products

The proposed BICM cycle will produce 1) A new set of georeferenced oblique images with associated GIS files, maps, pdf's, and metadata; 2) a set of photopairs comparing 2016 photos to current photos with associated GIS files, maps, pdf's, and metadata; and 3) updated historic Photo Time-series and potential development of aditional time-series.

3.1.3.2. Shoreline Position and Change Analysis

Purpose

The Louisiana Coastal Zone is losing land at an alarming rate, resulting in drastic changes to shoreline position and configuration (Byrnes et al. 2018). Shorelines along the Louisiana outer coast define the seaward geomorphic feature protecting more inland coastal wetlands. Erosion, migration, and deterioration of this boundary pose a long-term impact to coastal wetland geomorphology and ecology, thereby reducing the effectiveness of this coastal system as a buffer to storm energy. As such, shoreline positions for the outer coast of Louisiana are compiled to document historical changes since the mid-1800s and define the character and patterns of shoreline change within pre-defined reaches. Additionally, the BICM Program provides shorelines, baselines, measurement transects, and data for use in other analysis.
(https://cims.coastal.louisiana.gov/Viewer/Map.aspx?guid=7f3ed151-acca-4b7f-b5ef-d4298fc4f13b)

Objectives

1. Delineate the shoreline for the Louisiana coast during various time periods.
2. Measure the long-term and short-term changes in shoreline position to determine rates and patterns of shoreline change within coastal regions and reaches over time.
3. Provide high quality shorelines and change data for use in other efforts.

Methods

Shorelines are digitized from various source data, including CIR aerial photography to produce a complete shoreline position following standard procedures (Byrnes et al. 2018). Once shorelines are compiled and attributed, shoreline change analysis is completed using the U.S. Geological Surveys - Digital Shoreline Analysis System (DSAS) software, which is an extension to Esri ArcGIS.

BICM Shoreline analysis is conducted by establishing region-specific baselines and shore-perpendicular transects at 50-m (164-ft) longshore intervals (Figure 4). Rates of change are determined by subtracting shoreline positions from this common baseline, along each transect. This is done for distinct time periods and divided by the exact acquisition period for each shoreline location. Detailed quality control procedures are employed on a transect-by-transect basis to ensure accurate shoreline comparisons for region and reach data summaries.

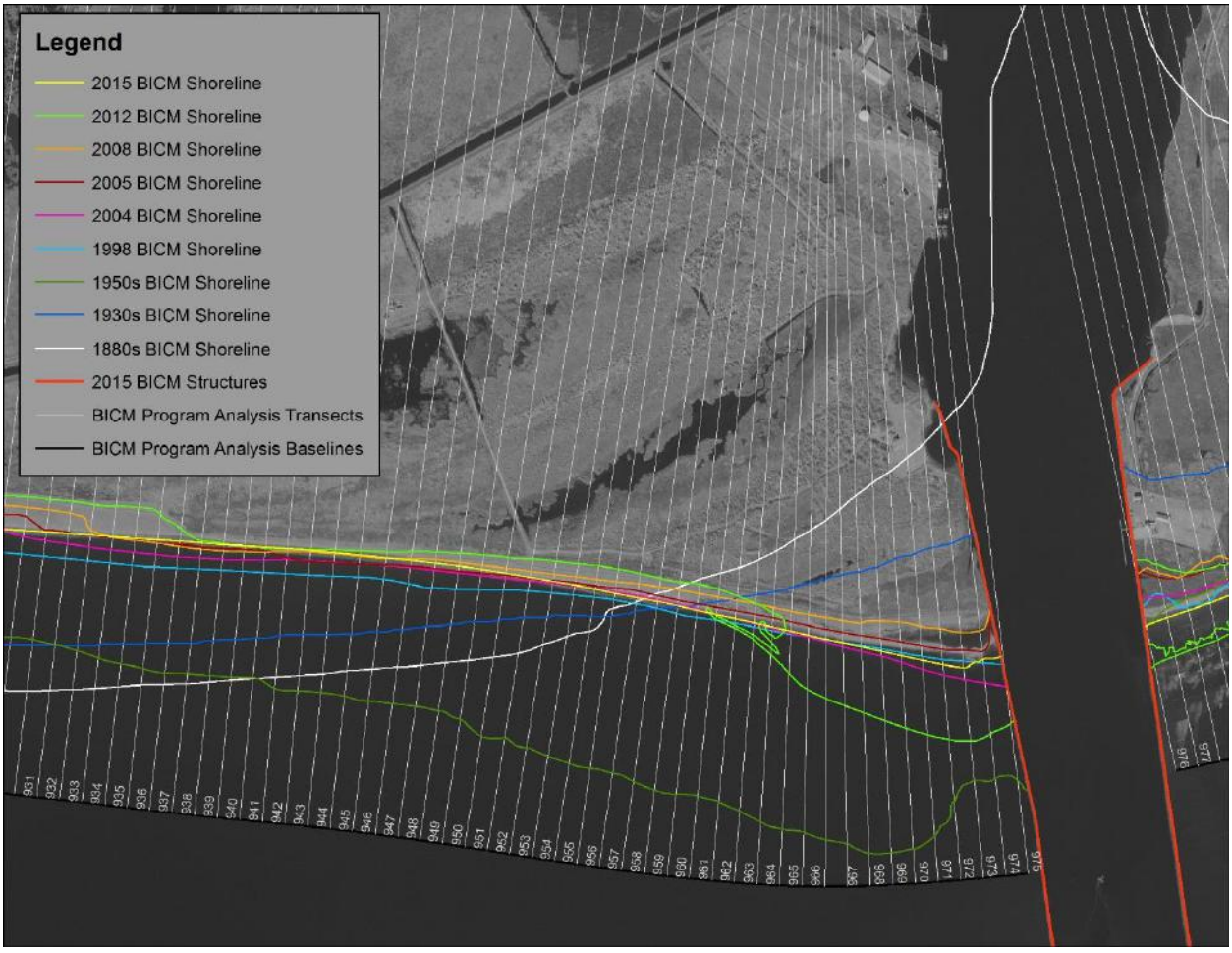

Figure 4: Example map showing existing BICM program shorelines and measurement transects.

Products

The proposed BICM cycle will produce 1) a 2021 shoreline shapefile from 2021 CRMS CIR photography with associated metadata; 2) Create shoreline change maps for BICM time periods with GIS files, and reports for each of the shoreline regions.

3.1.3.3. Sub-aerial Habitat Characterization and Change Analysis

Purpose

Barrier islands provide numerous ecosystem goods and services including storm protection and erosion control for the mainland, habitat for fish and wildlife, salinity regulation in estuaries, carbon sequestration in marshes, recreation, and tourism. These islands are dynamic environments due to their position at the land-sea interface. Storms, wave energy, tides, currents, and relative sea-level rise are powerful forces that shape barrier island geomorphology and habitats. As a result, natural resource managers are concerned with monitoring changes to habitats on these islands.

Habitat datasets provide a snapshot of barrier island composition and can be compared with historical and/or future datasets to evaluate these valuable natural resources over time. Sub-aerial habitat datasets have been developed for the BICM program by researchers at the University of New Orleans – Pontchartrain Institute for Environmental Sciences (UNO – PIES) for 1996/1998, 2001, 2002, 2004, and 2005 (Fearnley et al., 2009). In 2016, the BICM program partnered with the U.S. Geological Survey - Wetland and Aquatic Research Center (USGS-WARC) to develop sub-aerial habitat datasets for 2008 and 2015/2016 and assess change between these two years (Enwright et al. 2018). (https://cims.coastal.louisiana.gov/viewer/BICM-HRT.aspx)

Objectives

1. Delineate and quantify sub-aerial habitats for the Louisiana Gulf shoreline at regular time intervals.
2. Quantify long-term and short-term changes in sub-aerial habitats to determine rates and patterns of land loss and sub-aerial habitat change along Louisiana's coastline over time.
3. Provide high quality sub-aerial habitat and sub-aerial habitat change datasets for use in other efforts.

Methods

The BICM program has mapped barrier island sub-aerial habitats, referred to simply as habitats, utilizing both unsupervised and supervised classification methodologies. Through these different approaches, two habitat classification schemes have developed. Mapping efforts prior to the 2008 dataset were classified using a general eight-class habitat scheme. Habitat datasets for 1996/1998, 2001/2002, 2004, and 2005 were developed by the UNO - PIES using supervised and unsupervised classification of CIR ortho-photography. For more information on the methods used for these datasets, see Fearnley et al. (2009). Due to stakeholder input, a detailed 15-class habitat scheme was developed for 2008 and later datasets. However, this detailed classification builds on the general scheme used in previous BICM habitat mapping efforts. The additional classes included in the detailed scheme are primarily used to further delineate various dune habitats, separate marsh and mangrove, and distinguish between beach and unvegetated barrier flat habitats. To ensure comparability between this effort and

previously developed BICM habitat dataset products, the BICM program has cross-walked the detailed classes into the 8 general habitat classes allowing users to compare older datasets to the new data.

The classification methods currently used generate habitat datasets from CIR high-resolution ortho-photography using object-based analyses in the Trimble eCognition software (Figure 5). This software allows for a variety of data, such as aerial imagery and elevation data, to be integrated into the habitat classification process. The first step of object-based classification was to segment imagery into individual objects based on spatial and spectral similarities. Next, rather than classifying individual pixels, image objects are classified using object-level statistics. The mapping process utilized digital elevation models (DEMs) as ancillary data. These DEMs were developed from light detection and ranging (lidar) data available thru both BICM and other sources. Relative topography was extracted from the DEMs. The DEMs were also used to determine the probability of an area being intertidal or above extreme storm water levels. These processes also addressed vertical uncertainty of the DEM using error and bias information from a similar study (Enwright et al., 2017; Enwright et al. 2018). A minimum mapping unit (MMU) of 40 square meters was used to reduce noise. An accuracy assessment was conducted for each BICM region product using randomly sampled points and visual inspection of the map source data. For more details on the habitat mapping methods, see the habitat dataset metadata for an individual BICM region metadata Enwright et al. (2018) or Enwright et al. (2017), which was a barrier island habitat mapping effort for Dauphin Island, Alabama that used a similar mapping methodology.

