STATE OF THE COAST

IMPLEMENTING A SUSTAINABLE COAST FOR LOUISIANA

Proceedings Document

Abstract Compilation

CPRA
Coastal Protection and Restoration Authority of Louisiana

Coalition to Restore Coastal Louisiana

US Army Corps of Engineers®

State of the Coast Conference
June 8-10, 2010

Conference Summary

The State of the Coast (SOC) Conference was hosted on June 8-10, 2010 at the Baton Rouge River Center through a partnership of the Coalition to Restore Coastal Louisiana (CRCL), the Louisiana Coastal Protection and Restoration Authority (CPRA), and the U.S. Army Corps of Engineers (USACE).

The three-day conference included:

- 678 registered attendees
- 3 partners and 26 sponsors
- 43 exhibitors
- 66 oral presentations by leading experts in three concurrent sessions
- 21 session moderators
- 105 poster presentations, including 8 special oil posters
- 4 panel plenary sessions
- 4 keynote addresses
    - Garret Graves, Governor's Executive Assistant on Coastal Activities
    - Dr. Larry Robinson, Assistant Secretary of Commerce for Oceans and Atmosphere
    - Larry Schweiger, President and CEO of National Wildlife Federation
    - Nancy Sutley, Chair of White House Council on Environmental Quality
- Over 50 experts served on 5 conference planning committees (steering committee, program committee, café and beignets session sub-committee, policy plenary sub-committee and the sponsorship committee)

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Contents

Structural Protection

Concurrent Session I: Structural Protection I

Challenges in the Design and Construction of Levees in South Louisiana
Elif Acar-Chiasson, P.E.
Shaw Environmental & Infrastructure, Inc

Flood Risk Reduction Along the Inner Harbor Navigation Canal
Mathijs van Ledden[1], **Maarten Kluyver[1]**, Nancy Powell[2]
[1] Haskoning Inc. [2]US Army Corps of Engineers, New Orleans District

Coastal Physical Modeling Benefits to the Inner Harbor Navigational Canal Lake Borgne Hurricane Surge Barrier
Scotty Emmons[1], Peter Grant[2], and Jena Gilman[3]
[1]AECOM, New Orleans,[2]AECOM, Redmond [3]AECOM, Seattle

Technology Systems Design Considerations for Remote Instrumentation Monitoring and Surveillance of Flood Protection Systems
James B. Hummert, Jr
URS Corporation

Concurrent Session VII: Structural Protection II

Unified Approach for Design of Overtopped Coastal Levees
John R. Headland
Moffatt & Nichol

Use of Soil Mixing to Raise Levees
Thomas L Cooling, Bruce R. Lelong
URS Corporation

Steel Swing Barge Gate for the Houma Navigational Canal, Terrebonne Parish, Houma, LA
Oscar F. Pena, P.E., Don Collette, P.E.
Shaw Coastal Inc.

Poster Presentations

The Inner Harbor Navigation Canal Hurricane Protection Project Program Status & Lessons Learned During the Execution of USACE's Largest D-B Civil Works Contract
Charles M. Hess[1]
[1] Shaw Environmental & Infrastructure Group

Navigation Impacts of the Lake Borgne Surge Barrier on the Gulf Intracoastal Waterway at New Orleans
S. Keith Martin[1]**,** Gaurav Savant[2]
[1] USACE Coastal and Hydraulics Laboratory, [2] Dynamic Solutions

Integrated Flood Management Planning in California's Central Valley
Kari Shively[1], **Yung-Hsin Sun**[1]
[1] MWH Americas

The Ground is Moving - The Use of Wick Drains and Staged Construction in Orleans Parish Levee Construction Over Very Soft Soils
John C. Volk[1], R. Thandav Murthy[1], B. Dwayne Smith[1], Ariel Buenano[1]
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Challenges in the Design and Construction of Levees in South Louisiana

Elif Acar-Chiasson, P.E.
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Since the devastation caused by recent hurricanes, flood protection has positioned itself as one of the most sensitive subjects to the citizens of South Louisiana. The two major components of flood protection projects, levees and flood-control structures, have been the focus of much criticism due to the failures that occurred during Hurricane Katrina. This presentation will focus on the major challenges currently facing the levee districts, local sponsors and design engineers in the design and construction of the levee component of flood protection projects across South Louisiana.

Implications
The major challenges faced by local governments and state agencies in the construction of levees are the implementation of design criteria, locating borrow sources, dealing with existing subsurface conditions, environmental impacts (mitigation), pipeline and other utility relocations, and land acquisitions. Depending on how each challenge is handled, the time and dollars it takes for a levee to be constructed could be significantly increased.

Specific Topics of Interest
General Overview of the levee component of flood protection projects

Major challenges with design criteria, borrow sources, subsurface conditions, mitigation, relocations, and land acquisitions

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Flood risk reduction along the Inner Harbor Navigation Canal

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The IHNC project is one piece of the new Hurricane Storm Damage Risk Reduction System (HSDRRS) that is being built after Hurricane Katrina in 2005. This project will reduce risk along the New Orleans' Inner Harbor Navigation Canal from powerful storm surge in the event of future hurricanes. At the Lake Borgne side, two navigation gates along the 3 kilometer long floodwall are under construction to prevent water surging up the canal. Another barrier is planned on the Lake Pontchartrain side and the walls and levees along the IHNC canal system have been strengthened in order to achieve protection against surge and associated waves with a 1% annual exceedance in 2011. The much needed barriers for the IHNC will greatly reduce the risk of flooding for hundreds of thousands of residents in the St. Bernard, New Orleans East, Ninth Ward and Gentilly areas.

