An Approach to Identifying Environmental and Socio-Economic Performance Measures for Coastal Louisiana

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Acronyms

BFE	Base Flood Elevation
BTNEP	Barataria-Terrebonne National Estuary Program
BICM	Barrier Island Comprehensive Monitoring Program
CPRA	Coastal Protection and Restoration Authority
CORS	Continuously Operating Reference Stations
CRMS	Coast-wide Reference Monitoring System
DEQ	Department of Environmental Quality
FEMA	Federal Emergency Management Agency
FIM	Fisheries-Independent Monitoring
FQI	Floristic Quality Index
ICC	International Code Council
InSAR	Interferometric Synthetic Aperture Radar
LACPR	Louisiana Coastal Protection and Restoration
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
LIDAR	Light Detection and Ranging
LUMCON	Louisiana Universities Marine Consortium
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
QA/QC	Quality Assurance and Quality Control
SI	Spatial Integrity
SWAMP	System-Wide Assessment and Monitoring Program
TM	Thematic Mapper
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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Background

The Water Institute of the Gulf is working with the Coastal Protection and Restoration Authority (CPRA) to develop a programmatic Adaptive Management Framework to guide Louisiana's coastal restoration and protection program. An integral part of this effort is identifying performance measures to serve as indicators of the state's ability to fulfill the 2012 Coastal Master Plan's goals of restoration and protection while supporting the plan's multifaceted objectives.

The purpose of this report is to provide recommendations on key environmental and socio-economic performance measures that reflect the goals of CPRA and are relevant to coastal Louisiana. This report also identifies current data gaps and recommends monitoring strategies for performance measures that currently lack data-collection efforts. Two workshops were held with local, natural- and built-system experts to assist in this effort. Details regarding the workshops and the full suite of measures discussed can be found in Appendices I and II.

Approach

An integral component of Adaptive Management is the use of performance measures (also known as performance metrics or indicators) to track the progress towards meeting management goals and objectives. When monitored over time, performance measures can help reduce uncertainty surrounding predictive models and inform whether intended results are being achieved or if additional action is needed to fulfill program expectations. In addition to adaptive management, performance measures can also be used to inform the public of the system's response to management actions and overall health. Defining the health of a system is inherently complex, however, and requires a systematic approach to develop a manageable list of metrics that can be quantified and monitored over time.

Numerous efforts have sought to develop approaches for selecting performance measures and most primarily focus on the environmental or ecological health of the system (Harwell et al. 1999, Doren et al. 2009, Gunther and Jacobson 2002, NRC 2000). Characteristic of these approaches is the use of conceptual models that aim to capture relationships among complex ecological systems and their components. These models are used for identifying important attributes of the system (e.g. species diversity, sediment budget, water quality; Young et al. 1998) and can help guide the selection of performance measures. Carignan and Villard (2002) developed a list of desirable characteristics that may also assist in the identification of indicators:

- Ability to provide early warning of responses to impacts;
- Indicates cause of change rather than existence of change;
- Can assess a wide range and intensity of stresses (e.g., will not level off at certain thresholds);
- Cost-effective to monitor.

Once the performance measures have been selected, the necessary data to calculate the performance measure must be specified and evaluated to determine if monitoring is in place to generate the data. Monitoring typically has several goals: to bound natural variability, to assess temporal and spatial changes, to determine significant changes, and to provide necessary information for decision-making (Chapman 2012).

It is important to distinguish monitoring data separately from the performance measure. Monitoring data are used to track individual components of the system (e.g., water level, acres of wetland, etc.) while the performance measure is a synthesis of the monitoring data to evaluate system response to management actions (or inactions). The performance measure may be a compilation of several types of data and reported as an index, average, or time-series, for example, and scaled to a geographic area and time frame. Consequently, the accuracy and suitability of the performance measure is highly reliant on the quality of data collected.

Using these approaches as a guide, a suite of performance measures were identified for coastal Louisiana. A key aspect of this assessment was the inclusion of both environmental and socio-economic measures. The environmental measures reflect the master plan's objectives of providing coastal habitats and promoting use of the system's natural processes for restoration, while the socioeconomic measures reflect the objectives of reducing flood risk, ensuring a sustainable economy, and preserving Louisiana's cultural heritage.

Performance Measures for Coastal Louisiana

Two workshops were held with local system experts to identify and describe key performance measures to support adaptive management of the 2012 Coastal Master Plan. Workshop attendees were asked to identify important environmental and socio-economic attributes of coastal Louisiana that reflect the five objectives of the Master Plan. Performance measures were then developed for each of the attributes and evaluated against the following list of criteria:

- Natural variability should be distinguishable from the measure's response to program implementation (signal to noise ratio). This often requires long-term data collection and a clear understanding of factors that influence the measure.
- Clear expectation of the response time (rapid versus delayed) to action or no action is needed in order to accurately assess program performance.
- Response should be reliable and interpretable so that management decisions can easily be made.
- Data monitoring for the measure should be economically feasible and easy to implement.
- The measure must be relevant to CPRA and be scientifically defensible.
- The scale of the measure should be considered and appropriately applied.

Environmental Performance Measures

Environmental performance measures were developed to reflect the 2012 Coastal Master Plan's objectives of preserving coastal habitats and harnessing the natural processes of the system. A suite of attributes were identified that fit into six broad environmental categories: land quantity, landscape quality, landscape sustainability and resilience, geophysical processes, water quality, and faunal abundance and diversity (Appendix I – Table 1). For each of the attributes, performance measures were identified and evaluated against the criteria above (see Appendix I - Table 2 for criteria evaluation). A subset of those measures considered most relevant was selected for further evaluation in this report and is described in the summary table below (Table 1). The rationale behind each measure and additional monitoring methodology follows in the next section.

Table 1. Summary of main performance measures, definition[1], current monitoring, and data gaps.

Category	Performance Measure	Definition	Monitoring	Data Gaps
Land Quantity	Land Area	Change in land over time	CRMS, USGS	None identified.
	Fragmentation	Indicates the amount of fragmentation or patchiness in the landscape (Spatial Integrity Index).	None identified.	Fragmentation is not directly monitored but spatial imagery is available through USGS and may be used to calculate fragmentation.
	Rate of Shoreline Position Change	Lateral shoreline change for barrier islands and marshes	None identified.	Shoreline change is not currently being monitored but data are available to calculate measurement.
Landscape Quality	Forest Flooding Duration	Depth of water and duration of flooding in forested swamps	CRMS, USGS	InSAR and remotely sensed data are needed to monitor areas where gauges are unavailable.
	Floral Diversity	Used to track the distribution of species (Floristic Quality Index)	CRMS, USGS, USDA, BTNEP	Rapid assessment program is needed to survey presence/absence of invasives.
	Carbon Storage	Quantity of carbon stored or accumulated	None identified.	Additional research is needed to understand carbon sequestration.
Geophysical Processes	Salinity Regimes	Change in mean salinity over time	USGS, CRMS, LDWF	None identified.
	Sediment Input	Sediment input into the estuary (tonnes per year)	USGS	Improved data collection effort to measure sediment input at multiple river depths.
	Elevation	Elevation relative to water depth	Tide gauge, CORS	More CORS stations; Marsh field surveys; LIDAR
Water Quality	Nitrogen	Change in nitrogen concentration over time	DEQ	Additional stations near diversion sites.
	Dissolved Oxygen	Change in dissolved oxygen concentration over time	LDWF, LUMCON, DEQ	Additional stations near diversion sites.