Habitat change analysis summarizes habitat and land-water changes over numerous time periods using previous datasets developed by UNO-Pies (Fearnley et al. 2009). Current habitat change analyses depict and summarize habitat change between 2008 and 2015/2016. The results from the current analyses are summarized in two habitat change products (Figure 5). The first product depicts change in land and water coverage and the second product highlights changes based on tidal zones (e.g., water, intertidal-unvegetated, intertidal-vegetated, and supratidal). A MMU of 40 square meters and a width constraint of 2 meters width were used to remove noise in any areas detected as change. Similar to the habitat dataset products, an accuracy assessment was conducted for each BICM region product using randomly sampled points and visual inspection of the dataset source data.

A web-based Habitat Reporting Tool (HRT) has also been developed to allow users to easily review data and create maps based on BICM shoreline reaches. The tool uses current habitat and change datasets and allows users to choose BICM reaches and data types to create maps with acreages for any selected reach or reaches. Older datasets are being reformatted in order to integrate into the BICM HRT.

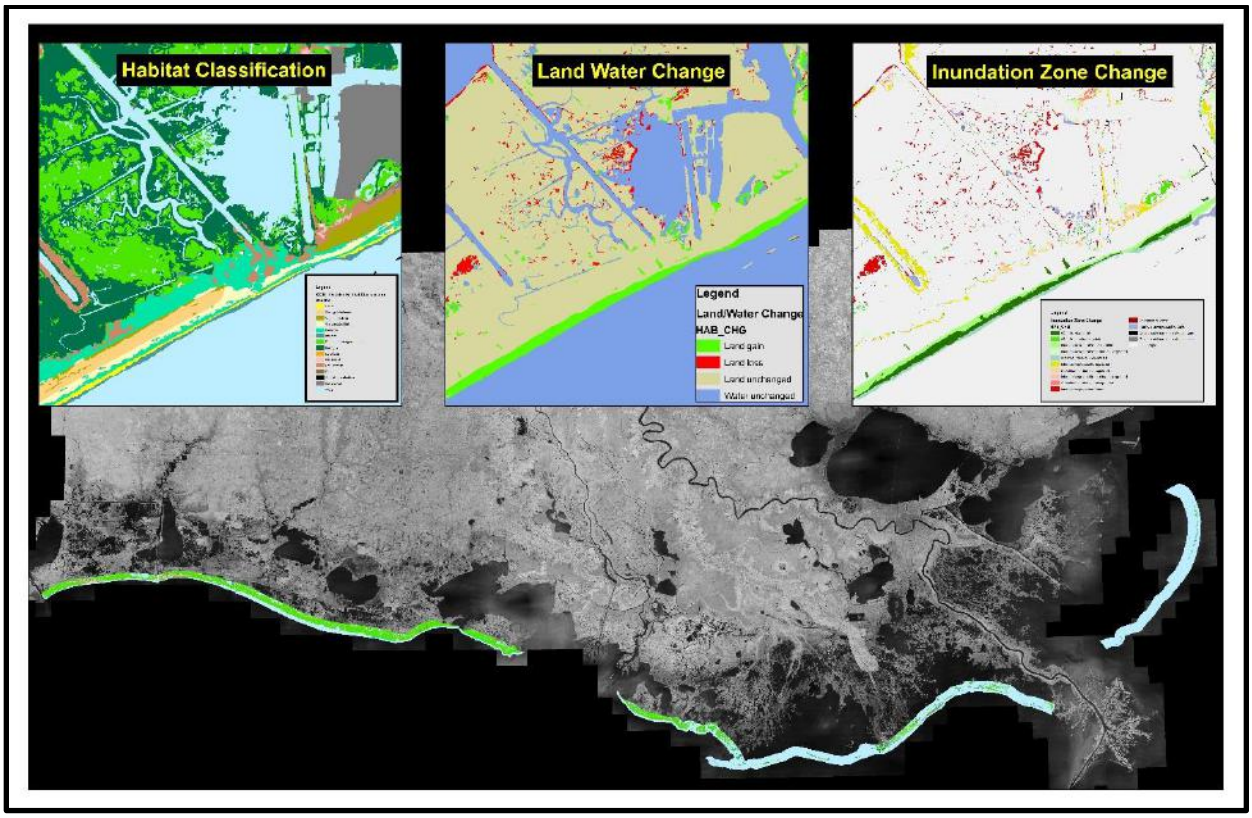

Figure 5. Habitat classification coverage, with examples of three data types available.

Products

The proposed BICM cycle will produce 1) Habitat classification dataset for 2021 CRMS CIR aerial photography (i.e., File geodatabase, accuracy assessment, metadata); 2) Habitat change analyses (i.e., inundation zone and land-water change datasets from 2015/16 to 2021; File geodatabases and metadata); 3) Updated Web-based habitat reporting tool; and 4) a final report.

3.1.3.4. Bathymetry Data Collection and DEM development

Purpose

The Barrier Island Comprehensive Monitoring (BICM) Program acquires regional bathymetric survey data to assist in documenting coastal response to both normal and storm processes over time. These processes cause changes in shoreface elevations, positions, and the transport of sediments in the near-shore environment. The acquisition of bathymetric data is essential for documenting patterns and rates of seafloor change and development of sediment transport rates. Additionally, bathymetry data is vital in the development and implementation of planning and project models to determine restoration impacts and future needs.

The BICM Program builds on both the U.S. Geological Survey and Louisiana Geological Surveys Seafloor Change Atlas published in 1994 (List et al. 1994), by resurveying large portions of the Louisiana coast line and adjusting older bathymetric datasets to facilitate comparisons with newer data. In addition, BICM surveys expand upon previous atlas coverages to survey the majority of the Gulf shoreline on a regular basis. BICM provides updated bathymetric data beginning in 2006, which has allowed comparisons to older data from the 1880's, 1930's, and 1980's over large portions of the coast. BICM bathymetry data is integrated with other efforts, such as SWAMP coastal bay bathymetry and regional

coastal LiDAR surveys, in order to provide integrated Topographic-Bathymetric Digital Elevation Model (Topo-Bathy DEM) development and analysis. Analysis of regional-scale sediment transport patterns, for all sections of the Louisiana Gulf shoreline, have been developed with BICM and SWAMP funds, utilizing BICM, SWAMP, and other datasets.
(https://cims.coastal.louisiana.gov/Viewer/Map.aspx?guid=9ed0a806-8dab-4185-bff4-591953db0523)

Objectives

1. Provide quality bathymetric datasets for the entire Louisiana Gulf shoreline at regular time intervals
2. Contribute data towards integrated Topo-Bathy Digital Elevation Models along the Louisiana Gulf shoreline at various intervals to facilitate operational sediment budget development and modeling.
3. Document region scale changes in bathymetry to determine restoration impacts to island elevations, longevity, and sediment budgets.
4. Document tidal pass morphology changes to facilitate a better understanding of tidal prism dynamics and hydrodynamic modeling.

Methods

The BICM program initially determined the boundary of the barrier island and nearshore "systems" as extending from the offshore depth of closure (~15-foot isobath), landward across the shoreline and back barrier marshes, to a maximum of 2,500 linear feet into the back bays. Shore perpendicular survey transects were established along the entire Louisiana coastline at approximately 1500 foot intervals to a distance of approximately 6,500 ft offshore as well as 2,500 foot into the bays. Additionally, approximately every third survey transect was extended offshore to approximately 23,000 foot providing better information on offshore environments and changes. Finally, a series of shore parallel survey lines, known as “tie lines”, are acquired offshore and in the backshore. These tie lines are an important quality check for determining consistency in soundings at the survey line crossings, as well as providing additional data coverage between shore perpendicular transects (Figure 6). Examples of methodologies and coverage are available in Stalk et al. (2017).

All data collection activities begin with the establishment of survey controls using static monuments established utilizing Continuously Operating Reference Stations (CORS) GPS survey sites. Once control monuments are established, single beam bathymetry data collection using a variety of small vessels are performed. All survey vessels used are equipped with integrated GPS receivers, high resolution echo-sounder systems, and real-time dynamic motion sensors. Additionally, sound velocity measurements are recorded during the survey, to correct for variability in speed of sound thru the water column. Lastly, bar checks and overlaps between vessels are included regularly to determine accuracy of the survey systems throughout the effort. Data are processed to achieve quality horizontal and vertical positions in the North American Vertical Datum of 1988 (NAVD88), using the latest Geoid models. Products include the survey track lines, data points, and methodology reports (which documents survey control, data processing, data quantity, and quality).

Early bathymetric datasets were processed to produce digital elevation models (DEMs) and surfaces were subtracted to determine elevation and volume changes along shore. DEMs for bathymetry and bathymetric change are available for use, along with the xyz point files.