This paper will discuss in-depth the hydraulic changes due to the construction of the barriers at Lake Borgne and Lake Pontchartrain. Normal tidal conditions but also hurricane conditions will be addressed. Results from detailed numerical models but also simplified analytical methods are being presented to increase the hydraulic understanding of this complicated system. Also, the effect of different sea level rise scenarios on the hydraulic behavior will be reviewed.

Implications
A thorough understanding of the hydraulic behavior of the IHNC system is key input to manage and operate the IHNC system after 2011. It gives insight in the timing, sequence and hydraulic conditions prior to closure and after opening of the various gates in the system. This information can assist responsible agencies in their decision making how to effectively operate this part of the HSDRRS. Moreover, the assessment of the different sea level rise scenarios is important in planning efforts to achieve the desired level of flood risk reduction in the coming decades.

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Coastal Physical Modeling Benefits to the Inner Harbor Navigational Canal Lake Borgne Hurricane Surge Barrier

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The New Orleans Inner Harbor Navigation Canal (IHNC) Lake Borgne Hurricane Surge Barrier is composed of nearly two miles of flood protection including vertical floodwalls, a vertical lift gate at Bayou Bienvenue, and 150-ftt wide buoyant sector gates on the Gulf Intracoastal Waterway (GIWW). The project, being the largest civil works design-build project ever undertaken by the United States Army Corps of Engineers, was supported by two dimensional (2-D) and three dimensional (3-D) 1:20 Froude scaled physical model studies of the floodwall and sector gates, respectively.

2-D physical model studies of the floodwall structure with different bathymetric site conditions were performed to evaluate scour of the design riprap under 1% and 0.2% probability storm conditions, resulting in an increase in the selected riprap on the protected side, or populated side, of the floodwall structure.

A full bathymetric, or 3-D, representation of the GIWW and the proposed buoyant sector gates including the monolithic structure and approach walls was used in physical models studies to measure hydrodynamic pressures from surge, waves, overtopping, and reverse head of a 1% chance probability storm.

Wave pressure, and the resulting forces, and induced vibration of the buoyant sector gates were investigated using a hydroelastic model under storm surge and wave conditions to provide confirmation that analytically determined loads were conservative and the buoyant sector gate was adequately designed for stability. Additionally, gate opening hydrodynamic force curves were developed under variable reverse head conditions, representing a storm's recession and the evacuation of flood waters. The establishment of these force curves enabled design engineers to appropriately select an adequately sized hydraulic actuating cylinder.

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Technology Systems Design Considerations for Remote Instrumentation Monitoring and Surveillance of Flood Protection Systems

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This presentation will review state-of-practice instrumentation and remote data acquisition systems technologies being used to monitor flood protection systems world-wide. Both conventional instrumentation and metallic/optical time domain reflectometry applications will be discussed. The presentation will include application of GPS structural monitoring systems for both embankments and floodwalls.

There will be presentation of one or more emerging technologies including distributed temperature sensing techniques for monitoring levee systems on a day-to-day basis and during storm events using fiber optic cables. In addition, the use of new solid state IP video camera systems for remote surveillance of critical levee sections will be discussed.

Methodologies for leveraging the instrumentation data to develop comprehensive baseline data sets that can be used as part of an early alert system will be presented. Where applicable case history results from the London Avenue Canal Load Test and other recent instrumentation projects will be used. Lessons learned from these projects will be summarized.

The presentation will conclude with a discussion of how these types of systems can be integrated into an engineered risk management program using risk based screening tools and alignment with the potential failure modes associated with typical coastal flood protections systems.

Implications
Flood protection systems within the United States are vast, aging and becoming more critical all the time. Methods of remote surveillance coupled with early alert systems can be valuable tools to provide incremental risk reduction associated with management of flood protection systems.

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A Unified Approach For Design of Overtopped Coastal Levees

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This paper extends design methods for overtopped coastal structures including levees. Rather than relying on the nebulous descriptions for allowable overtopping discharges (e.g., "well-protected" crest and rear slope) cited in most references (e.g., EurOTop (2007)), mechanistic/quantitative design methods are advanced. The approach here is to compute the wave overtopping velocities and flow depths over the seaward face, crest, and rear slope (Shuttrumpf et al 2002, Van Gent 2002, Bosman et al, 2008). Probability distributions for the various velocities are developed using methods described in Van den Bos (2006.) Using formulae for critical velocities and scour behaviour of soil/grass/stone (Hoffmans and Verheij, 1998), the soil/stone performance can be evaluated quantitatively. Similarly, rock stability formulae for crest and rear slopes of overtopped structures can be used to size rock for armouring purposes. This treatment can serve to promote further research regarding design of overtopped surfaces such that design procedures reach a level of maturity comparable to that currently associated with armour stone sizing and wave runup/overtopping. This paper presents example applications for several case histories including: (1) wave overtopping field tests in the Netherlands (Van der Meer, 2008), (2) damage experienced during Hurricane Isabel in the Chesapeake Bay (Headland et al, 208), and (3) levee performance (both failure and survival) during Hurricane Katrina (IPET, 2007.)