[1] The statistic reported for each performance measure (e.g., mean) in this document serves as an example and upon further evaluation and input from experts, may be revised in order to accurately represent the response to program implementation. A rigorous set of analytical procedures will need to be established for each metric to ensure accurate calculation of the appropriate statistic. Additional information regarding the refinement of the performance measures can be found at the end of this document under Next Steps.

Category	Performance Measure	Definition	Monitoring	Data Gaps
Faunal Abundance and Diversity	Nekton Abundance	Change in the distribution and abundance of recreationally and commercially important species over time (CPUE)	LDWF	Supplemental surveys near project sites. Zooplankton surveys should be implemented.
	Nekton Diversity	Diversity indices to track changes in nekton diversity over time	LDWF	Supplemental surveys near project sites.
	Wildlife Abundance	Change in abundance of nesting shorebirds, colonial nesting birds, or threatened/endangered species over time	National Audubon Society, LDWF, BTNEP	Annual coast-wide surveys should be conducted for key species, such as the Piping Plover or the Brown Pelican.

Land Quantity

Land Area

Louisiana has lost more than 1,880 square miles of land[2] since the 1930s. As a result, the main focus of most (if not all) restoration projects has been building new land and sustaining those lands that still exist. Change in land and water area over time reflects both land gain and the conversion to open water. As part of the Coastwide Reference Monitoring System (CRMS), satellite imagery (e.g., Landsat Thematic Mapper (TM) multi-spectral imagery) is acquired every three years for regional assessment of changes in land and water distribution (Folse et al. 2012). In concert with these efforts, the U.S. Geological Survey conducts landscape analysis to look at land cover changes and document land loss. However, localized, micro-scaled measurements can be costly and difficult to do over large areas. Scaling-up the measurement to the coast is difficult using high resolution (sub-meter) imagery, but is commonplace using 30m resolution TM imagery.

Fragmentation (Spatial Integrity Index)

Spatial integrity relates to the stability or sustainability of the landscape. A fragmented landscape has less spatial integrity than a landscape with fewer patches. The Spatial Integrity (SI) Index was used by the Louisiana Coastal Protection and Restoration (LACPR) in 2007 to classify both the amount of area occupied by water and the spatial configuration of land and water patches within a defined area. Although the SI index has previously been used, it can be difficult to calculate over large spatial scales using high resolution imagery and is also dependent upon the grid area size for analysis. Currently, USGS acquires satellite imagery for calculating land area change over time, and this imagery can also be used for the SI. However, the SI index assumptions and methodologies need further validation and testing.

Rate of Shoreline Position Change

Tracking lateral shoreline change over time (meters per year) should be separated for marshes and barrier islands because of differences in the underlying dynamics that cause these groups to change. Rate of shoreline change can be tracked by interpreting historical satellite imagery and tracking position through time. The USGS has generated shoreline change maps for barrier islands in the past and the Barrier Island Comprehensive Monitoring Program (BICM) evaluated shoreline change for barrier islands

[2] Land refers to natural landscape features including barrier islands, ridges, and wetlands.

up to 2005. Shoreline change in marshes is not currently being monitored, although data are available to support such an effort.

Landscape Quality

Floral diversity and richness

The quality of the landscape is reflected in its ability to support diverse vegetative communities. Diversity of marsh types or number of species present (e.g., richness) can be tracked over time but is highly dependent on the scale of measurement. The CRMS network quantifies herbaceous marsh and forested swamp vegetation composition at the local (individual site) scale on an annual basis and tracks if marsh types (e.g., fresh, intermediate, brackish, saline) change over time. Land use/land cover maps have also been generated by USGS, although analysis typically focus on saline, brackish, intermediate, and freshwater marshes, as opposed to individual species. No data gaps were identified for this measure.

Forest Flooding Duration

Forest regeneration is dependent upon water depth and duration of flooding. Seedlings are unable or unlikely to germinate in permanently flooded conditions. The USGS and CRMS networks have stations located in forested areas. Water depth is tracked in these locations and can be used to track length of time an area is inundated. Interferometric Synthetic Aperture Radar (InSAR) has also been used to detect relative water level changes in swamp forests in Louisiana, and is particularly useful for monitoring water conditions in areas where gauge networks are lacking (Kim et al. 2009). Acquiring remotely sensed data would allow for further testing of InSAR methods.

Distribution of Invasive Species

Introductions and spread of exotic species can lead to negative impacts on native communities. A Floristic Quality Index can be used to track the distribution of exotic plants. It scores species based on their tolerance to disturbance and fidelity to a habitat, but can be customized to classify species that are exotic or invasive (Cretini et al. 2011). Several agencies conduct species-specific monitoring of exotics, including the USGS monitoring of apple snails, USDA APHIS monitoring of the big cactus moth, and LSU Agricultural Center and LDWF monitoring of *Salvinia*. In general, species-specific monitoring is motivated by agency or public interest. The Barataria-Terrebonne National Estuary Program (BTNEP) and the University of New Orleans (UNO) is currently developing an Early Response/Rapid Response program that will train field agents from various state and federal agencies to identify new exotic invasions and report them. Another option for monitoring invasive species is a Rapid Assessment Program which consists of intense field surveys of specific sites for presence/absence of invasives, conducted every five years. There is currently not a Rapid Assessment Program in Louisiana, although the Louisiana Aquatic Invasive Species Task Force submitted a management plan in 2005 which may serve as a useful guide for implementing an invasive species monitoring program[3].

Carbon Storage

Carbon accumulation (e.g., grams m^{-2} yr^{-1}) or change in carbon storage (e.g., change in tonnes per year) is difficult to monitor and little is known about carbon sequestration in Louisiana. Further research is needed to understand the implications of wetland loss on carbon storage.

[3] http://is.cbr.tulane.edu/docs_IS/Louisiana-AIS-Mgt-Plan.pdf

Geophysical Processes

Salinity Regimes

Salinity regimes can be tracked by monitoring changes in salinity over time (weeks to years), but its use as a performance measure is dependent upon the spatial scale of the measurement. Salinity is monitored through USGS and CRMS gauges and the Louisiana Department of Wildlife and Fisheries inshore Fisheries-Independent Monitoring (LDWF FIM) program. These gauges may be sufficient for coast-wide assessments but additional monitoring stations would be needed for higher resolution tracking of salinity changes.

Sediment Input

Sediment input into the estuary (tonnes per year) can be tracked by isokinetic suspended-sediment samplers to get sediment concentration. Suspended sediment load (tonnes per time interval) can then be calculated by multiplying sediment concentration by diversion discharge. The USGS uses isokinetic depth-integrated sampling protocols to measure river sediment loads up to 12 times a year. An improved data collection effort would measures sediment input at diversion outfall sites and integrate sampling at multiple water depths.