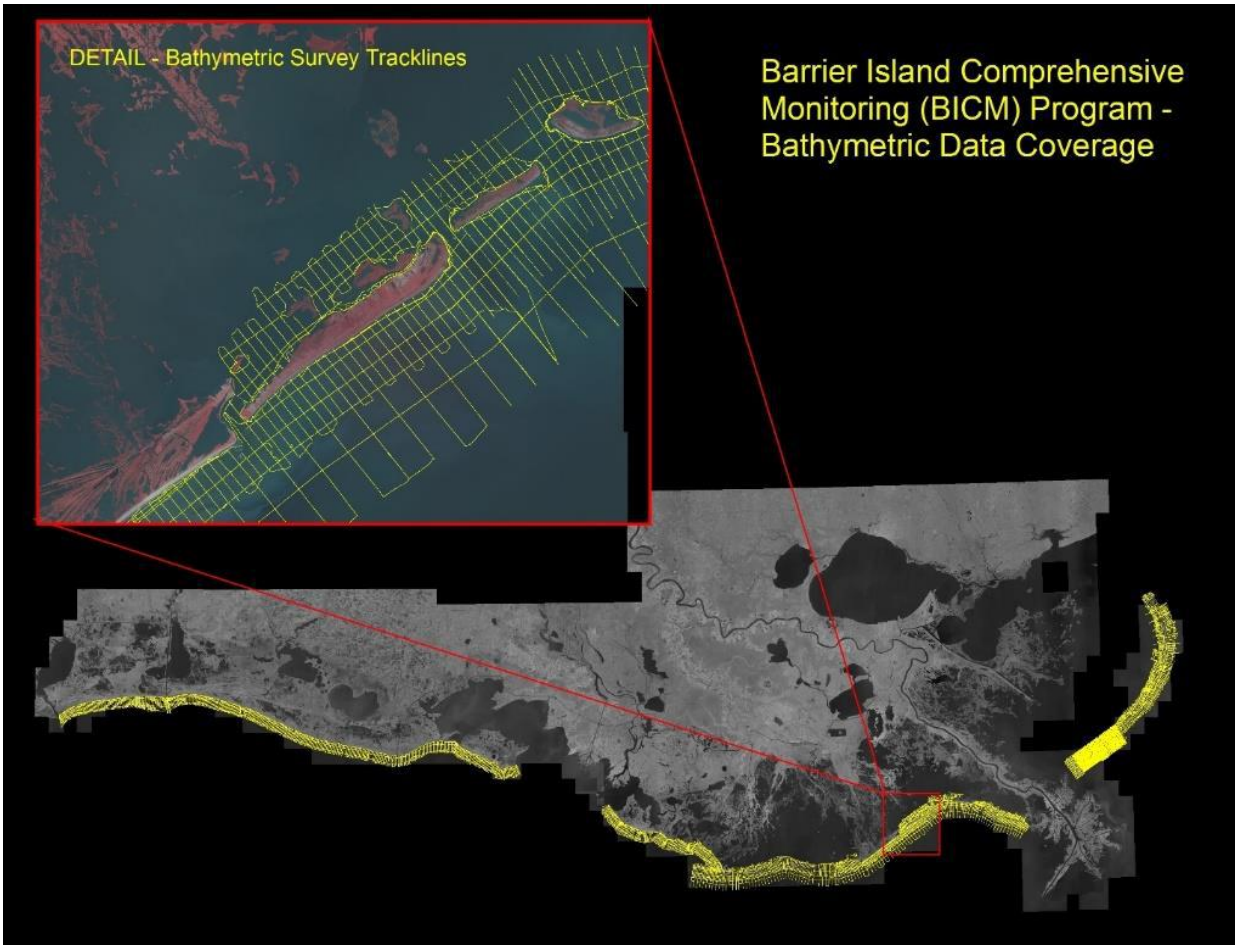

Figure 6. Bathymetric survey lines showing typical BICM program coverage.

Products

The proposed BICM cycle will produce 1) a 2022/23 bathymetric dataset (i.e., File geodatabase and metadata); 2) Bathymetric countours; and 3) final survey report(s).

3.1.3.5. Topographic Data Collection and DEM development

Purpose

The Barrier Island Comprehensive Monitoring (BICM) Program acquires topographic survey data to assist in documenting coastal response to both normal and storm processes over time. These processes cause changes in beach and dune elevations, positions, and the transport of sediments in the near-shore environment. The acquisition of topographic data is essential for documenting patterns and rates of elevation change and development of habitats and sediment transport rates. Additionally, topographic data is vital in the development and implementation of planning and project models to determine restoration impacts and future needs.

BICM provides updated topographic data beginning in 2006, which has allowed comparisons to older data from the 2001 and 2002 over large portions of the coast. BICM topography and bathymetric data is integrated with other efforts, such as SWAMP coastal bay bathymetry and regional coastal LiDAR surveys, in order to provide integrated Topographic-Bathymetric Digital Elevation Model (Topo-Bathy DEM) development and analysis. Analysis of regional-scale sediment transport patterns, for all sections of the Louisiana Gulf shoreline, have been developed with BICM and SWAMP funds, utilizing BICM, SWAMP, and other datasets.
https://www.usgs.gov/core-science-systems/ngp/tnm-delivery

Objectives

1. Provide quality topographic datasets for the entire Louisiana Gulf shoreline at regular time intervals
2. Contribute data toward integrated Topo-Bathy Digital Elevation Models along the Louisiana Gulf shoreline at various intervals to facilitate operational sediment budget development and modeling.
3. Document region scale changes in topography to determine restoration impacts to island elevations, longevity, and sediment budgets.
4. Document sub-aerial morphology changes to facilitate a better understanding of shoreline and habitat changes.

Methods

Topographic data will be collected utilizing airborne LiDAR and ground based GPS RTK surveying. The term LiDAR, derived from light detection and ranging, refers to active optical techniques that use a pulse of laser light to make range-resolved remote measurements. Distance between the LiDAR sensor and reflecting target(s) is calculated as a function of time elapsed between transmission of a well-characterized laser pulse and its return to the detector (i.e., the two-way travel time), and the speed of light in the medium of transmission. Different LiDAR systems were used to map coastal Louisiana. Each LiDAR system consists of slightly different hardware. As a result, unique processing software has been developed for each system. Common to all system is the application and integration of high precision differential GPS techniques and data processing steps to produce and QC an XYZ dataset. Typically, QA/QC'ed LiDAR datasets are used to generate various topographic grid products as TIN grids or DEM grids, the bare earth DEM grids or specialized vector information as a shoreline or topographic contours.

Previous topographic datasets developed thru BICM include cooperative efforts with USGS in 2002, 2006/07 and 2015. In addition, the SWAMP program has conducted regional LiDAR efforts with USGS beginning in 2013 and together SWAMP and BICM have provided complete regional coverage of the LA coast (Figure 7).

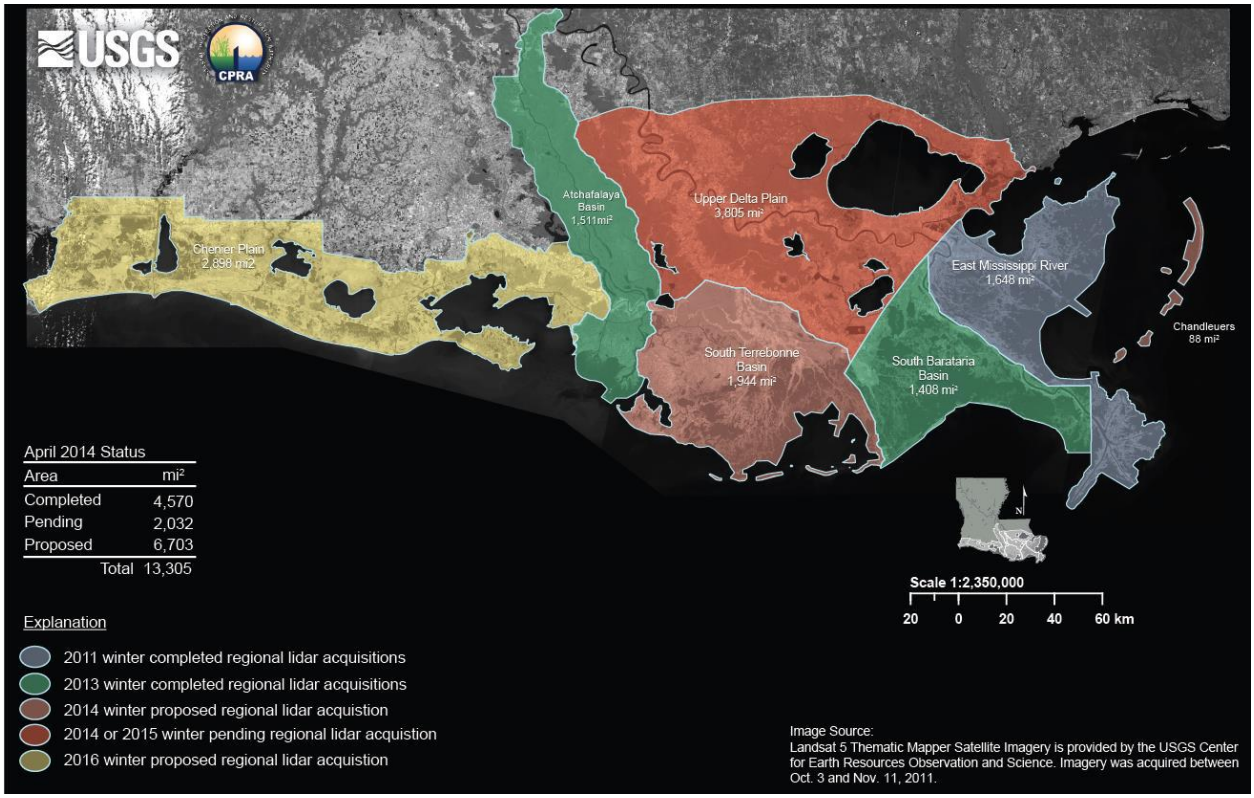

Figure 7. USGS NGP recent southern Louisiana topographic LiDAR data acquisitions.

Products

The proposed BICM cycle will produce 1) a 2022/23 LiDAR derived bare-earth topographic dataset within the BICM reaches (i.e., File geodatabase and metadata); 2) Topographic contours; and 3) final survey report(s).

3.1.3.6. Topo-Bathy Digital Elevation Model Development

Purpose

The Louisiana Coastal Zone is losing land at an alarming rate, resulting in drastic changes to shoreline positions and configurations. Shorelines along the Louisiana outer coast define the seaward geomorphic feature protecting more inland coastal habitats. Erosion, migration, and deterioration of this boundary pose a long-term impact to coastal wetland geomorphology and ecology, thereby reducing the effectiveness of this coastal system as a buffer to storm energy as well as a reduced availability of these unique barrier habitats. As such, integration of topographic and bathymetric data into seamless topo-bathy DEMs is necessary to enhance our understanding of geomorphic controls on barrier island system evolution therefore providing guidance for present-day restoration efforts. The BICM program in conjunction with other efforts such as SWAMP have compiled multiple topo-bathy DEMs (Figure 8) and evaluated geomorphic changes which are used in identifying dominant sediment transport pathways.