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Use of Soil Mixing to Raise Levees

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The levee ring protecting New Orleans East includes five miles of earthen levee known as LPV 111, which borders the Bayou Sauvage National Wildlife Refuge along the Gulf Intracoastal Waterway. As part of the post-Katrina improvements to the New Orleans Area's levees, the LPV 111 levee presently is being raised 10 feet and the soft, underlying native soils are being strengthened by a ground improvement process called the Deep Mixing Method (DMM). The DMM operations in LPV 111 are one of the largest DMM projects ever undertaken in North America.

DMM was selected to improve the underlying ground to meet considerable design challenges: soft, underlying soils; the magnitude of the levee raise and the short time to accomplish it; and the need to reduce environmental impacts to the wildlife refuge. This technique involves mixing the native soil with cement in the ground to form "soil-crete" in a panel arrangement to strengthen the underlying soils against stability failures beneath the levee embankment. DMM elements also are being installed at transitions between floodwalls and earthen levee to reduce differential settlement and eliminate downdrag on the supporting pilings.

One critical quality issue is verifying the *in-situ* strength of the soil-crete elements meets the specified strength. The strength is measured during construction by core samples obtained from representative DMM elements. To have high confidence that the design strength is achieved during construction, statistically based specifications were developed considering typical variations in soil-crete strength, sample frequency, and core recovery during sampling of the DMM elements.

This presentation will describe the methodologies for designing the DMM panels, construction sequencing considerations, differential settlement considerations between the levee and the panels and at levee/floodwall transitions, and the statistical sampling techniques for verifying the *in-situ* strengths of the DMM elements.

Implications
The use of the DMM permits the strengthening of soft soils so that levees or levee raises of any significance can be completed within months or years instead of decades. The method also results in a much smaller levee footprint than a levee that does not use the DMM. The use of DMM at transitions and floodwalls and earthen levees results in reducing settlement, reducing long term maintenance issues, and reduces issues associated with the piles of the floodwalls.

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Steel Swing Barge Gate for the Houma Navigational Canal, Terrebonne Parish, Houma, LA

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In 2009 the Terrebonne Levee & Conservation District (TL&CD) implemented the Terrebonne Interim Flood Risk Reduction Program (T.I.F.R.R.P.) along the Morganza to the Gulf Hurricane Protection System Alignment. As part of this program, a floodwall and gate structure is proposed in the Houma Navigation Canal (HNC) that can be closed to stop the storm surge that travels northward from the Gulf of Mexico up the HNC. A Steel Swing Barge Gate (SBG) is being designed for installation in the HNC for the TL&CD near Houma, LA.
The project's goal is to construct a structure across the HNC that will control the storm surge and resulting crest in the HNC in concert with the levees on both sides thereby minimizing storm induced flooding in Terrebonne Parish. During normal HNC water levels, the gate will be open allowing canal traffic and water flow to pass through the opening. At the threat of impending weather, the swing barge gate will be dewatered to a floating position, winched into position across the HNC, and ballasted into a close position against two (2) receiving structures. This project will result in the design of the gate, receiving structures, floodwalls, pumps, winches, and pull structure necessary for the operation with the structural integrity needed to withstand the forces that will occur in a storm event.

Implications
Although this type of structure has been used in smaller waterways, it is thought that it could be utilized more in hurricane protection systems. This could reduce the overall initial cost thereby allowing more protection to be constructed. The HNC SBG will be the largest gate of this type constructed in Louisiana.

Specific Topics of Interest
General Project Overview – Specific design and construction challenges

Comparisons of differing gate designs - A conventional concrete monolith structure, a concrete swing barge with monolith concrete abutments, and a steel swing barge with steel abutments

Cost and schedule advantages of utilizing the Steel Swing Gate

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The Inner Harbor Navigation Canal Hurricane Protection Project Program Status & Lessons Learned During the Execution of USAGE' Largest D-B Civil Works Contract

Charles M. Hess[1]
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In April of 2008, the US Army Corps of Engineers awarded their largest ever Design-Build Civil Works contract to Shaw Environmental & Infrastructure, Inc. (Shaw E&I, Inc.) for the design and construction of the Inner Harbor Navigation Canal Hurricane and Storm Damage Risk Reduction Project. This critical component of the New Orleans hurricane protection system (sometimes referred to as the New Orleans protection system keystone) has been challenging on multiple fronts.

Implications
This presentation will address the lessons learned that have arisen from contract award to date on this non-traditional Corps approach to Civil Works Program execution, which in turn may decrease the cost and or time for these type projects.

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Navigation Impacts of the Lake Borgne Surge Barrier on the Gulf Intracoastal Waterway at New Orleans, LA

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New Orleans has been susceptible to flooding since its inception in 1718. After the passage of Hurricane Betsy in 1965, the establishment and maintenance of storm surge protection for the city was widely recognized as an important element of the city infrastructure. As a result, protection from such flooding is important to the United States Army Corps of Engineers (USACE). The occurrence of Hurricane Katrina heightened interest in this high priority area. This presentation focuses on the numerical modeling of current velocities in the Gulf Intracoastal Waterway near New Orleans, LA. This modeling was done as part of the Lake Borgne Surge Barrier project. Adaptive Hydraulics (ADH), a USACE hydrodynamic code, was used for the modeling simulations.