Elevation

Elevation relative to water depth is important for understanding the impacts of sea level rise on coastal land. Elevation change is currently monitored through long-term tide gauge stations and Continuously Operating Reference Stations (CORS). The CORS are fixed, high-vertical-accuracy, global positioning system (GPS) stations that record elevation in real time, and over several years allow quantification of trends in elevation change at the site. Additional CORS stations would improve estimates of subsidence and calculations of elevation change. Field surveys using real-time kinematic and static GPS instruments that are referenced to the CORS network could also be conducted to create a comprehensive network of elevations across the coast. Light Detection and Ranging (LIDAR) data has been collected by the U.S. Geological Survey and Army Corps of Engineers for limited areas of the Louisiana coast, including the Isles Dernieres, Timbalier Island, Grand Isle, Breton Islands, Chandeleur Islands, Central Wetlands near Lake Borgne, and other areas of southeast Louisiana.

Water Quality

Water quality is important for oyster bed health, fisheries, and vegetation growth and production. During the workshop, water quality was identified as an important attribute, but no clear consensus was established on how water qulaity should be quantified. Nitrogen and dissolved oxygen concentration were suggested, but it was recognized that the ability to detect change (signal-to-noise ratio) is very low, particularly for dissolved oxygen.

Nitrogen Concentration

Increases in nutrient loading can create algal blooms and lead to hypoxic conditions. Change in nitrogen concentration (parts per million) before and after a diversion could be tracked to determine if water quality conditions are deteriorating or improving. The Department of Environmental Quality (DEQ) collects monthly samples and performs laboratory analysis for nitrogen concentration (and several other parameters). Additional stations may be needed, particularly near proposed diversion sites to accurately assess water-quality conditions.

Dissolved Oxygen

Another parameter frequently used to represent water quality is dissolved oxygen concentration. It is monitored through Louisiana Department of Wildlife and Fisheries' Fisheries Independent Monitoring program (LDWF FIM), some LUMCON stations, and Department of Environmental Quality. Additional

stations may be needed, particularly near proposed diversion sites to accurately assess water quality conditions.

Faunal Abundance and Diversity

The coastal habitats of Louisiana provide valuable breeding, spawning, feeding and nursery grounds for commercially and recreationally important fisheries and shellfish. They also serve as critical stopping grounds for Neotropical migrants and waterfowl, and support threatened and endangered species such as the brown pelican and bald eagle. There was strong group consensus on the use of fisheries-independent monitoring data to assess the distribution and abundance of nekton, but quantifying wildlife diversity was less certain. For instance, bird surveys are highly impacted by "noise" and attributing changes in abundance to program implementation will be very difficult.

Nekton Abundance

Change in the distribution and abundance of commercially and recreationally important species can be tracked with the LDWF FIM Program. This dataset can be used to track changes in community composition as well as individual species of interest. The LDWF FIM program uses several gear types to collected finfish, shellfish, and other marine organisms. The program should be expanded with additional sampling near proposed project sites.

Nekton Diversity

The LDWF FIM dataset can also be used to derive a variety of diversity indices. As previously mentioned, the LDWF FIM program uses several gear types to collect finfish, shellfish, and other marine organisms. The program should be expanded with additional sampling near proposed project sites.

Wildlife Abundance

Nesting shorebirds on beaches and barrier islands, colonial nesting birds, resident marsh birds, bald eagles or brown pelicans were identified as potential indicators of wildlife abundance in coastal Louisiana. Currently, BTNEP is conducting numerous Piping Plover surveys on the Caminada Headland including Fourchon Beach to West Belle Pass. They have also proposed an additional BTNEP breeding bird survey in Barataria-Terrebonne Basins, and possibly the entire coastal area for Wilson's Plover, snowy plover, American oystercatch, and least tern. This would allow for comparison to existing surveys conducted in 2005, 2010, and 2011. However, funding is currently not available to support this survey. In general, improvements in monitoring (e.g., more transects) could improve birding datasets and address the signal-to-noise ratio concern.

Socio-Economic Performance Measures

Socio-economic performance measures were developed to reflect the 2012 Coastal Master Plan's objectives of reducing flood risk, to support the coast's unique cultural heritage, and to provide a viable working coast that supports businesses and industries. A suite of socio-economic attributes were identified that fit into four broad categories: resilient community, robust and resilient economy, quality of life, and reduced flooding and damages (Appendix II – Table 1). Using the established criteria above, several measures were recommended for each of the attributes (Appendix II – Table 2), but general consensus on which measures to use in Adaptive Management or report cards was not reached. As a result, a subset of those measures considered most relevant were selected for further evaluation in this report and are described in the summary table below (Table 2). The rationale behind each measure follows in the next section.

Table 2. Summary of main performance measures identified, definition, current monitoring, and data gaps.

Category	Performance Measure	Definition	Monitoring	Data Gaps
Resilient Community	Time to Return Home/Work	Following a storm or event, time it takes to return to "normal" daily activities	Variable; Specific to individual events	Utility monitoring data, return rates for households.
	Operation of Critical Infrastructure	Telecommunications; electrical power; transportation; water supply; emergency services; continuity of government	Variable; Specific to individual events	Tracking and monitoring availability of these services during storm events.
	Population per Community	Number of residents per community by age and cultural group	U.S. Census Bureau	None identified.
	Unemployment Rates	Unemployment rates per city or change in rate over time	Bureau of Labor Statistics	None identified.
Quality of Life	Cost of Living	Index used to compare cost of living differences among urban area	Council for Community and Economic Research	Limited to certain cities.
	Natural Resources Available to Communities	Fish and shellfish abundance.	LDWF FIM	None identified.
	Flood Insurance	Number of insurers, number of policies, or number of people insured	NFIP; FEMA	None identified.
	Outdoor Recreation	Fishing and hunting licenses; boat ramps; trail access or number of trails	LDWF	None identified.
Resilient and Robust Economy	Housing Sales	Housing sales and per capita income	U.S. Census Bureau's Economic Database	Data available every 10 years, although more frequent data may be available to researchers.
	Continuity of Economic Activity	Small business and enterprise statistics and economic indicators	U.S. Census Bureau's Economic Database	None identified.
	Commerce	Waterborne, oil and gas, agriculture, commercial fisheries	USACE Waterborne Commerce Statistics Center, NOAA Fisheries, LDNR	None identified.

Category	Performance Measure	Definition	Monitoring	Data Gaps
Reduced Flooding and Damages	Levee Protection	Level of protection from storm event	USACE National Levee Database; CPRA Intelligent Levee Project	Intelligent Levee Project only for 12 months.
	Homes at Base Flood Elevation	Computed elevation to which floodwater is anticipated to rise during the base flood	FEMA	None identified.
	Detention Capacity	Quantity of water that can be temporarily stored and then released	TBD	Uncertain.

Resilient Community

Whether it results from hurricanes or economic stress, resilient communities are those that can recover quickly from periods of instability and resume "normal" functioning. A community relies on the people that reside in it, the operation of critical infrastructure, and a government to support them.

Time to Return Home/Work

Following an event (e.g., a storm), the time it takes for the population/community to return to home or work can be used as a performance measure of a resilient community. It was concluded that efforts should be implemented to work with individual parishes and local governments to track and monitor rates of return for households during and after an event. Utility monitoring for individual households and communities is considered another data set which might be able to provide insight into recovery time rates of coastal communities.