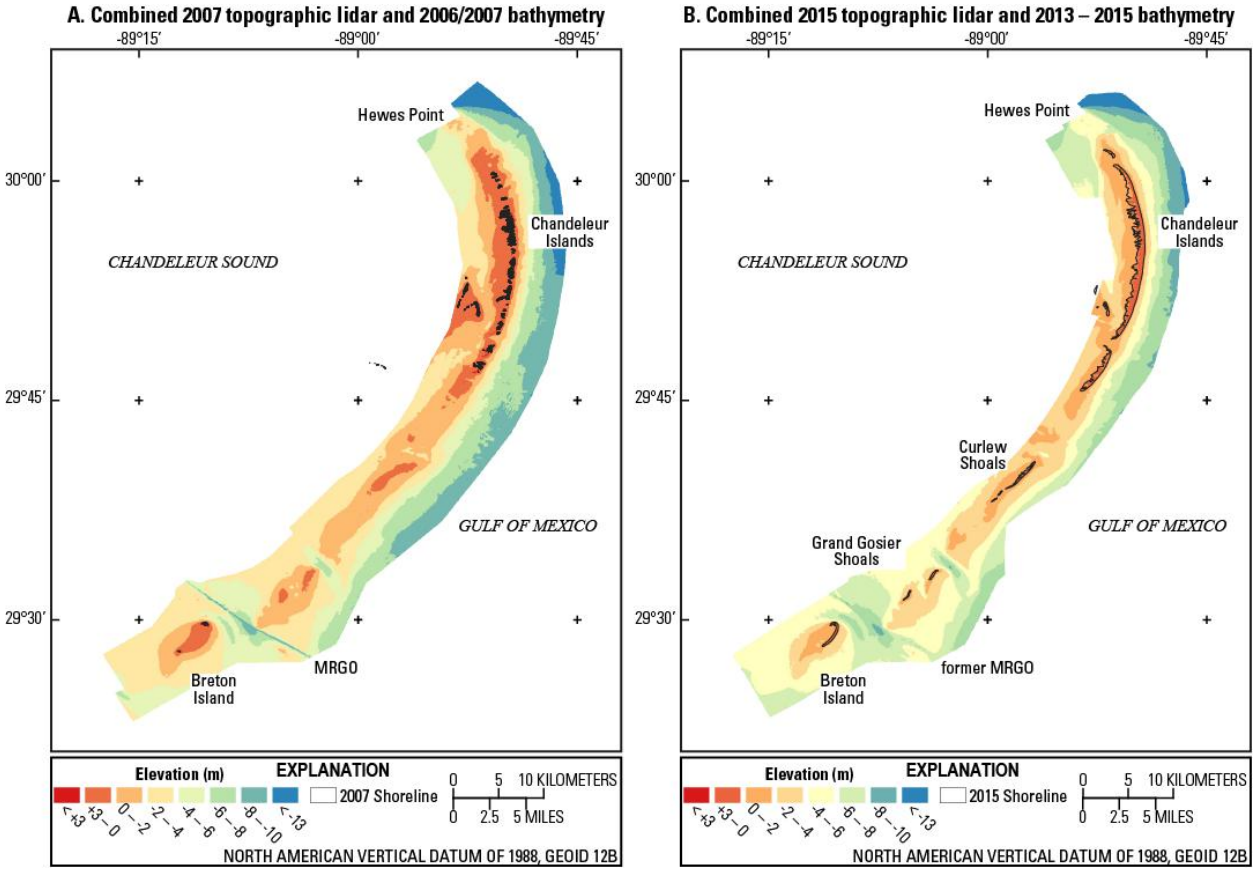

Figure 8. Topobathymetric DEM for the 2006 – 2007 (A) and 2013 – 2015 (B) time periods created by combining the topographic (LiDAR), bathymetric, and spline interpolated data points (Flocks et al. IN PRESS).

Objectives

1. Provide temporally discrete Digital Elevation Models for the Louisiana coast during various time periods by integrating topographic and bathymetric datasets
2. Document region scale changes in elevations to determine restoration impacts to barrier systems elevations, longevity, and sediment budgets.

Methods

Topographic LiDAR and single-beam bathymetry, outlined in earlier tasks, will be utilized to develop a Topographic/Bathymetric DEM (Topo-Bathy DEM) for the surveyed BICM program area (Figure 1). Topographic LiDAR and single-beam bathymetry are completely different elevation acquisition techniques, and are commonly collected at different spatial resolutions, different time periods, and referenced to different datums. There are often gaps in coverage between the shoreline derived from lidar and the water depth at which acoustic bathymetry can be feasibly recorded. As a result of these inconsistencies there is inherent vertical uncertainty when merging the two datasets (Amante, 2018). To accurately assess volumetric change time periods, datasets are integrated to produce discrete temporal DEMs. Bare earth lidar elevation datasets are integrated with bathymetric data as seamlessly as possible (figure 8). The processes may vary slightly (ACRE 2020, Flocks et al. IN PRESS, Fugro 2020), but methods are utilized to provide a realistic transition across the shoreface where sediment transport processes are

the most dynamic, and is important not only for change assessment but for hydrodynamic modeling efforts as well (Figure 9).

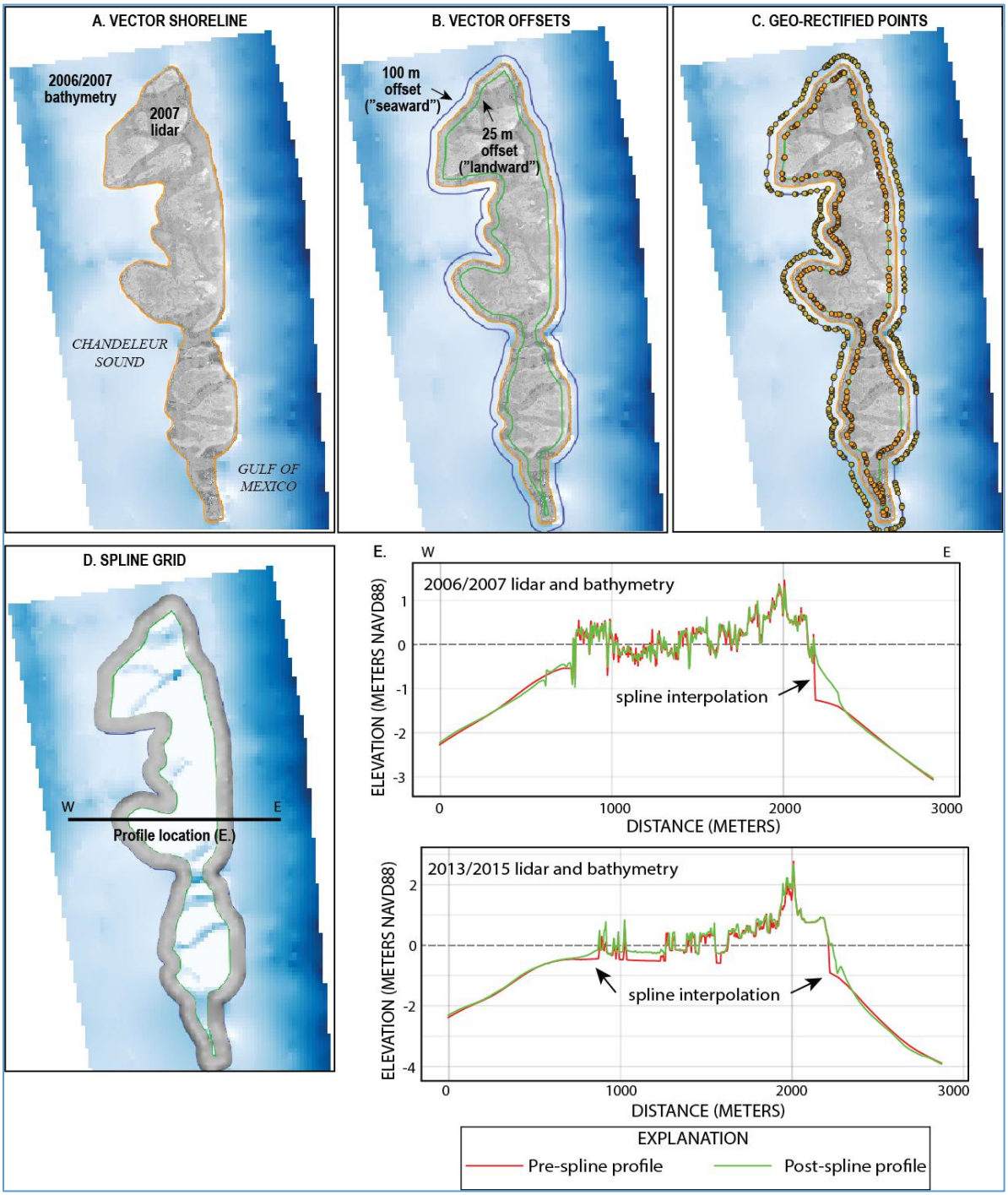

Figure 9. Visualization showing the processing steps utilized to add interpolated points across the topographic to bathymetric transition using a spline method, which resulted in a more natural representation of the transition in the resulting DEM (Flocks et al. IN PRESS).

Products

The proposed BICM cycle will produce a 1) 2021/22 integrated topo-bathy dataset within the BICM reaches (i.e., File geodatabase and metadata); 2) Topo-Bathy DEM (i.e., File geodatabase and metadata); 3) Topo-Bathy contours (i.e., File geodatabase and metadata); and 4) final methods report(s).

3.1.3.7. Sediment Characteristics Data collection and Change Analysis

Purpose

The Louisiana Coastal Zone is losing land at an alarming rate, resulting in drastic changes to shoreline positions and configurations. Shorelines along the Louisiana outer coast define the seaward geomorphic feature protecting more inland coastal habitats. Erosion, migration, and deterioration of this boundary pose a long-term impact to coastal wetland geomorphology and ecology, thereby reducing the effectiveness of this coastal system as a buffer to storm energy as well as a reduced availability of these unique barrier habitats. As such, surficial sediment characteristics for the barrier dunes, beach, shoreface, and nearshore environments of Louisiana are compiled to define the character and patterns of surficial sediments and changes within pre-defined reaches.