Implications
A detailed description of two different flood protection structures is given as well as the resulting flow fields and qualitative conclusions. These simulations were run for boundary conditions from June 2006 and analyzed with emphasis on peak conditions such as maximum flood and ebb. The analysis focused on durations of events in which navigation may be impeded due to current velocities within the structures. Results from a separate simulation will be presented which illustrate vessel effects on the flow fields within the structure.

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Integrated Flood Management Planning in California's Central Valley

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California's Central Valley boasts the most agriculturally productive lands in the world, the State's political seat, the hub of a complex water supply system, a vibrant economy - and a long history of flooding. The devastation and loss of life along the Gulf Coast in 2005 raised public awareness of flood risks, prompting California voters to approve $5 billion in State funding for flood risk management in 2006 and legislators to pass several bills addressing flood protection and liability in 2007. As part of this legislation, the California Department of Water Resources is required to prepare a sustainable, integrated flood management plan for the Central Valley by 2012. The Central Valley Flood Protection Plan (CVFPP) is being developed in close coordination with local, regional, and federal partners and stakeholders. This presentation will describe the strategy for development of the CVFPP recognizing the interconnection of flood management actions within the broader water resources management and land-use planning setting; the need to coordinate across geographic and jurisdictional boundaries and consider system-wide implications; and the importance of environmental stewardship and sustainability.

Implications
Successful flood management planning in California must balance public safety with economic and environmental sustainability, while recognizing the values and perspectives of a broad range of stakeholders. Further, planning efforts must provide a broad canvas for decision-makers to assess trade-offs and apply regional and local values. Strategies and lessons learned from this effort are directly applicable to restoration and protection planning along the Gulf Coast.

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The Ground is Moving - The Use of Wick Drains and Staged Construction in Orleans Parish Levee Construction over Very Soft Soils

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"LPV 109.2a" is a 7.5 mile reach in New Orleans East. The existing levees will be raised approximately four to seven feet with a protected side raise on virgin ground. The new levee construction requires embankment construction in two stages to heights of 18 to 22 feet above existing grades of the tidal marsh. The raise will be accomplished with the use of stability berms, wick drains and high-strength geotextiles.

The subsurface conditions indicate soft clay deposits to depths of 30 to 40 feet below the ground surface. To allow for strength gain in the soft clay soils and to avoid a shear failure, the levee construction will be accomplished in two controlled stages with approximately a three-month waiting period between completing Stage 1 and the construction of Stage 2. Wick drains (150 to 220 feet in width) will be installed at a five feet triangular spacing to a depth not closer than 6 feet from any pervious sand stratum. The wick drains shorten drainage paths for the pore water to exit the compressible clay soils and thus reduce the time for settlement and strength gain. A test section was designed and constructed to optimize the wick drain design and estimate time of consolidation for the staged construction. High-strength geotextile reinforcement will be installed to increase stability and meet appropriate factors of safety.

This presentation will describe the design methodology and challenges. These include: a SEEP/W finite-element seepage analysis in the design of the drainage blanket and wick drains; a fully instrumented test embankment with three wick drain spacings to optimize the wick drain design; the slope stability analyses with high-strength geotextiles; site characterization of soft clays with triaxial shear UU testing, cone-penetrometer testing, and vane shear testing; and stability analyses of soil mixing panels under drainage structures.

Implications
The uses of these techniques allow the levee to be constructed and put into service in an expedited way. These techniques greatly reduce the time of settlement from years to months allowing for construction of higher fills because of the soil's rapid strength increase. The use of the wick drains and staged construction resulted in a very cost-effective solution to raising levees over soft soils, and reduced the construction duration significantly.

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Sediment Management

Concurrent Session I: Sediment Management I

An Overview of Sedimentary Resources for Coastal Restoration and Protection in Louisiana
Syed M. Khalil[1] and Charles W. Finkl[2],
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Potential Sand Resources in Buried Paleo-channels on the Continental Shelf Offshore Coastal Louisiana
Charles W. Finkl[1] and Syed M. Khalil, [2],
[1]Department of Geosciences, Florida Atlantic University, [2]Louisiana Applied Coastal Engineering & Science Division

Tiger and Trinity Shoals Complex: A Potential Sand Source for Coastal Restoration in Western Louisiana
Clint H. Edrington[1], Harry H. Roberts[1], and Syed M. Khalil[2]
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Delta Deposition in the Northern Gulf of Mexico as Modulated by Sea Level
Harry H. Roberts
Coastal Studies Institute, Louisiana State University

Concurrent Session VII: Sediment Management II

Sediment Inventory for Federal Navigation Channel Maintenance in Louisiana: A Resource Tool for Coastal Planners
Edward Creef[1] and **Jeff Corbino**[1]
[1]US Army Corps of Engineers, New Orleans District

Simulation and Analysis of Sediment Transport in Calcasieu Ship Channel and Surrounding Wetlands
Ning Zhang, Saikiran Yadagiri
Department of Engineering, McNeese State University