Operation of Critical Infrastructure

As part of the emergency response plan, operation of critical infrastructure is assigned to different agencies depending on the type of infrastructure. Working with individual parishes and local and federal agencies would be necessary to track and monitor if and when infrastructure is up and running.

Population per Community

A change in population size is reflective of the stability of the population but may not necessary reflect the response to program implementation. The workshop attendees agreed that a static population does not necessarily equate to stability, but rather a sudden drop in population size following an event may reflect instability. The U.S. Census Bureau's website contains a variety of statistics and analyses supporting their Economic Database, which includes information ranging from household per capita income to demographic maps.

Unemployment Rates

The unemployment rate reflects job security and is relevant to the 2012 Coastal Master Plan's objective of promoting a working coast. The rates are inherently "noisy," however, and may take a long period of time to respond to program implementation. Data related to unemployment are readily available through the Bureau of Labor Statistics.

Quality of Life

A citizen's satisfaction with the conditions in which they live is tied to the community's ability to meet its citizens' own physical, social, and economic needs. Although deeply personal in nature, the quality of life can be reflected in cost-of-living indices, through the opportunities available to citizens, and fairness granted across socioeconomic groups.

Cost of Living

Cost of living indices are produced by the Council for Community and Economic Research for comparison among urbanized areas. Data are available for the following coastal cities: Lafayette, Hammond, Baton Rouge, Lake Charles, and Slidell. Indices for additional cities would need to be produced for a coastwide view of Louisiana.

Natural Resources Available to Communities

Many coastal communities rely on natural resources such as fish and shellfish for personal consumption. Fisheries abundance can be tracked through the Louisiana Department of Wildlife and Fisheries (described under Nekton Abundance in previous section).

Flood Insurance

The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA) and works with private insurance companies to offer flood insurance. Insurance rates and number of insurers would be available through the program, but additional research is necessary to determine number of people insured.

Outdoor Recreation

Hunting and fishing licenses' sales are reported by the Louisiana Department of Wildlife and Fisheries on an annual basis for each parish. The LDWF also has information on boat ramps and trails throughout the state.

Resilient and Robust Economy

A resilient and robust economy is one that can withstand stress, but also recover quickly during times of instability. Tracking its performance will provide insight into the "health" of the state. Housing sales, continuity of economic activity, and commerce are a few of the metrics identified for tracking the resilience of the economy.

Housing Sales

The U.S. Census Bureau reports a variety of statistics related to construction and housing that are reported every 5 years. The 10 year census provides housing sales, but more frequent data may be available through the Census Bureau Research Data Center in Atlanta.

Continuity of Economic Activity

The U.S. Census Bureau's website contains a variety of statistics and analyses supporting their Economic Database which includes information ranging from business dynamics statistics, county business and demographic maps, small business statistics, enterprise statistics, and economic indicators and studies. The census, which is taken every 10 years, is helpful in providing county and parish-wide snapshots, which are effective indicators of economic development and growth patterns, all contributing to the resilient and robust nature of coastal economies. The U.S. Census Bureau also provides information pertaining to small business development trends. Additional research is necessary to determine what census datasets can be applied to coastal Louisiana and how frequently data are collected.

Commerce

Commerce is inclusive of waterborne commerce, oil and gas, agriculture, and commercial fishing. Waterborne commerce is tracked by the U.S. Army Corps of Engineers' Waterborne Commerce Statistics Center. Data include foreign and domestic tonnages and trips by commodity for major ports and waterways. The Louisiana Department of Natural Resources' Technology Assessment Division provides data on oil and gas production, prices, revenues, permits, and reserves. The U.S. Department of Agriculture's Economic Research Service produces data on farm income and finances program measures, forecasts, and explains indicators of economic performance to the farm sector and major crop and livestock farm groups. The National Oceanic and Atmospheric Administration's Fisheries Statistics Division tracks data on commercial fisheries landings.

Reduced Flooding and Damages

One of the main goals of the 2012 Master Plan is reducing flood risk through structural and non-structural projects. Several performance measures can be used to track flood risk: the level of protection offered by levees, homes at Base Flood Elevation (BFE), and detention capacity.

Levee Protection

The U.S. Army Corps of Engineers (USACE) National Levee Database contains data and map schematics of Louisiana's levees, including the system inspection rating, last inspection date, type and executive summary for each. Intelligent Levee Systems Project is a real-time monitoring, warning and response system currently being evaluated for 12 months in levees surrounding New Orleans. Additional support of this monitoring program could provide data related to levee protection.

Homes at Base Flood Elevation

Base Flood Elevation (BFE) is the computed elevation to which floodwater is anticipated to rise during the base flood. Statistics related to compliance with BFE standards and general building standards can be tracked through FEMA's Building Science Program and the International Code Council (ICC).

Detention Capacity

Detention capacity is the quantity of water that can be temporarily stored and then released to prevent flooding in an urbanized area. Data related to detention capacities could not be found.

Next Steps

Refinement of the performance measures will be conducted to identify a subset for use in the Adaptive Management Framework and/or coastal report card. Although this document identifies current monitoring programs, it does not comprehensively cover all monitoring efforts in the state of Louisiana. As a result, a large-scaled Needs Assessment should be conducted to identify a monitoring program for coastal Louisiana. The CPRA, with assistance from The Water Institute, is currently evaluating the needs and framework for the System-Wide Assessment and Monitoring Program (SWAMP). Use of the metrics identified herein will also require participation from agencies with ongoing monitoring efforts, including the Louisiana Department of Wildlife and Fisheries, Louisiana Department of Environmental Quality, Louisiana Department of Natural Resources, U.S. Army Corps of Engineers, U.S. Geological Society and others. Given the large number of potential data sources, a regional partnership may be necessary to coordinate data-collection efforts and integrating data quality assurance and quality control (QA/QC) protocols.

The NRC (2000) recommends the following questions should be considered when implementing a QA/QC program:

- How and by whom will quality control over input data be ensured?
- Who are potential users of the data and how can their needs be met?
- How can the data be used to improve the models on which the indicator is based?
- How can the archival system best accommodate technological changes in both data collection and archiving methods?
- Who will coordinate and manage the archives?
- How can the system respond to complex user queries that may require new analyses and interpretation of existing data?
- How will the data storage systems be integrated with other archival systems of federal, state, and local governments?

The CPRA's Data Management Plan, developed with assistance from The Water Institute of the Gulf, communicates the resource requirements, policy needs, data handling procedures, and storage structures necessary to facilitate access to data associated with the state of Louisiana's coastal protection and restoration efforts. Implementing a Data Management Plan should be priority in moving forward with Adaptive Management to preserve the quality of data. In order for performance measures to be useful in Adaptive Management or report cards, there must also be a clear expectation of change or performance. Several points of reference need to be considered for each performance measure in order to evaluate program success (adapted from RECOVER 2005):

- Desired target condition or level;
- Expected future condition with program implementation (Future-With Scenario);
- Baseline or reference condition prior to program implementation;
- Actual condition during program implementation;
- Programmatic trigger (e.g., decision criteria) during program implementation.