Grain size analysis in coastal systems is commonly used to determine the distribution of clastic sediments, provide insight into local and regional sediment transport trends, and help distinguish among geomorphic environments (e.g. dune, berm, beach face). As differences in grain size distribution do exist from the dune base, across the beach, and offshore, reported changes between environments, or within environments over time can be used to infer coastal changes, including among other things sediment transport trends. Grain-size characteristics have significant impacts on the accuracy of sediment budget calculations and modeling of cross-shore and longshore transport processes along beaches. They possess documented roles in assessing regional sediment transport pathways in conjunction with other datasets, including bathymetry and resulting seafloor change, and shoreline change analysis. These surficial sediment data points are integral components in the evaluation and assessment of restoration projects as well as programmatic mapping and sediment management efforts. As such the BICM Program provides these data for use in project assessments and other analysis, such as surficial sediment distribution mapping, sediment budget analysis, and system modeling and design.
(https://cims.coastal.louisiana.gov/Viewer/Map.aspx?guid=bfa398dc-7e8f-46e7-97a9-a38be6a36f07)

Objectives

1. Characterize the surficial sediments for the Louisiana coast during various time periods.
2. Measure the long-term and short-term changes in surficial sediment types and characteristics to determine patterns of change within coastal regions and reaches over time.

Methods

Surficial sediment samples are collected utilizing petite ponar or hand scoop grab samples along coastal Louisiana's barrier shorelines within each BICM region (Georgiou et al. 2019). The cross-shore range of environments that are sampled within each geographic location include: 1) back-barrier marsh, 2) washover platforms, 3) dune, 4) beach berm, 4) upper shoreface at the mean low water (MLW), 5) middle shoreface and 6) base of the shoreface or Depth of Closure (DoC). Across the subaerial or shallow water environments samples are taken using hand scoops, whereas in subaqueous locations a Petite Ponar sampler is deployed manually from a boat to obtain a sample with a target amount of 500 grams.

At the completion of the field sampling effort each bag of sediment is opened and visually described to characterize the type of sediment (sand, mud, shells, etc.) and the percent abundance of detrital and organic sediment present. Visual sediment characterization includes parameters such as percent sand, silt and clay, organics and shell content, sorting, and color according to a Munsell chart. From the database of visual descriptions, any sample estimated to contain at least 70% sand is quantitatively analyzed using laser particle size analyzer methods in order to quantify sediment types and grain size distributions within the samples.

The products generated by these efforts and available for use will include datasets with visual descriptions and laser analysis data of each sample, metadata, methodology reports, and maps showing the distributions and types of sediment samples that are collected. Additionally, the program compiles change analysis for the differences in grain size, sand content, sorting, skewness, and kurtosis, between comparable points from multiple time periods (Figure 10).

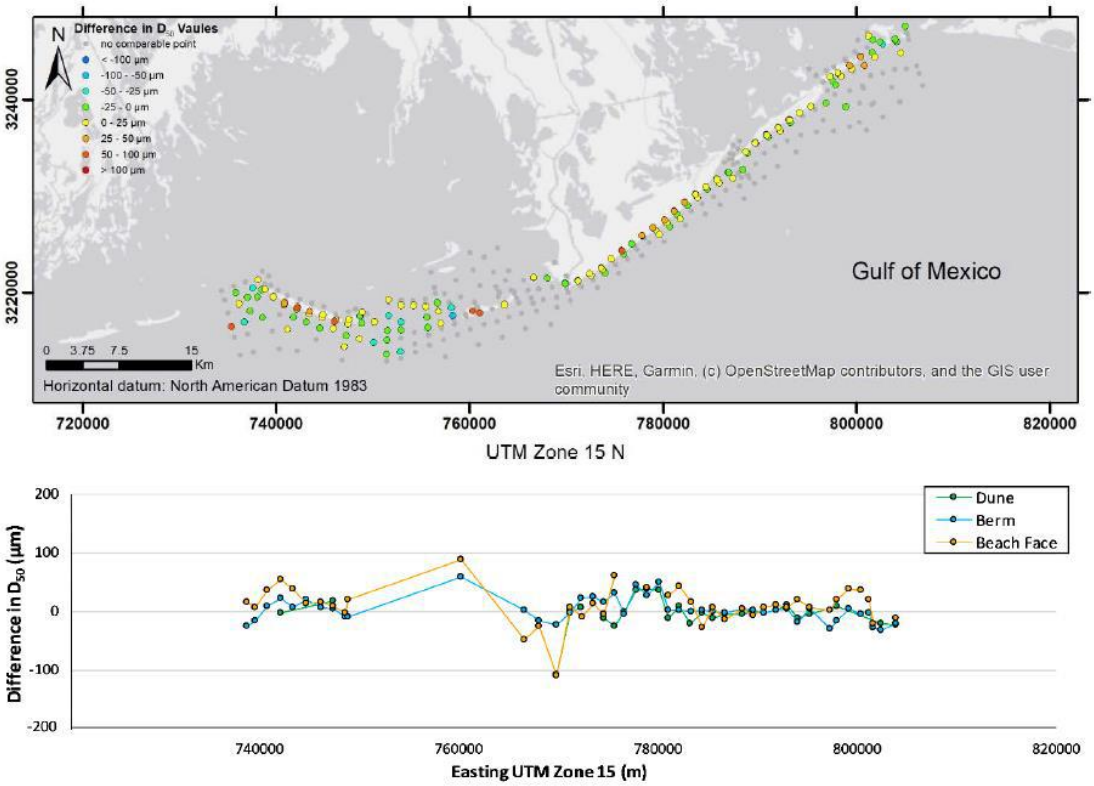

Figure 10: The difference in D_{50} along the Late Lafourche Delta from 2008 to 2015 in plan view (top) and graphically (bottom) for onshore environment (dune, berm and beach face).

Figure 10. Grain size changes along the Late Lafourche Delta region with specific changes in the Dune, Berm, and Beach face (Georgiou et al. 2019).

Products

The proposed BICM cycle will produce 1) a 2022/23 sediment sample datasets with metadata; 2) updated sediment characteristic maps; 3) a change analysis dataset and maps including metadata; and 4) a report including methods and change results.

3.1.3.8. Subsidence Monitoring

Purpose

Subsidence in south Louisiana is a fundamental process and major uncertainty influencing restoration planning and design, as well as wetland habitat resilience. Consolidation of Holocene deposits is considered the primary contributor to subsidence. Primary consolidation occurs as soil volume is reduced due to dewatering under the weight of overlying sediment. Thicker sediment deposits contain more interstitial water available for removal, which leads to high rates of subsidence as they consolidate. In addition to consolidation of the existing Holocene deposits, the deposition of large sediment volumes via restoration adds additional consolidation stress. Understanding the causes and rates of subsidence across the Louisiana coastal zone, including the barrier shoreline is critical to successful planning and implementation for State Master Plan projects.

The CRMS program is currently resurveying deep rod benchmarks. These efforts do not comprehensively cover the barrier shoreline and as such creates a missing component necessary to address an integrated subsidence program. The collection of subsidence information along the shoreline will allow the development of an additional coast-wide dataset that will facilitate future updates of the existing SWAMP subsidence effort and the development of an integrated coastal subsidence monitoring effort that includes the barrier shoreline.

Objectives

1. Monitor subsidence rates relative to the Holocene geologic framework along the Louisiana barrier system over time.
2. Document region scale subsidence rates to determine restoration impacts to barrier systems elevations, longevity, and sediment budgets.
3. Integrate barrier shoreline subsidence within the overall SWAMP program subsidence efforts.

Methods

Elevation measurements at CORS primary benchmarks and CPRA/NGS secondary benchmarks within the barrier system will be evaluated for determining subsidence velocities. Emphasis will be on reoccupying existing subsidence benchmarks already established through SWAMP subsidence efforts (ACRE 2021) as well as expanding data coverage along the gulf shoreline (Figure 11). High-resolution vertical measurements for CPRA/NGS secondary sites will be collected utilizing static GPS survey techniques by licensed surveying firms or Federal agency personnel. Additional historical raw GPS static survey datasets (RINEX files) for locations within the BICM regions will be compiled, including static GPS measurements recorded as part of this effort. Static GPS observations are recorded at existing secondary benchmarks for 14- to 28-hr durations over a period of two to four days at each benchmark. These surveys will follow protocols for data collection, processing, and adjustments for acquiring ellipsoid heights to sub-centimeter level accuracy (combined session durations ≥ 9 hours; Snay et al., 2002; Gillins et al., 2019). Separation between observation dates will be set so session observations are collected under differing atmospheric conditions and different satellite constellations. All efforts will be made to minimize potential random and systematic errors. Prior to performing static GPS observations, equipment will be calibrated for correct antenna height measurements and checked for vertical accuracy. After field surveys are completed, all survey data, raw files, and documents will be processed as described in Fenstermaker (2017) with updated subsidence rates calculated and site graphs produced.

Figure 11. Current CPRA subsidence site locations for southeastern Louisiana project area with a current scarcity of barrier shoreline sample locations (ACRE 2021).

Products

The proposed BICM cycle will produce 1) a 2022/23 high-resolution geodetic GPS elevation measurement dataset at selected CPRA/NGS secondary benchmarks with raw GPS data and metadata; 2) updated subsidence rate graphs; and 3) a survey report including methods and change results.

3.1.3.9. Overwash and Recovery Monitoring

Purpose

The Louisiana coastal Barrier islands and barrier shorelines are formed by waves, tides, and currents moving sediment as well as a function of sea level transgression. In order for barriers to retreat and be sustained during conditions of sea-level rise, sediment must be transported from the nearshore and foreshore of the barrier to the backbarrier. Processes driving this landward sediment transport include transport through tidal inlets, including those of temporary inlets cut by storms, washover of sand during storms, and aeolian transport. The importance of overwash is amplified as sea-level rise accelerates because an increased rate of transgression typically leads to more frequent overwash events.