A National Sediment Monitoring Network
Jim Stefanov
US Geological Survey

Poster Presentations

Geological Framework of the Tiger and Trinity Shoals Complex: Relics of the Early and/or Middle Holocene Mississippi River Delta… Yet Possible 'Reincarnation' as a Sand Resource for Today's Modern Delta
Clint H. Edrington[1], Harry H. Roberts[1], and Syed M. Khalil[2]
[1] Louisiana State University, [2] Office of Coastal Protection and Restoration
STUDENT POSTER – 1st Place in SOC Student Poster Contest

Preservation and Resource Potential of Fluvial and Marine Deposits Along the Louisiana Inner Shelf: Characterizing the Geologic Framework to Support Coastal Management
James Flocks[1], Michael Miner[2], Mark Kulp[3], and S. Jeffress Williams[4]
[1]U.S. Geological Survey, Center for Coastal and Watershed Studies, [2]Pontchartrain Institute for Environmental Sciences, University of New Orleans, [3]Department of Earth and Environmental Sciences, University of New Orleans, [4]U.S. Geological Survey, Science Center for Coastal and Marine Geology

Are Federal Sandy Shoals off Louisiana Ecologically Important?
Gelpi, G. Carey Jr.[1], Richard Condrey[1], John Fleeger[1], Mark Grippo[1], Stanislas Dubois[2], Greg Stone[1], Felix Jose[1]
[1]Louisiana State University, [2]French Research Institute for Exploitation of the Sea (IFREMER)
STUDENT POSTER – 2nd Place (tie) in SOC Student Poster Contest

Louisiana Sand Resources Database - Compiling, Standardizing and Utilizing Geoscientific Data
Melany Larenas[1], Syed Khalil[2], Jeff Andrews[1], and Kenneth Duffy[3]
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Long-Term Sediment Yields from Six Coastal Watersheds in the Northern Gulf of Mexico
Yi-Jun Xu[1], **Timothy Rosen[1]**
[1]Louisiana State University Agricultural Center
STUDENT POSTER

Effect of Externally Generated Turbulence on Sediment Transport
Heather D. Smith[1], Agnimitro Chakrabarti[1]
[1] Louisiana State University

An Overview of Sedimentary Resources for Coastal Restoration and Protection in Louisiana

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Louisiana's environmentally sensitive marshlands, beaches, and dunes require remediation if this destructive trend is to be mitigated. This can be achieved by placing dredged sediments on degraded beaches, dunes, and marshes. Restoration efforts will be severely compromised if sufficient compatible sediment is not located either offshore on the continental shelf or in rivers (main channel or distributaries). Sediment volumes required for initial restoration of degraded coastal Louisiana are estimated to be in the range of hundreds of millions of cubic meters. Barrier island restoration requires large sand volumes that must be dredged from offshore sources and pumped or transshipped to the project areas. Fluvial sand/sediment resources from the Mississippi River are not yet cost effective for barrier island restoration. These sediments can, however, restore interior marshes if sediment diversions are placed in appropriate locales. Qualitatively compatible and quantitatively adequate sediment is thus a vital factor in restoration efforts with almost 80% of the restoration-budget allocated to exploration, exploitation, and emplacement of sediment. Restoration and protection of coastal Louisiana thus requires a systematic approach in exploration of offshore sand as well as geoscientific data management that manages an enormous amount of geotechnical data to effectively reduce costs. The Louisiana Sand Resource Database (LASARD) has been initiated in response to this need to function as a database primarily for managing enormous amounts of historical and current geoscientific data. In order to be successful in its present enormous undertaking of restoring and protecting coastal Louisiana, the State needs a planned systematic approach to its marine sedimentary resources. This talk will provide an overview of sediment/sand resources in coastal Louisiana and will also emphasize the need of a regional approach of managing sediment. The Louisiana Sediment Management Plan (LASMP) which has been conceptualized and formulated for better planning and coordination and will be presented for the first time to the scientific community.

Implications
Restoration efforts for sediment starved systems such as those that occur along the Louisiana coast depends on emplacement of sufficient sediment volume to build up barrier and deltaic systems. Qualitatively compatible and quantitatively adequate sediment is thus a vital factor in restoration efforts with almost 80% of the restoration-budget allocated to exploration, exploitation, and emplacement of sediment. Because this cost is directly proportional to the distance of borrow sources from the project area, the success of restoration depends on locating sufficient sediment volumes that are suitable for placement on beaches and dunes, and for creating marshes. However, it is realized that identification and delineation of sand/sediment resources is not enough. A very systematic effort on a regional basis is needed for a planned and coordinated approach to restoration and protection of Coastal Louisiana which will be provided by the Louisiana Sediment Management Plan.