The desired target condition may represent a historical condition or some "ideal" state that enables the goals and objectives to be fulfilled. The expected future condition can be calculated using numerical models and the best available science to predict what the future condition would be, given program implementation and other drivers. This value may differ from the desired target condition because of a changing system so it is important to evaluate what future conditions may hold. The baseline condition is the value prior to implementation or a reference site that is not impacted by program implementation. The actual condition will be monitored after program implementation to assess change. The monitoring of the condition should include a sufficient sample size in order to detect significant changes and an appropriate resolution to distinguish natural variability from program response. Coupled with the actual condition is the establishment of programmatic triggers or decision criteria to determine when the measures' response is beyond a desired threshold value, indicating change or action is needed. In all of these values, uncertainty and variance exists either a result of data collection (e.g., too few samples), model predictions, natural variability, and other unknowns associated with future conditions. To reduce uncertainty, a sensitivity analysis is also recommended for each of the measures to determine at what spatial and temporal resolutions change can be detected. It is important that the scale of the measure match the scale of the response. The points of reference, particularly the expected future conditions, will need to be revised every two to five years using updated monitoring data and improved models. This will reduce uncertainty surrounding predicted conditions and improve the use of performance measures.

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Appendix I:
Performance Measures Workshop
Natural Environment
January 29, 2013
Meeting Summary

About this Meeting Summary

The purpose of the meeting summary is to provide documentation of the performance measures identified, issues discussed, available data sources, and monitoring recommendations related to the natural coastal system. The meeting summary does not serve as a meeting transcript, nor does it attribute comments or suggestions to specific individuals. It does attempt to characterize areas of emerging agreement and areas requiring future deliberation, as well as important next steps.

Meeting Attendees

- **Invited** – John Ettinger, David Fruge, Rick Hartman, Quin Kinler, Bill Klein, Darin Lee, Michael Massimi, David Muth, Andy Nyman, Bryan Piazza, Greg Steyer, Jenneke Visser, Dona Weifenbach
- **The Water Institute** – Ann Hijuelos, Taylor Marshall, Denise Reed, Clint Willson
- **CPRA Project Team** – Natalie Peyronnin, Rick Raynie, Carol Parsons Richard

Background

The Water Institute of the Gulf is working with the Coastal Protection and Restoration Authority (CPRA) to develop a programmatic Adaptive Management Framework to guide Louisiana's coastal restoration and protection program. As part of this effort, The Water Institute held a workshop with local experts to identify key performance measures that will be used to track the progress of CPRA's programs and achieve the goals of restoration and protection described in Louisiana's 2012 Coastal Master Plan.

Approach

Attendees were asked to identify broad, ecological attributes as they relate to the coastal system. The initial list was refined after group discussions and organized into seven categories (Table 1). Some attributes appear in more than one category. For instance, wind damage is an important attribute that relates to both sustainability and people. Once the revised list was agreed upon, attendees were asked to identify performance measures for each of the attributes and determine if the measure adheres to a set of pre-determined criteria:

1. Signal-to-noise ratio (sensitivity to action versus natural variability)
2. Rapid response to action/no action
3. Reliability and specificity of response to action/no action
4. Ease and economy of monitoring
5. Program relevant and scientifically defensible
6. Applicability to region versus localized area (scale of measure)
7. Understandable to multiple audiences

For each criterion, a plus-minus scale was used to identify agreement or disagreement, respectively. A zero was used to denote if agreement with the criteria was uncertain or not applicable. The plus-minus scale was designed to allow for quick review of the list of proposed measures and determine those which needed further consideration or should be disregarded altogether.

Performance Measures

For each of the attributes, a list of potential performance measures was generated. Group discussion may have led to the dismissal of certain measures and the identification of alternatives, if any. In cases where there was dialogue regarding the scaling of the criteria, notes are provided below the table. Otherwise, the plus-minus-zero notation is provided in Table 2. In some instances, alternative measures were suggested but the criteria were not considered and are thus left blank in Table 2.

Table 1. Refined list of ecological attributes that relate to the natural, coastal system.

Land Quantity	Landscape Quality	Sustainability / Resilience	Geophysical Processes	Water Quality	Faunal Abundance and Diversity
Land Area Change	Diverse Vegetation	Soil Strength and Soil Type	Wave Energy	N Load	Fishery Production
Fragmentation	Forest Regeneration	Accretion	Tidal Prism	Phosphorus	Nekton Diversity and Productivity
Shoreline Position	Flora & Fauna / Exotics and Invasives	Sediment Input to Estuary	Salinity Regime	Silica	Wildlife Diversity and Productivity
Diverse Water Depths	Carbon Storage	Elevation	Longshore Transportation	Carbon Storage	Phytoplankton Productivity
Carbon Storage		Resilience to Storms	Freshwater Availability	Dissolved Oxygen	Exotic Fauna
		Surge Reduction	Sediment Input	Phytoplankton Production	
		Exotic and Invasive Species	Sediment Load	Swimmable Water	
		Wind Damage	Accretion	Freshwater Availability	
		Fragmentation	Hydrologic Connectivity		
			River Discharge		
			Estuarine Gradients		

Table 2. Proposed performance measures and criteria scoring. Performance measures were evaluated on a plus-minus-zero scale to assess agreement with each of the seven criteria. In some cases there was not consensus on the criteria scoring so more than one score may be present or a score may not have been assigned. Measures that were proposed after the evaluation period during the workshop were not scored and criteria boxes are left blank.

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action/No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Land Quantity	1. Land area change	Change in land/water area over time	0	+	+	+	+	+	+
	2. Fragmentation	Spatial Integrity Index	0	+	+	+	+	0	0/+
		Or land area vs. edge (land/water/edge)							
	3. Shoreline Position	Rate of Change (meters/year)	0	+	+	0	+	+	+
Landscape Quality	1. Diverse Vegetation	Diversity of Marsh Types	0	+	+	+	+	+	+
		Species Richness	0	+	0	0	+	+	+
	2. Forest Regeneration	Depth and Duration of Flooding	0	0	0	-	+	+	+
		Recruitment within a vegetation type							
	3. Exotic and Invasive: Flora	Diversity Index/Customized Floristic Quality Index (FQI)	+	-	-	+	0	+	-/+
		Coast-wide Distribution of Species (% cover in given area)	0	0	0	0	+	+	+
	4. Carbon Storage	Change in carbon storage	0	0	0	-	+	+	-
Geophysical Processes	1. Salinity Regime	Change in salinity	0/+	+	+	+	+	+	+
	2. Sediment Input	Tonnes/year (into estuary)	+	+	+	-/+	+	+	+
	3. Accretion	Deposition rate	+	+	+	+	+	+	+
	4. Hydrologic Connectivity	Changes in natural connections vs. un-natural connections	+	+	+	+	+	+	-