Overwash is the process by which storm surge, wave set-up, and wave run-up cause a flow of sediment-laden water to overtop a barrier, transporting sediment to the backbarrier. Washover refers to the deposit of sediment landward of the beach caused by overwash. Coastal overwash occurs frequently and is most evident following hurricanes and winter storms. These storms produce significant shoreline

change on the barrier islands of Louisiana and the changes are magnified by the lack of sediment transported into the area. Such storms and lack of sediment have produced a northward beach-face retreat and loss of barrier island surface area. These low-lying barrier islands typically have less than 2 m (6.6 foot) elevation above mean sea level, a washover-flat topography with occasional, poorly developed, dune-terrace consisting of low broken dunes. The islands consist of salt-marsh deposits overlain by overwash sands along the Gulf of Mexico shoreline. Sand thicknesses range from zero behind the beach to less than 2 m (6.6 ft) under the berm crest, and back to zero in the first nearshore trough. Storms can strip this sand veneer from the beach face, exposing the underlying marsh deposits.

BICM will provide detailed information on overwash and recovery processes at various locations and across a spectrum of impacts over time. This effort will be used to estimate the volume of sediment lost from the shoreface and contained in selected washover fans, size and frequency of overwash. These volumes are combined with estimates of return intervals of inundation levels to better estimate the cross-shore sediment flux during the events. Additionally, continued monitoring after the event will determine the fate of these deposits, but also document any shoreface recovery. The aim in doing so is to establish how the studied section of barrier is performing in relation to a spectrum of high energy events and improve planning the design of future efforts. This information can feed project decisions as well as supplement the Operational Sediment Budget and feed decision making and modeling over time. BICM will build information on the impacts of various events and their potential to alter long-term shoreline trends.

Objectives

1. Characterize various "storm event" related impacts to specific gulf reaches over time to determine both overwash and recovery processes and impacts on system responses.
2. Determine overwash and recovery sediment elevation and volume changes along specific reaches of shoreline due to various event locations and magnitudes.
3. Provide reference information on shoreline sediment conservation of mass trends in relation to the sediment budget and individual events.

Methods

BICM will select two sections of recently impacted Gulf sandy shore per 5 yr BICM cycle and monitor several variables utilizing similar field methods as components above, including bathymetry, topography, sediment, and vegetation sampling. The collection of these datasets with the various large scale BICM datasets and any project related datasets will be utilized to determine impacts of the event on elevation, shoreline position, shoreface change, and sediment characteristics. Selection of sites will include recent dated washover deposits and new washovers as they occur and integrate with any existing project monitoring that maybe occurring. This monitoring task will use existing BICM variables along with other datasets at a higher special and temporal frequency for a few years after the event. Final development of protocols and implementation of sampling will be developed and implemented to produce a baseline methodology for the BICM program.

Once datasets have been acquired and compiled each section of shore reach monitored will be assessed and a report generated to provide greater detail on overwash and recover processes and

impacts, including volumes changes combined with estimates of return intervals of documented inundation levels to better estimate the cross-shore sediment flux during the monitored events.

Products

The proposed BICM cycle will produce 1) a series of post-event datasets with metadata on elevation, sediments, and other factors that document the changes to small sections of the sandy shoreline system, including the shoreface, 2) updated estimates of expected cross-shore sediment flux across a spectrum of events; and 3) an assessment report including methods and change results per site.

3.1.3.10. Vegetation Composition

Purpose

Barrier islands provide numerous ecosystem goods and services including storm protection and erosion control for the mainland, habitat for fish and wildlife, salinity regulation in estuaries, carbon sequestration in marshes, recreation, and tourism. These islands are dynamic environments due to their position at the land-sea interface. Storms, wave energy, tides, currents, and relative sea-level rise are powerful forces that shape barrier island geomorphology and habitats. As a result, natural resource managers are concerned with monitoring changes to vegetation communities and their relation to habitat classes on these islands.

The barrier islands of the Louisiana Gulf coast are highly dynamic systems containing a number of interrelated, but distinct, plant communities. Despite their highly dynamic setting, barrier islands and headlands exhibit characteristic vegetated habitat types due to environmental factors associated with their proximity to the open ocean. Although assessment of vegetation communities is a basic aspect of virtually all ecosystem monitoring efforts, the implementation of an efficient and effective monitoring plan for Louisiana barrier islands is challenging because of the diverse habitats occurring on barrier islands (i.e., both supratidal and intertidal), as well as the transient geomorphology of these coastal formations.

Objectives

1. Determine species composition and diversity of vegetation within major habitat types on the barrier islands.
2. Supplement remotely sensed habitat data to determine subtle changes occurring in species composition and coverage within the major habitat classes.
3. Provide reference information on plant species composition, coverage, diversity, and vigor for project evaluations.

Methods

Methods are to be finalized, but initial development of a BICM sampling protocol have been developed by Hester and Willis 2015. Basic sampling follows a stratified random design implemented within BICM reaches to determine vegetation characteristics utilizing species compositions, ocular estimations of cover, and dominant species height measurements. This sampling plan is designed to accommodate the highly dynamic nature of barrier island formations while focusing on a feasible number of highly informative metrics. The procedures for implementation of the BICM sampling plan can generally be described in the following categories: a) Review the BICM reaches and acquire the land access

rights for all sampling components, b) Generate the shoreline sections (strata) and prepare to establish initial transect and vegetation composition and cover sampling plot locations based on geo-rectified imagery, sub-aerial habitat data, and elevations, c) Implement the sampling design in the field and make any necessary adjustments to the placement of transects and plots in order to capture the basic geomorphic forms present including fore dune, dune, back-barrier swale, and intertidal wetlands, d) Perform field sampling of vegetation plots utilizing CRMS sampling procedures (Folse et al. 2018), e) QA data and enter into CIMS database for analysis and public use, and f) develop mapping/reporting products.

Final development of protocols and implementation of sampling will occur to produce a baseline dataset for the BICM reaches.

Products

The proposed BICM cycle will produce 1) a 2022/23 vegetation compositions and cover dataset with metadata; 2) updated vegetation characteristic maps/charts; and 3) a report including methods and results.

3.1.3.11 Final Report

Purpose

Final reports, similar to current BICM final reports (Kindinger et al 2013), will be developed and posted on the website and document reference system. Reports will include a compilation of datasets to ascertain general results and trends for all facets of the coast, including new conclusions, information, and recommendations for restoration efforts as well as future BICM program changes.

Objectives

1. Compile and summarize all BICM datasets.
2. Produce an integrated assessment of barrier shoreline conditions and change trends to assess restoration impacts.
3. Document lessons learned and recommend programmatic adaptive management actions for future projects as well as the BICM program.

Methods

A team lead by CPRA, and including TIG Trustee agency representatives, will collaborate to identify the content to be included in the final report and/or other synthesis products as needed to inform DWH NRDA restoration and MAM. The Program will develop and produce an integrated report. The report will be produced using CPRA personnel with contracted consultations as required. An outline will be developed and efforts will be conducted that will be finally integrated into a completed draft report. Once a draft is produced reviews will be initiated within various restoration programs such as NRDA, CWPPRA, and others. Comments will be addressed and a final document published.

Products

The proposed BICM cycle will produce 1) a comprehensive report on the status of the Louisiana Gulf of Mexico shoreline, 2) additional analysis datasets with metadata, and 3) a lessons learned and adaptive recommendations documentation.

3.1.1. Budget

A detailed budget by task and year budget, including CPRA administrative costs, can be found in Table 2. The total funding for CPRA to continue the BICM Program with support from NRDA in Louisiana for the next data collection cycle is $9,415,347.70 for 5 years. This along with project specific monitoring efforts will ensure adequate spatial and temporal coverage to properly evaluate benefits and impacts from future restoration projects and recovery from the DHWOS system-wide.

Table 2: Total cost to NRDA for BICM including CPRA's administrative costs to administer the program.

COLLECTION EFFORT	FY23	FY24	FY25	FY26	FY27
Shoreline Assessment	$ 120,000.00				$ -
Shoreline Position		$ 160,500.00		$ -	$ -
Habitat	$ -	$ 533,500.00		$ -	$ -
Bathymetry	$ 1,532,000.00	$ 505,000.00	$ 525,000.00		$ -
LiDAR	$ 800,000.00	$ -	$ -		$ -
Topo/Bathy DEM			$ 475,000.00		
Sediment	$ 185,000.00	$ 302,000.00			$ -
Subsidence	$ 63,250.00	$ 63,250.00	$ 63,250.00	$ 63,250.00	$ -
Overwash/Recovery	$ 275,000.00	$ 275,000.00			
Vegetation	$ 600,000.00	$ 600,000.00	$ -	$ -	$ -
Final Report	$ -	$ -	$ -	$ 743,000.00	
CPRA ADMIN	$ 96,360.00	$ 96,360.00	$ 96,360.00	$ 96,360.00	$ 96,360.00
MISC	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00
IDC @ 212.65%	$ 204,909.54	$ 204,909.54	$ 204,909.54	$ 204,909.54	$ 204,909.54
	$ 3,881,519.54	**$ 2,745,519.54**	**$ 1,369,519.54**	**$ 1,112,519.54**	**$ 306,269.54**
				BICM 3 =	**$ 9,415,347.70**

3.1.2. Timeline

The activities described above and in Figure 2 reflect a continuation of previous BICM cycles. This MAIP requests that FY23 and FY24 of the proposed third BICM cycle be funded by the LA TIG to aid in restoration planning and monitoring for habitats that received direct injury during the DWH oil spill. In total, the NRDA LA TIG will be enhancing the BICM Program by supporting the collection of another data collection cycle and providing additional variables identified thru adaptive management process to further restoration monitoring, both baseline and post-project, assessments for injured habitats, and management of restoration projects in Louisiana that are important ecosystem components.

3.1.3. Implementation Roles

CPRA will be the Implementing Trustee and will be responsible for coordinating with the LA TIG, providing overall direction and oversight for the MAM activity, including contract administration,

compliance, financial tracking, annual reporting, and approval of deliverables. LA TIG agencies will have the opportunity to provide technical input into development and review of the deliverables for all tasks.

CPRA as the Implementing Trustee will employ various contracting options for implementation of the proposed tasks. Contracted efforts will include field data collections, data qa/qc, data formatting and delivery, reporting, data analysis, and summarization product development as needed to provide task deliverables outlined above.