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Potential Sand Resources in Buried Paleo-channels on the Continental Shelf Offshore Coastal Louisiana

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Deltaic sands in the Mississippi Delta region off Louisiana are vital to restoration of barrier islands due to the large volumes that are required. The cost-effective search for quality sand in a predominantly muddy environment needs a comprehensive and systematic approach. Analyses of high-resolution seismic reflection profile survey data, for example, shows that much of the delta region seafloor is characterized by fine-grained (muddy) deposits that are occasionally interspersed by sand deposits in paleo-distributaries and inter-distributaries of abandoned delta complexes, delta front sands, and shoal sands. Sand deposits are mostly identified as acoustically transparent facies whereas fines are discernable as layered signatures. Seismic profiles show that large distributary channels can occur as singularities or as broad channel fields comprised by smaller distributary channels. These kinds of channels range up to 30 m in thickness but average about 15 m. The textural characteristics of distributary deposits are highly variable, ranging from 20% to 90% sand. Distributary channel sands may be exposed on eroded seafloor or buried by sheets or splays of mixed sediments (muddy overburden). The thickness of muddy overburden is crucial, from a cost-benefit point of view, to exploitation of underlying channels sands. Generally, a ratio of 1:1 (muddy overburden to channel sand) is a cutoff value below which exploitation becomes uneconomical. It is not economical, for example, to sidecast 3 m of muddy overburden to exploit 1 m of channel sand (3:1 ratio) but if 1 m of muddy overburden covers 3 m of channel sands (1:3 ratio), then it becomes economically attractive to mine the sand. Because parts of some buried paleo-channels contain sands that are suitable for barrier island restoration, these deposits should be further studied to ascertain their potential as a sand resource. They retain comparative advantage when they occur closer to projects than do sandy shoals and banks.

Implications
Offshore sand and mixed sediment deposits are finite resources, the use of which must be judiciously applied if the needs of barrier island restoration are to be met. Although large sand bodies occur offshore in shoals and banks, their great distance from some restoration sites increases transport costs. Because sand resources in some paleochannels occur closer to project sites, it thus seems responsible to investigate the potential of paleochannels as sediment sources for restoration work in coastal Louisiana. Determination of sand resources in paleochannels via geophysical and geotechnical means has important implications to project cost and availability of additional sediment sources in a shelf region that known for its extensive fine-grained sediments (*i.e.* muds) and limited supply of coarser grained sandy deposits that are required for beach and dune restoration. Location of usable paleochannel deposits closer to restoration sites will reduce overall project costs and increase marine sand reserves.

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Tiger and Trinity Shoals Complex: A Potential Sand Source for Coastal Restoration in Western Louisiana

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During the transgressive phase of delta building, a sediment starved delta lobe succumbs to subsidence and physical oceanographic processes, and is eventually reworked into a submarine shoal. Two such shoals, located on the western Louisiana inner continental shelf, are Tiger and Trinity Shoals. These adjoining submarine sand bodies are thought to be remnants of separate Holocene Mississippi River delta lobes. A study was sponsored by Minerals Management Service (MMS) and Louisiana Office of Coastal Protection and Restoration (OCPR) to evaluate the potential dredgeable sand from these bodies to help facilitate coastal restoration in this part of Louisiana Coast. An initial marine geophysical survey collected approximately 1,150 km of high resolution subbottom profiles (chirp sonar) across the study area. Based on initial interpretations of profiles, 46 vibracores were extracted. Cores were analyzed for sedimentological studies and also sampled for geochronological studies. Analyses and synthesis of preliminary results reveal both similarities and contrasts between Tiger and Trinity Shoals. The sand fraction of both shoals decreases vertically in grain size with depth, and laterally from east to west. However, the sand in Trinity Shoal is almost entirely very-fine sand, whereas the sand in Tiger Shoal's ranges from medium sand in its extreme eastern section to very-fine sand towards west. The stratigraphic framework of the study area as interpreted from the subbottom profiles indicates that the Tiger shoal is lesser both in thickness and in surficial area than Trinity Shoal. This obviously is an indication that volume of sand in Tiger Shoal is much less than in Trinity Shoal. This study also intends to shed light on geochronology and stratigraphic architecture of both the shoals by evaluating the sedimentology, stratigraphy, and depositional history of Tiger and Trinity Shoals.

Implications
The dredging of offshore sand resources for coastal restoration projects has the potential to play a critical component in the overall effort to mitigate land loss in south Louisiana. However, the delineation of sand resources is not enough. There are other factors viz. the high cost of dredging, transportation, and then emplacement which are crucial for any restoration project. Coastal managers need data on sand volumes along with the physical properties of delineated sand sources for cost-benefit analysis, whereas coastal researchers need information of depositional models to exploration offshore sand resources. This study will provide geological and geophysical data of the sand resources of Tiger and Trinity Shoal Complex to both the communities.

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Deltaic Deposition in the Northern Gulf of Mexico as Modulated by Sea Level