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action/No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Biological Productivity / Secondary Productivity	1. Fishery Production	Species specific commercial fishery productivity (using landings and fishery independent sampling)	-	+	0	+	+	+	+
	2. Fishery Productivity	Catch per unit effort (CPUE)	0/-	+	0	+	+	+	+
	3. Nekton Diversity	Standard measures of diversity indices	+	0	0	+	+	+	-
	4. Nekton Productivity	Nekton abundance	0/+	+	0	+	+	+	+
	5. Wildlife Diversity	Shorebirds on Barrier Islands	-	-	-	0/+			0/-
		Alligators	-	+	+	+	+	+	+
Water Quality Measures	1. Nitrogen	Change in concentration (input vs. output)	-	+	-	-	0		
	2. Dissolved Oxygen	Dissolved Oxygen levels	-	+	-	0/+	0		+
Sustainability / Resilience	1. Elevation	Duration of flooding	0	0	0	-	+	+	+
		Measuring water levels for elevation above sea level	+	+	+	-	+	+	+
	2. Soil Strength	Change in Minimum Strength (top 50 cm)	0/+	0/+	0/+	0/+	+	+	-/+
	3. Storm resilience	Acres lost vs. acres recovered							
		Hazard insurance rates							

Land Quantity

Land Area Change

The ratio of land to water was examined as a potential performance measure. After group discussions, it was determined that the ratio does not represent a specific, spatial area and a more appropriate measure would be change in land and water area over time. There may be some "noise" in the measurement as a result of seasonal variability and the response may be delayed depending on the type of project and the area in which it is applied. Land-change monitoring is ongoing and data are available and widespread. Localized, micro-scaled measurements can be costly and difficult to do over large areas. Scaling-up the measurement to the coast is difficult using high resolution (sub-meter) imagery, but commonplace using 30m resolution Thematic Mapper (TM) imagery.

Fragmentation

A spatial integrity (SI) index was identified as the performance measure. It can be difficult to calculate over large spatial scales using high resolution imagery and is also dependent upon the grid area size for analysis. The final output is visually easy to understand in areas undergoing dramatic change, such as marsh creation areas, however may not be as easily interpretable in areas undergoing slow change over time. The SI index assumptions and methodologies need further validation and testing to see how well they adhere to the set of pre-determined criteria. Other patch metrics could be used to assess fragmentation, such as edge to area ratio, but would also need further validation and testing.

Shoreline Position

The rate of change in shoreline position (e.g., meters per year) was identified as the performance measure. Measurements for marshes and barrier islands should be separated due to difference in expectations. This metric can be calculated by digitizing photos and calculating an average rate of change based on linear distance between points. The signal-to-noise ratio is highly variable among habitats (e.g., barrier islands versus marsh).

Diverse Water Depths

Initially, bathymetric change was identified as a performance measure. This metric was put in the context of barrier islands, but the group did not agree if diverse depths were really the appropriate measure. Although diverse depths are designed to characterize the performance of barrier islands, there are other metrics that can be used. As a result, it was determined that diverse water depths can be indirectly represented in the performance measures identified for nekton and water quality.

Landscape Quality

Diverse Vegetation

The diversity of marsh types was identified as a performance measure but was recognized as a difficult measure to quantify. Diversity of marsh types (through the use of a diversity index) or number of species present (e.g., richness) can be tracked over time but is highly dependent on the scale of measurement.

Species Richness

Although identified as an attribute, species richness may also serve as the performance measure. It can be difficult to implement in monitoring protocols and is sensitive to local disturbances.

Forest Regeneration
Forest regeneration is dependent upon water depth and duration of flooding. Recruitment and the distribution of basal areas of trees were proposed as performance measures but they are also dependent on habitat type/characteristics.

Exotic and Invasive: Flora
The Floristic Quality Index (FQI) scores species based on their tolerance to disturbance and fidelity to a habitat and can be customized to classify species that are exotic or invasive. Alternatively, the coast-wide distribution of species or percent cover in a defined area could be used as performance measures, but require species-specific monitoring protocols.

Carbon Storage
Defined here as an attribute, carbon storage can also be quantified as carbon accumulation (e.g., grams m^{-2} yr^{-1}) or change in carbon storage (e.g., change in tonnes per year). Carbon storage can be difficult to explain to an audience and is difficult to monitor, although new remote techniques are being developed and implemented elsewhere.

Geophysical Processes

Wave Energy
Shoreline change can be used as a proxy for wave energy. Fetch was also considered a proxy for wave energy but is also impacted by water depth and tidal prism. It was concluded that wave energy is important to monitor but should not be used as a performance measure.

Salinity Regime
Mean weekly/monthly/annual change in salinity is dependent upon scale of measure and has different meanings at certain locations. The signal-to-noise ratio is influenced by scale as well. A trend in salinity rather than a change was also a proposed metric. It is important to recognize that salinity change over time is dependent on future conditions.

Estuarine Gradients
Vegetative diversity was initially identified as a performance measure but given the large amount of variability across basins, interpreting data would be difficult. As a result, no performance measure was identified for this attribute.

Sediment Input
Although identified as an attribute, sediment input (measured as tonnes per year) is also the performance measure.

Accretion
Accretion or deposition rate was identified as an important metric to monitor but should not be used as a performance measure. Soil elevation relative to water depth is the metric of interest.

Hydrologic Connectivity
Changes in connections between main waterways and estuaries, quantified as a binary response, were identified as the performance measure. It was also suggested that whether the connection was “natural” should be tracked, although defining what’s considered natural may be difficult. Resident time was also considered as a proxy, but the measurement may be subjective and is not clear what a change in residence time really means.

Faunal Abundance and Diversity

Nekton Abundance

Species specific landings and fishery independent sampling can be used as performance measures. These metrics track distribution and abundance over time, not production. Datasets from the Louisiana Department of Wildlife and Fisheries (LDWF) can be useful as they tease out commercial and non-commercial estuarine species. They can be used to track changes in community composition as well as individual species of interest.

Nekton Diversity

Fisheries-independent monitoring data can be used to derive diversity indices or quantify nekton abundance. They are difficult to explain to non-scientific audiences.

Wildlife Diversity

Nesting shorebirds on beaches and barrier islands, colonial nesting birds, and bald eagles were suggested as performance measures for wildlife diversity. These metrics are highly impacted by "noise" and attributing changes in abundance to program implementation will be very difficult. Improvements in monitoring (e.g., more transects) could improve datasets, but in general breeding bird surveys and waterfowl surveys are inherently noisy. Alligators and threatened and endangered species (e.g., piping plovers) were also suggested but signal to noise is still an issue.

Water Quality

Fecal coliform, dissolved oxygen, total nitrogen and phosphorus are all important parameters for monitoring. Monitoring efforts by the Department of Environmental Quality could provide additional insight into these metrics. The group determined the amount of total nitrogen into and out of estuary could be used as the performance measure, but how that metric would be calculated was not certain.

Sustainability/Resilience

Elevation

Duration of flooding was identified as the performance measure for elevation. This metric would be used strictly in wetland environments. Elevation above sea level/water level (a fixed point) could be used in open-water areas.

Soil Strength

Change in minimum strength, within the top 50 cm (down core), by soil and vegetation types, was identified as a performance measure. It may be difficult to explain if change in strength is "bad" or "good."

Resilience to Disturbance

Initially, the attribute was identified as resilience to storms, but group discussions lead to the inclusion of all disturbances, including droughts and high-river events. The group did not identify a performance measure but did conclude that the ability to "bounce back" was important. Given the dynamic nature of the coast, some areas will recover more so than others, but the overall "balance" stays the same. How and when you measure the "balance" is uncertain.