3.1.4. Data management and reporting

Data management by CPRA includes all QA/QC datasets, final reports, and graphics. These program products will be disseminated through an established CPRA internet-based portal. All final products are delivered to CPRA and will be available to CPRA, members of the LA TIG, and the public. This data storage system currently serves as the primary data storage platform for the BICM Program. All BICM Program products will also be provided concurrently to the NRDA LA TIG and made available through the LA TIG for storage and public access on the DIVER Restoration Portal (Section 10.6.5 of SOP; DWH NRDA Trustees, 2016).

The DWH Trustees, as stewards of public resources under OPA, will inform the public on the MAM activity's progress and performance. Therefore, CPRA will report the status of the proposed activity via the Data Integration, Visualization, Exploration, and Reporting (DIVER) Restoration Portal annually, as outlined in Chapter 7 of the PDARP/PEIS (DWH Trustees, 2016). All reports compiled as part of this activity will also be stored on the DIVER Restoration Portal. Data storage and accessibility will be consistent with the guidelines in Section 3.1.3 of the MAM Manual (DWH NRDA Trustees 2019). In the event of a public records request related to data and information that are not already publicly available, the Trustee to whom the request is addressed would provide notice to the other Louisiana TIG members prior to releasing any data that are the subject of the request. Some of the data collected may be protected from public disclosure under federal and state law (e.g., personally identifiable information under the Privacy Act) and therefore would not be publicly distributed.

4. Consistency of MAM Activity with the PDARP/PEIS

This MAM activity is consistent with and supports multiple programmatic goals (section 5.3) in the PDARP/PEIS, including a variety of restoration types (section 5.5) and restoration approaches (Appendix 5.D). This MAM activity supports the programmatic goals of, (1) Restore and conserve habitat; (2) Replenish and Protect Living Coastal and Marine Resources; (3) Provide and enhance recreational activities; and (4) Provide for monitoring, adaptive management, and administrative oversight to support restoration implementation. The BICM Program will support a variety of restoration types described in the PDARP/PEIS, mainly Sections 5.5.2, *Wetlands, Coastal, and Nearshore Habitats* and 5.5.15, *Monitoring and Adaptive Management*. However, the BICM Program also supports the goals of the restoration type sections of 5.5.3, *Habitat Projects on Federally Managed Lands*; 5.5.6, 5.5.8, *Submerged Aquatic Vegetation*; 5.5.10, *Sea Turtles*; 5.5.12, *Birds*; and 5.5.14, *Provide and Enhance Recreational Opportunities*. The PDARP/PEIS makes numerous references to creation and restoration of multiple habitat types, including barrier islands and dunes. The BICM Program will also provide data for monitoring and adaptive management of important resources, including determining recovery from injury during the DWH oil spill.

Therefore, the BICM Program continues to provide data for future, planned barrier shoreline maintenance in Louisiana's Coastal Master Plan, provide important resource management data and is an essential part of Operations, Maintenance, and Adaptive Management Plans (OMAM) for large-scale shoreline restoration projects in Louisiana. Below, the rationale for how this data supports and is consistent with a variety of restoration approaches found in the PDARP/PEIS appendices 5.D and 5.E. Restoration approaches listed in the PDARP/PEIS are appropriate under the Oil Pollution Act (OPA).

- Habitat Restoration Approaches (D.1)
  - Create, Restore, and Enhance Barrier and Coastal Islands and Headlands (D.1.4)
    - Barrier Islands and Headlands represent coastal landforms and habitats important to coastal stability and ecology in the Gulf of Mexico.
    - Currently NRDA has implemented several projects, including barrier island and dune restoration.
    - BICM Program data would be used to update models for project planning, act as baseline, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
  - Restore and Enhance Dunes and Beaches (D.1.5)
    - Dunes and Beaches provide important coastal habitat for shorebirds, federally listed threatened and endangered beach mice, and sea turtles among other ecosystem services.
    - BICM Program data would be used to provide information for project planning, act as baselines, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
  - Restore and Enhance Submerged Aquatic Vegetation (D.1.6)
    - Healthy SAV serves critical ecological functions in the Gulf of Mexico, including habitat and forage for fish and wildlife, decreased wave energy, soil protection, and increased sediment accretion
    - Sea Grasses in Louisiana are associated with the Chandeleur Islands which are included in the BICM Program coverage.
    - BICM Program data would be used to provide information for project planning, act as baselines, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
  - Protect and Conserve Marine, Coastal, Estuarine, and Riparian Habitats (D.1.7)
    - This approach can provide habitat connectivity across habitat types or geographic areas, and minimize habitat loss by reducing or avoiding impacts from activities such as development.
    - In addition, protecting habitats can provide public access for the use and enjoyment of the Gulf of Mexico's natural resources
    - Large sections of the Louisiana Barrier Islands and Headlands are managed through Federal or State agencies.
    - The BICM Program data would inform the conservation and preservation of these sites and provide input to restoration approaches for development and implementing management activities at restoration projects by providing data and trends, as well as pre- and post- project monitoring.
- Sea Turtle Restoration Approaches (D.4)
  - Enhance Sea Turtle Hatchling Productivity and Restore and Conserve Nesting Beach Habitat (D.4.3)

        - While limited in Louisiana, improving and maintaining the suitability of nesting beach habitat for sea turtles is important.
        - BICM Program data would be used to provide information for project planning, act as baselines, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
- Bird Restoration Approaches (D.6)
    - Restore and Conserve Bird Nesting and Foraging Habitat (D.6.1)
        - Barrier Islands and Headlands provide important habitats necessary for conserving and restoring target habitat areas or land parcels for bird resources.
        - Dunes and Beaches provide important coastal habitat for shorebirds among other ecosystem services.
        - BICM Program data would be used to provide information for project planning, act as baselines, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
- Recreational Use Restoration Approaches (D.8)
    - Enhance Public Access to Natural Resources for Recreational Use (D.8.1)
        - Barrier Islands and Headlands provide important habitats for various recreational activities
        - Maintaining and management of access and creating new or improved access to natural resources without negative impacts for recreational purposes is important.
        - BICM Program data would be used to provide information for project planning, act as baselines, construction phase and post-construction monitoring data for projects and regions, provide the ability to adaptively manage project outcomes as benefits and impacts become more clear.
- Monitoring and Adaptive Management (5.E)
    - The BICM Program would provide both project level (E.3.1) and resource level (E.3.2) monitoring
        - This coast-wide data set will provide for project specific, especially in the case of Barrier Islands and Headlands, monitoring that will "*inform restoration planning, supports the evaluation of project performance and ensures project compliance*." It will also provide feedback information in order to adaptively manage projects.
        - The coast-wide data set would also provide important resource information and "*can fulfill data and information needs for multiple projects benefitting a common injured resource, thereby promoting efficiency and consistency in data collection and restoration evaluation."*

The BICM Program activities described above will clearly address many of the key areas of restoration outlined in the PDARP/PEIS by leveraging a coast-wide, long-term data set that monitors the ecosystem that received direct injury during the DWH oil spill. The BICM Program will provide valuable data towards NRDA TIG's vision of large-scale restoration of multiple coastal and marine habitats and the ability to conduct proper monitoring and adaptive management on restoration projects and important system resources.

5. Evaluation of NEPA Evaluation

The Trustees' approach to compliance with NEPA summarized in this section is consistent with, and tiers where applicable from the PDARP/PEIS Section 6.14.4. Resources considered and impacts definitions (minor, moderate, major) align with the PDARP/PEIS. Relevant analyses from the PDARP/PEIS are

incorporated by reference. Such incorporation by reference of information from existing plans, studies or other material is used in this analysis to streamline the NEPA process and to present a concise document that briefly provides sufficient evidence and analysis to address the Louisiana TIG's compliance with NEPA (40 CFR 1506.3, 40 CFR § 1508.9). All source documents relied upon are available to the public and links are provided in the discussion where applicable.

As discussed in Chapter 6 of the PDARP/PEIS, a TIG may propose funding a planning phase (e.g., initial engineering, design, and compliance) in one plan for a conceptual project, or for studies needed to maximize restoration planning efforts. This would allow the TIG to develop information needed leading to sufficient project information to develop a more detailed analysis in a subsequent restoration plan, or for use in the restoration planning process. Where these conditions apply and activities are consistent with those described in the PDARP/PEIS, NEPA evaluation is complete and no additional evaluation of individual activities is necessary at this time.

5.1. NEPA Review of MAM Activity

Consistent with the impacts considered in the PDARP/PEIS, this activity would include minimally intrusive field activities and data-based activities. These activities will include aerial overflights; bathymetric data collection utilizing various vessels equipped with integrated GPS receivers, high resolution echo-sounder systems, and real-time dynamic motion sensors; topographic surveying and LiDAR data collections; sediment sampling by hand or petite ponar dredge; and vegetation cover estimation and height measurements. Temporary impacts to the biological and physical environment could include short-term, temporary disturbance of habitats and species; and minor disturbance to terrestrial, estuarine and marine environments through the use of a variety of gear types that may temporarily disturb vegetation, sediments, and benthic habitats during sampling.

Analysis of the data collected, planning meetings, and preparation of reports are data-based components of this activity.

Consistent with the analysis in Section 6.4.14 of the PDARP/PEIS, environmental consequences would be direct, short-term, minor impacts through the associated field work. The data gathered would provide critical data on the population status of a variety of important habitats and that were injured in the DWH oil spill as well as important baseline and MAM data for future large-scale restoration initiatives in Louisiana.

CPRA has years of experience in this type of data collection and have developed a thorough program for these types of sampling. Previous data collection activities have developed reports that include methodologies and results. Based on review of the proposed activities against those actions previously evaluated in the PDARP/PEIS, no additional NEPA evaluation is likely necessary.

NEPA Conclusion

After review of the proposed activities against those actions previously evaluated in the PDARP/PEIS, the Louisiana TIG determined that the environmental consequences resulting from this MAM activity falls within the range of impacts described in Section 6.4.14 of the PDARP/PEIS, thus no additional NEPA evaluation is necessary at this time.

6. Compliance with Environmental Laws and Regulations

Technical assistance with appropriate federal regulatory agencies is complete for the proposed activities described in this BICM MAIP. See table 1 below for the status of compliance by statute, at the time of this MAIP.