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Deltaic deposition in the northern Gulf of Mexico has taken place under constantly changing conditions of sea level during Quaternary times. During this period, sea level has fluctuated well over 100m in repeated cycles of approximately 140kyrs duration. Each cycle has involved global cooling and glaciation resulting in a falling sea level followed by global warming and deglaciation resulting in a sea level rise. These cycles have forced the advance and retreat of fluvial-deltaic depositional systems as they tracked sea level across the continental shelf. The preservation potential of fluvial and deltaic deposition associated with these cycles is greater at the shelf edge and in the deeper Gulf than updip sites on the continental shelf and near the present shoreline where erosion during transgressions and entrenchment during periods of sea level fall erode previously deposited sediments. The result is stacked deltas at the shelf edge and stacked fans on the continental slope and basin floor, products of multiple sea level and associated depositional cycles. The imprint of these cycles on the continental shelf is quite different. The shelf is characterized by multiple entrenched alluvial valleys and channels as well as highly eroded delta remnants. Sand bodies developed from the concentration of coarse sediments related to the erosion of deltaic and other coastal sediments are also present (e.g. the submarine shoals and barrier islands off Louisiana and the sand ridges off Mississippi, Alabama, and western Florida). Over the rising -to-high part of the latest Pleistocene-to-Holocene sea level cycle, the Mississippi River produced a series of six major delta-building pulses that have built the delta plain as we know it today. Following the latest Pleistocene glacial maximum, sea level rose rapidly from approximately -120 m, which is beyond the present shelf edge break in slope, to a few meters from present levels. However, at approximately 7-8 kyrBP the rapid sea level rise rate decreased significantly. At this point, all the world's great rivers started delta-building and sedimentation from the Mississippi River was able to prograde the coastline and not simply fill and backstep into the large alluvial valley produced during the falling limb of the sea level cycle. These events have determined the depositional fabric and geomorphology of Louisiana's present coastal plain and shelf. A detailed knowledge of this geololgic framework is essential for making informed decisions concerning many aspects of coastal restoration.

Implications
Understanding the sedimentary framework of the modern Mississippi River Delta and its alluvial valley are fundamental to the success of must coastal restoration efforts. Knowing where to explore for sands to rebuild our disappearing barrier islands, where best to extract sediments for building coastal protection structures, estimating where subsidence that impacts restoration project effectiveness will be maximized and where it will be minimal, and where to place river diversions so they will be most efficient in building new land and enhancing surrounding marshlands are but a few examples that require a detailed knowledge of Mississippi River Delta history and associated geologic framework.

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Sediment Inventory for Federal Navigation Channel Maintenance in Louisiana; A Resource Tool for Coastal Planners

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The U.S. Army Engineer District, New Orleans (MVN), maintains over 2,800 miles of waterways in Louisiana, and implements the largest maintenance dredging program in the nation. An average of 67 million cubic yards (mcy) of dredged material are removed annually from 11 major navigation channels extending across the coast from Texas to Mississippi, and as far north as Simmesport. Funding allocated to maintenance allows for the average annual beneficial use of about 16.5 mcy of dredged material for marsh creation, beach nourishment, barrier island restoration, and construction of "bird islands". To date, over 39 square miles of these coastal habitats have been created during routine channel maintenance. Additional beneficial use opportunities are limited by dredged material suitability, availability of sites for inland and ocean channel reaches, and other operational constraints. A dredged material inventory for MVN has been compiled from dredging records over the last decade that includes dredging quantities and frequencies, general sediment quality, and current placement practices for each channel reach. This inventory will help coastal restoration planners locate potential sediment resources near project sites, develop engineering solutions for transporting dredged material to project sites, generate cost estimates for placement alternatives, and identify obstacles to transport or placement of material based on current land-use and infrastructure within the project area.

Implications
The utilization of sediments removed during annual maintenance dredging of Federal navigation channels for coastal restoration has lately become a topic of increased focus. This presentation seeks to correct misinformation that has been circulated in the press regarding dredging and disposal practices, and promote partnerships with coastal restoration groups to increase beneficial use of this resource. An inventory of sediments proposed for removal during future maintenance events will provide coastal planners an opportunity to identify sediment sources for restoration projects or find new applications for dredged material that will help achieve restoration goals.

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Simulation and Analysis of Sediment Transport in Calcasieu Ship Channel and Surrounding Wetlands

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Calcasieu Lake is one of the major watersheds in the Chenier Plain. The Calcasieu Ship Channel passes through the Calcasieu Lake and connects the port of Lake Charles to the Gulf of Mexico. The ship channel is getting deeper and wider and thus altered the circulation of the lake water significantly, thus causes some problems. One of the problems is the excessive sedimentation found in the ship channel. Millions of dollars have to be spent each year to remove the unwanted sediments. It is very important to identify the source in order to prevent and reduce the sediments in the future. The numerical simulations were conducted to study the sediment transport in the entire system, including the watersheds and wetlands. The area of the interests includes the entire Calcasieu Lake, the Calcasieu Ship Channel, the Calcasieu River, and parts of the Intra-Coastal Canal connected to the ship channel. Particle tracking technologies will be applied in addition to the hydrodynamic simulations results to show the path of sediment particles. Mineralogical analysis of some collected samples was also conducted to assist the simulations by providing required data, as well as serving as validations. The study provides a better understanding of the entire dynamic system, therefore, make it possible to predict the sources of the sediments in the ship channel.

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National Sediment and Water-Quality Monitoring Network

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A National Sediment and Water-Quality Monitoring Network, composed of some 400 to 450 sites is proposed for implementation at an annual estimated cost of $75-$90 million. This level of funding will generate a nationally consistent data set that will help address the environmental, engineering, and socioeconomic impacts associated with sediments, nutrients, and sediment-associated chemical constituents (see Constituent List, p. 4) While the cost of this program is not minor, it can be shown to amount to <1% of the current annual estimated costs for dealing with ongoing sediment and water-quality issues. The proposed monitoring program will not only establish a long-term historic record, but will improve the science surrounding sediment and water-quality monitoring, as well management capabilities for maintaining sustainable national water resources. This monitoring program will build on, fill in the gaps, and provide a nationally consistent framework for existing and future programs, and permit the tracking of sediments, nutrients, sediment-associated chemicals, and water quality from headwater streams Hydrologic Benchmark Network, through medium-sized river basins National Water Quality Assessment Program, through major river basins National Stream Quality Accounting Network, and ultimately to coastal outlets.