Monitoring

It was identified that bird surveys, using established protocols and survey methodologies should be expanded across the coast. Power analysis should be performed during planning stages to determine

how many transects are needed. Rapid assessments of exotics/invasives should be performed every 4-5 years. Nutrient flow to calculate total nitrogen into and out of the basin may be achievable with the help of the DEQ. Although a long-term fishery/nekton dataset exist with LDWF, there is room for improvement and protocols should be reviewed to ensure the quality of the dataset is maximized. Soil strength and carbon could be quantified once every 3-5 years, with more frequent observations initially. Land area, fragmentation, and shoreline position could be done using remote sensing and image analysis, but site-specific surveys may be necessary for project-level information. Vegetative communities, depth and duration of flooding datasets exist under the Coast-wide Reference Monitoring System (CRMS). LIDAR technologies continue to evolve and may be useful down the road.

Appendix II:
Performance Measures Workshop
Built Environment
January 31, 2013
Meeting Summary

About this Meeting Summary

The purpose of the meeting summary is to provide documentation of the socio-economic performance measures identified in the built-system workshop as well as issues discussed, available data sources, and monitoring recommendations. The meeting summary does not serve as a meeting transcript, nor does it attribute comments or suggestions to specific individuals. It does attempt to characterize areas of emerging agreement and areas requiring future deliberation, as well as important next steps.

Meeting Attendees

- **Invited** – Stephen Barnes, Rex Caffey, Jeff Carney, Laurie Cormier, Windell Curole, Malay Hajra, Scott Hemmerling, John Lopez, Camille Manning-Broome, John Monzon
- **The Water Institute** – Ann Hijuelos, Taylor Marshall, Denise Reed, Clint Willson
- **CPRA Project Team** – Natalie Peyronnin, Carol Parsons Richard

Background

The Water Institute of the Gulf is working with the Coastal Protection and Restoration Authority (CPRA) to develop a programmatic Adaptive Management Framework to guide Louisiana's coastal restoration and protection program. As part of this effort, The Water Institute held a workshop with local experts to identify key performance measures that will be used to track the progress of CPRA's programs and achieve the goals of restoration and protection described in Louisiana's 2012 Coastal Master Plan.

Approach

Attendees were asked to identify built-system attributes as they relate to coastal Louisiana. The initial list was refined after group discussions and organized into four categories (Table 1). Some attributes appear in more than one category. For instance, public infrastructure is important for a resilient community and for quality of life. Once the revised list was agreed upon, attendees were asked to identify performance measures for each of the attributes and determine if the measure adheres to a set of pre-determined criteria:

1. Signal-to-noise ratio (sensitivity to action versus natural variability)
2. Rapid response to action/no action
3. Reliability and specificity of response to action/no action
4. Ease and economy of monitoring
5. Program relevant and scientifically defensible
6. Applicability to region versus localized area (scale of measure)
7. Understandable to multiple audiences

For each criterion, a plus-minus scale was used to identify agreement or disagreement, respectively. A zero was used to denote if agreement with the criteria was uncertain or not applicable. The scale was designed to allow for quick review of the list of proposed measures and determine those which needed further consideration or should be disregarded altogether.

Performance Measures

For each of the attributes, a list of potential performance measures was generated. Group discussion may have led to the dismissal of certain measures and the identification of alternatives, if any. In cases where there was dialogue regarding the performance measure or the scoring of the criteria, notes are provided below the tables. Otherwise, the performance measures and plus-minus-zero notation are provided in Table 2. In some instances, alternative measures were suggested but the criteria were not considered and are thus left blank in Table 2.

Table 1. Refined list of built-system attributes that relate to the coastal system.

Resilient Community	Quality of Life	Resilient and Robust Economy	Reduced Flooding and Damages
Recovery Time	Cost-Of-Living	Job Security	Reduce Flooding and Damages
Population Shifts	Public Infrastructure	Enhanced Coastal Zone Management	Restoration with Community Consideration
Interagency Communication	Education Opportunities	Economic Security	Flood Protection Levels
Enhanced Local Government Capacity/Decision Making	Physicality of Adapting	Private Investment	Water Management (Surge, Drainage, Pumping, River)
Education Opportunities	Economic Security	Agriculture	Risk Communication
Informed/Educated Public	Building Design	Supporting Fishing Communities	Risk Awareness
Public Infrastructure	Socioeconomic Fairness and Equality	Supplies (Oil and Gas) to Nation	Chenier and Chenier Forest
Supporting Small Business	Relocation	Continuity of Economic Activity	Vulnerability to Risk (Natural And Technological)
Sustainable Levees	Community Connectivity	Navigation Channels	Technology Improvements
Job Security	Natural Resources Available to Communities	Oil and Gas Channels	Relocation
Time Frame of Land Building	Insurance Rates	International/National Connectivity	Mississippi River
Availability Of Insurance		Evacuation Thresholds	
Building Design		Property Rights	
Tax-Base		Technology Improvements	
Robust Utility Network			
Risk Communication			
Land Management Tools			
Land Use Plan			
Evacuation Thresholds			
Relocation			
Diversity of Cultural Groups			

Table 2. Proposed performance measures and criteria scoring. Performance measures were evaluated on a plus-minus-zero scale to assess agreement with each of the seven criteria. In some cases there was not consensus on the criteria scoring so more than one score may be present or a score may not have been assigned. Measures that were proposed after the evaluation period during the workshop were not scored and criteria boxes are left blank.

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Resilient Community	Recovery Time	Time it takes to get back to work	-	+	+	+	+	+	+
		Time it takes to get back home	+	+	+	0	+	+	+
		Critical infrastructure / facilities in operation	+	+	+	+	+	+	+
	Population Stability	Population per community over time (age, cultural group, socio-economic group, etc.)	-	-	+	+	+	+	+
	Interagency Communication	FEMA recovery framework	+	0	0	+	+	+	+
	Enhanced Local Government	Implementation of plans (whether they exist, and whether they were implemented)	-	+	+	+	+	+	+

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Resilient Community	Education Opportunities or Job Training/Re-training	Education level, degree, certificates issued within a population	-	-	-	+	+	+	+
		Number of varying levels of schooling							
		Number of students per population							
	Informed/ Educated Public	curriculum or public meeting attendance	-	-	+	-	+	+	+
	Supporting Small Business	Number of small businesses per population	-	-	-	+	-	+	+
	Sustainable Levees	Levee performance and position	+	+	+	0	+	+	+
		Potential levee failure or breeches	+	+	+	+	+	+	+
	Job Security	Unemployment rate/ claims per population	-	-/+	-	+	0/-	+	+
		Long term job placement	+	+	+	0	-	+	+
	Availability of Insurance	Insurance costs, FEMA insurance map, number of insurers	+	+	0	+	+	+	+