The LA TIG Trustees agree that all applicable consultations and regulatory compliance activities must be completed and appropriately documented prior to utilizing LA TIG MAM funds to undertake these BICM activities and that the terms and conditions of all federal and state permits must be complied with in the course of implementing these BICM activities. Federal environmental compliance responsibilities and procedures follow the Trustee Council Standard Operating Procedures (SOP), which are laid out in Section 9.4.6 of that document. Following the SOP, the Implementing Trustees for each activity will ensure that the status of environmental compliance (e.g., completed vs. in progress) is tracked through the Restoration Portal.

Table 1. Status of federal regulatory compliance reviews and approvals for the proposed BICM MAM project.

Federal Statute	Compliance Status
Bald and Golden Eagle Protection Act (USFWS)	In Progress
Coastal Barrier Resources Act (USFWS)	In Progress
Coastal Zone Management Act	In Progress
Endangered Species Act (NMFS)	Complete
Endangered Species Act (USFWS)	In Progress
Essential Fish Habitat (NMFS)	Complete
Marine Mammal Protection Act (NMFS)	Complete
Marine Mammal Protection Act (USFWS)	In Progress
Migratory Bird Treaty Act (USFWS)	In Progress
National Historic Preservation Act	In Progress
Rivers and Harbors Act/Clean Water Act	N/A
National Environmental Policy Act	Complete, in NEPA analysis section above

Documentation of regulatory compliance will be available in the Administrative Record that can be found at the DOI's Online Administrative Record repository for the DWH NRDA (https://www.doi.gov/deepwaterhorizon/adminrecord). The current status of environmental compliance can be viewed at any time on the Trustee Council's website: http://www.gulfspillrestoration.noaa.gov/environmental-compliance/.

7. Activity Close Out

In accordance with Section 9.5.1.6 of the TC SOPs, the Implementing Trustee shall provide the LA TIG with a closeout report after all activities and expenditures have been accomplished. The Final Report shall include a description and any documentation of the completed activity, estimated benefits to natural resources, the final funding balances and any transfers described in Section 7 of the TC SOPs, a summary of the results of monitoring, and any recommendations on adaptive management for the activity. Upon request, the Implementing Trustee shall provide the LA TIG with additional information and supporting documents to complete the closeout report.

8. Literature Cited

Amante, C., 2018, Estimating coastal digital elevation model uncertainty, Journal of Coastal Research, v. 34, p. 1382 – 1397, accessed 10/29/20, at https://doi.org/10.2112/JCOASTRES-D-17-00211.1

Applied Coastal Research and Engineering (ACRE), 2020. Louisiana Operational Sediment Budget: Raccoon Point to Sandy Point, 1985-89 to 2013-16. Final Report prepared for Louisiana Coastal Protection and Restoration Authority, Contract 4400009020, Task 5, 118 p. plus appendices

Applied Coastal Research and Engineering (ACRE), 2021. Recent Subsidence Trends for Southeastern Louisiana Derived from Static GPS Measurements at Primary and Secondary Benchmarks. Final Report

prepared for Louisiana Coastal Protection and Restoration Authority, Baton Rouge, LA. 56 p. plus appendices.

Byrnes, M.R., J.L. Berlinghoff, S.F. Griffee, and D.M. Lee. 2018. Louisiana Barrier Island Comprehensive Monitoring Program (BICM): Phase 2 – Updated Shoreline Compilation and Change Assessment, 1880s to 2015. Prepared for Louisiana Coastal Protection and Restoration Authority (CPRA) by Applied Coastal Research and Engineering, Mashpee, MA and Metairie, LA, 46 p. plus appendices.

CPRA. 2017a. Louisiana's Comprehensive Plan for a Sustainable Coast. Coastal Protection and Restoration Authority. 184 pp. http://coastal.la.gov/wp-content/uploads/2017/04/2017-Coastal-Master-Plan_Web-Single-Page_CFinal-with-Effective-Date-06092017.pdf

DWH Trustees. 2016. Deepwater Horizon oil spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Deepwater Horizon (DWH) Natural Resource Damage Assessment Trustees Retrieved from http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan

DWH Trustees. 2017. Monitoring and Adaptive Management Procedures and Guidelines Manual Version 1.0. Appendix to the Trustee Council Standard Operating Procedures for Implementation of the Natural Resource Restoration for the DWH Oil Spill. December. Available: http://www.gulfspillrestoration.noaa.gov/.

Enwright, N.M., Borchert, S.M., Day, R.H., Feher, L.C., Osland, M.J., Wang, L., and Wang, H., 2017, Barrier island habitat map and vegetation survey—Dauphin Island, Alabama, 2015: U.S. Geological Survey Open-File Report 2017–1083, 17 p., accessed September 5, 2018, at https://pubs.usgs.gov/of/2017/1083/ofr20171083.pdf

Enwright, N.M., SooHoo, W.M., Dugas, J.L., Conzelmann, C.P., Laurenzano, C., Lee, D.M., Mouton, K., and Stelly, S.J., 2020, Louisiana Barrier Island Comprehensive Monitoring Program—Mapping habitats in beach, dune, and intertidal environments along the Louisiana Gulf of Mexico shoreline, 2008 and 2015–16: U.S. Geological Survey Open-File Report 2020–1030, 57 p., https://doi.org/ 10.3133/ ofr20201030.

Fearnley, S., Brien, L., Martinez, L., Miner, M., Kulp, M., and Penland, S., 2009, Chenier Plain, South-Central Louisiana, and Chandeleur Islands, Habitat mapping and change analysis 1996 to 2005, Part 1—Methods for habitat mapping and change analysis 1996 to 2005—Louisiana Barrier Island Comprehensive Monitoring Program (BICM) 5: New Orleans, University of New Orleans, Pontchartrain Institute for Environmental Sciences, 11 p.

Fenstermaker, 2017. Surveying and Analysis Services – Barataria Basin Area CORS and Benchmark Subsidence Study using Static GPS Observations. C.H. Fenstermaker & Associates Final Report to Louisiana Coastal Protection and Restoration Authority (CPRA), Baton Rouge, LA, 1,377 p

Flocks J.G., Forde, A.S., and Bernier, J.C. 2022. Louisiana Barrier Island Comprehensive Monitoring Program 2015-2020. Chandeleur Islands to Breton Island Bathymetric and Topographic Datasets and Operational Sediment Budget Development: Methodology and Analysis Report. U.S. Geological Survey Open-File Report 2022–1020, 48 p., https://doi.org/10.3133/ofr20221020.

Folse, T.M., Sharp, L.A., West, J.L., Hymel, M.K., Troutman, J.T., McGinnis, T.E., Weifenbach, D., Boshart, W.B., Rodrigue, L.B., Richardi, D.C., Wood, W.B., and Miller, C.M., 2008, revised 2018. A Standard Operating Procedures Manual for the Coast-wide Reference Monitoring System-Wetlands: Methods for Site Establishment, Data Collection, and Quality Assurance/Quality Control. Louisiana Coastal Protection and Restoration Authority. Baton Rouge, LA. 226 pp.

Fugro, 2020. Topographic and Bathymetric Analysis: Cheniere Ronquille (BA-0076) & Shell Island West (BA-0111). Prepared for Louisiana Coastal Protection and Restoration Authority by Fugro, Lafayette, LA. 28. p

Georgiou, I.Y., Yocum, T.E., Amos, M.L., Kulp, M.A., Flocks, J., 2019. Louisiana Barrier Island Comprehensive Monitoring Program 2015-2019 Coastal Surface-Sediment Characterization Analysis: Methods and Results. Prepared for the Louisiana Coastal Protection and Restoration Authority (CPRA), Pontchartrain Institute for Environmental Sciences, University of New Orleans, New Orleans, LA, 38pp.

Gillins D. T., D. Kerr and B. Weaver, 2019. Evaluation of the Online Positioning User Service for Processing Static GPS Surveys: OPUS-Projects, OPUS-S, OPUS-Net, and OPUS-RS. Journal of Surveying Engineering, 145:(3). https://doi.org/10.1061/(ASCE)SU.1943-5428.0000280

Hester, M. W. and Willis, J.M. 2015. Proposed Standard Operating Procedures Manual for Louisiana Barrier Island Plant Communities Sampling. Prepared for Louisiana Coastal Protection and Restoration Authority (CPRA) by Institute for Coastal and Water Research, Coastal Plant Ecology Lab, Department of Biology, University of Louisiana – Lafayette, Lafayette LA. 22 p.

Kindinger, J.L., Buster, N.A., Flocks, J.G., Bernier, J.C., and Kulp, M.A. 2013. Louisiana Barrier Island Comprehensive Monitoring (BICM) Program Summary Report: Data and Analyses 2006 through 2010: U.S. Geological Survey Open-File Report 2013–1083, 86 p.

List, J.H., Jaffe, B.E., Sallenger, A.H., Williams, S.J., McBride, R.A., and Penland, S., 1994, Louisiana barrier island erosion study: Atlas of seafloor changes from 1878 to 1989: U.S. Geological Survey and Louisiana State University, Miscellaneous Investigations Series I–2150–A, 81 p.

Snay RA, T. Soler, and M. Eckl, 2002. GPS precision with carrier phase observations: Does distance and/or time matter? Professional Surveyor, 22(10): 20-24.

Stalk, C.A., DeWitt, N.T., Bernier, J.C., Kindinger, J.G., Flocks, J.G., Miselis, J.L., Locker, S.D., Kelso, K.W., and Tuten, T.M., 2017, Coastal single-beam bathymetry data collected in 2015 from the Chandeleur Islands, Louisiana: U.S. Geological Survey Data Series 1039, https://doi.org/10.3133/ds1039.

Westphal, K. 2018. Louisiana Barrier Island Comprehensive Monitoring Program (BICM) Phase 2 – 2017 Oblique Aerial Photo Assessment of the Louisiana Barrier Shoreline. Prepared for CPRA by UNO – PIES, New Orleans, LA. 76 p. https://cims.coastal.la.gov/RecordDetail.aspx?Root=0&sid=21693