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Resilient Community	Sustainable Community Design	Code compliance (base flood elevation) or homes not protected	+	+	+	-	+	+	+
	Tax base	Property values	0/-	0	-	+	-	+	+
		Per household tax inventory							
	Evacuation Thresholds	Evacuation requirements per category storm per community	+	+	+	+	+	+	+
		Individual dollars spent on evacuation per year	+	+	+	0	+	+	+
	Relocation	Number of buy-outs	+	+	+	+	+	+	+
Quality of Life	Cost of Living	Cost of living index	-	0	-	-			
	Public Infrastructure	All public infrastructure							
		Critical infrastructure	-	0	0	+	0	+	+
		Parks and recreation							
		Public access (trails and handicap accessibility)							

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Robust and Resilient Economy	Economic Security	Housing sales	+	+	+	+	+	+	+
		Construction permits	+	-	+	+	+	+	+
		Dodge hill reports	+	-	+	0/-	+	+	+
	Enhanced Coastal Zone Management	Coastal use permits							
	Supporting Fishing Communities	Number of licenses	-	+	+	+	0	+	+
		Fisheries-independent data	-/+	+	+	+	+	+	-
		Price of seafood							
	Agriculture	Agriculture summary or national agricultural statistics	-	+	+	+	+	+	+
	Supplies of Oil and Gas to Nation	Royalties to federal government	-	-	-	+	+	+	+
		Department of Energy port data	-	-	-	+	+	+	+
	Navigation Channels	Beneficial use of dredged material	+	0	+	+	+	+	+
		Waterborne commerce	-	0	0	+	0/+	+	+
	Continuity of Economic Activity	Continuity of economic activity	+	+	+	-	+	+	+
		Projected changes (losses) via regional economy							

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Reduced Flooding and Damages	Reduced Flooding and Damages / Flood Protection	Number of homes at Base Flood Elevation (BFE)	+	+	+	+	+	+	+
		Homes outside of flood protection system (or homes at or above certain level	+	+	+	0	+	+	+
	Levees	Level of protection	+	+	+	0	+	+	-
	Other possible performance measures	Number of structures built to building code							
		Number of acquisitions/buy-outs							
		Amount of land lost or gained							
		Quantity of vegetation to reduce damages							
		Number of repetitive losses							
		Community rating systems (CRS)							

Category	Attribute	Performance Measure	Signal-to-Noise Ratio	Rapid Response to Action / No Action	Reliability and Specificity	Easy and Economy of Monitoring	Program Relevant and Scientifically Defensible	Applicability to Region vs. Localized Area	Understandable to Multiple Audiences
Reduced Flooding and Damages	Water Management	Detention capacity	+	+	+	+	+	+	+
		Number of outputs of floodways in river (cfs)	+	+	+	+	+	0/-	+
	Risk Communication and Risk Awareness	Education in schools (at multiple levels)	0	+	+	0	+	+	0/+
	Other possible performance measures	Public notification of residual risk	+	+	+	+	+	+	0/-
		Accuracy of hurricane models							
		Insurance rates							
		Storm awareness							
		Public meeting attendance							
	Chenier/Chenier Forest	Miles/quality and height	+	+	+	-/+	+	+	+
	Technology	Number of intelligent levee systems	+	+	+	-	+	+	+

Resilient Community

Recovery Time

The group defined recovery time as the time it takes to get back home and/or to work. This could be measured by the operation of critical infrastructure and facilities (hospitals, police, fire, utilities, sewer, etc.). Utility outage reports may assist in identifying whether or not those facilities are operating. These metrics are mainly applicable to storms and should be related to pre-storm/event levels. Communities that take longer to return indicate they have a lower level of resilience.

Population Stability

The population and demographics per community, as well as the relationship of the number of jobs to people, could reflect the population's ability to sustain itself. Post-event population numbers ideally should "bounce back" to the pre-event levels, if the population is stable. On the other hand, it was recognized that static population numbers do not necessarily mean "stability." Stability would be lowered if communities move out of parish or state.

Enhanced Local Government

The existence and/or implementation of land-use plans or evacuation plans (as a binary measure) would be relevant at a local level but difficult to scale up. It also requires cooperation with local government and a strong, local community effort. This may be difficult for CPRA to control.

Availability of Insurance

The availability of insurance (specifically flood insurance) and insurance rates would reflect the flood risk associated with a particular area. Some recommended a state-wide program to assist in informing the public on insurance rates and coordinate claims.

Tax Base

Property values would provide indication of the tax base and could be important in cost-benefit analysis for projects. There is the potential for basin-wide impacts, depending on scale of project.

Relocation

Buyouts could be used as a proxy for relocation, although there is a chance that individuals would relocate and not sell property. There are also communities that do not own land (e.g., Native American groups), but their relocation could be tracked in the population stability attribute.

Quality of Life

Public Infrastructure

A distinction between critical infrastructure, parks/recreation infrastructure, and public access to restored areas was made. Not all public infrastructure is relevant to program but critical and public access are metrics to be considered.

Economic Security

The future-with and future-without scenarios should also be considered with an economic perspective. This could be captured in housing sales, bank loans, and construction permits.

Socio-Economic Fairness

The effect of relocation or government-based compensation for restoration is indicative of socio-economic fairness. The level of protection per economic class could be used as a performance measure for the Adaptive Management Plan but not necessarily for a report card.

Community Connectivity

Cohesiveness of a community reflects the quality of life along the coast. There are examples of whole communities relocating together. Actively engaging whole communities in restoration planning is also important.

Robust and Resilient Economy

Enhanced Coastal Zone Management

This attribute was considered vague, but coastal-use permits can be used as a performance measure that represents economic development. There are also conflicting metrics: economic/ infrastructure development (e.g., roads or utilities) in a coastal area that will no longer be protected and restored (i.e., dead areas).

Navigation Channels

This attribute can have a negative connotation when considering the environment, but positive when thinking about the economy. Beneficial use of dredged material, miles of channel, waterborne commerce, and total value of trade out of ports all provide different information for this attribute.

Continuity of Economic Activity

Input-output analysis (IOA) was recommended, although would require simulations/modeling as opposed to monitoring. This attribute is particularly important when considering storm events and the need to look at the implication of these storms on economic activity.

Technological Improvements

Although not directly related to the Master Plan, location of strategic assets and subsurface utilities (e.g., power) would lead to a more robust and resilient economy through less utility downtime.

Reduce Flooding and Damages

Flood Protection

Home elevations both inside a flood protection system and outside, as well as the level of protection from a levee system, are the main metrics when considering flood protection.

Levees

Reporting return period may not be understood by the general public, but providing maps that show levees authorized at 50 yr, 100 yr, etc. floods would be effective. The levee elevation could also be reported out to the public.

Water Management

There is a strong need to have better water management in cities. There is a potential connection to buyouts, whereby unoccupied lands could be used as detention areas.

Risk Communication and Awareness

Communicating risk is dependent upon the professionals that share the information during storm events as well as education in schools. Public awareness may be reflected in the dollars spent advertising or campaigning. Residual risk would be reflected in insurance rates. There is also storm-related communication and the accuracy of models.

Technology

Non-destructive monitoring (e.g., fiber optics) on concrete walls and levees provide information on the "health" of a levee.

Restoration with Community Consideration

This attribute links back with the idea of bringing both protection and restoration awareness to the communities. Community involvement is important in the beginning and not after the project has already been implemented. There was discussion regarding what a public meeting should look like and the need to reinvent the public meeting.