This proposal describes the need for a national network, but focuses on the thrusts and requirements for initiation of a Mississippi River Basin (MRB) Pilot Program. The MRB Program includes some 68 monitoring sites, at a cost of $18 million in the first year, and about $14 million per annum in subsequent years (see Budget, pp. 5-6, and Site Map, p. 4) and is proposed until it is subsumed by initiation of the National Network.

A MRB Pilot Program will address two major objectives:

1. Establish a sediment, nutrient, and sediment-associated chemical monitoring program for the Mississippi, Missouri, and Ohio Rivers, and their major tributaries, that can be used to compute accurate sediment, nutrient, and sediment-associated chemical budgets, at critical spatial and temporal scales, within acceptable and quantifiable error limits, and
2. Using the data collected and budgets computed in Objective 1, along with available historic data, determine the availability of sediment for various uses; trends in suspended-sediment concentrations (SSC), sediment character/grain size, nutrients, sediment-associated chemistry; and the impacts of spatial and temporal trends in these constituents on various economic, ecologic, and restoration activities and characteristics in the MRB.

Detailed goals, the approach, benefits, costs, monitoring locations, constituents to be monitored, and related information are contained in the main proposal at:
ftp://ftpext.usgs.gov/pub/er/va/reston/jrgray/mrb_proposal_mrb_sed_qw_full_proposal_1_27_2010

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***1st Place in the SOC Student Poster Contest** STUDENT

Geological Framework of the Tiger and Trinity Shoals Complex: Relics of the Early and/or Middle Holocene Mississippi River Delta… Yet Possible 'Reincarnation' as a Sand Resource for Today's Modern Delta

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During the transgressive phase of delta building, a sediment starved delta lobe succumbs to subsidence and physical oceanographic processes, and is eventually reworked into a submarine shoal. Two such shoals, located on the western Louisiana inner continental shelf, are Tiger and Trinity Shoals. These neighboring submarine sand bodies are thought to be remnants of separate Holocene Mississippi River delta lobes. However, neither their geochronology nor their stratigraphic architecture is adequately known. This study addresses this lack of understanding by evaluating the sedimentology, stratigraphy, and depositional history of Tiger and Trinity Shoals.

An initial marine geophysical survey collected approximately 1,150 km of high resolution subbottom profiles (chirp sonar) across the study area. Based on initial interpretations of profiles, 46 vibracores were extracted. Cores were logged and imaged using a GEOTEK core logger, described texturally, sampled at 50 cm intervals for grain size analysis, and sampled for various dating techniques. Preliminary results and further interpretations reveal both similarities and contrasts between Tiger and Trinity Shoals. First, the sand fraction of both shoals fines with depth, and from east to west. However, the mean sand fraction of Trinity Shoal is entirely very-fine sand, whereas Tiger Shoal's mean sand fraction ranges from medium sand in its extreme eastern section to very-fine sand westward. Second, the base of Tiger Shoal is at a much higher subbottom elevation than is the base of Trinity Shoal. Third, the stratigraphic framework of the study area establishes Tiger shoal as both thinner and smaller in area than Trinity Shoal; hence, Tiger Shoal is volumetrically much smaller.

Though research is ongoing, this study illuminates the retrogradational nature of shoal evolution, and suggests that Tiger Shoal was deposited post-Trinity Shoal, under higher relative sea-level conditions, and that its sediment delivery was on a much smaller scale and from a separate source.

Implications
The mining of offshore sand resources for coastal restoration projects has the potential to play a critical component in the overall effort to mitigate land loss in south Louisiana. However, merely locating sand resources based on bathymetric anomalies is inadequate when considering the high costs of extracting in situ sediment, transporting it, and then emplacing it at the site of restoration. Coastal Planners need accurate sediment budgets (e.g. precise grain size and volumes) for cost-benefit analysis, whereas coastal researchers need accurate depositional models in exploring for undiscovered sand resources. This study uses rigorous exploration techniques to provide such data in regards to Tiger and Trinity Shoals.

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Preservation and Resource Potential of Fluvial and Marine Deposits Along the Louisiana Inner Shelf: Characterizing the Geologic Framework to Support Coastal Management

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Comparative studies documenting the evolution of the southern Louisiana coastline during the past century demonstrate that shoreline retreat, land-loss and translocation occur at highly variable rates and magnitudes. Understanding the processes that drive this coastal evolution is key to effectively managing and reducing the degradation of this critical coastal environment. The Mississippi River Delta Plain is composed of a complex geometry of deltaic muds, deposited at various spatial scales. Interspersed within this muddy environment are discrete packages of sandier material that originated as the coarse fraction of the fluvial sediment discharge. During the life-cycle of a delta complex, as the river seeks a more favorable gradient, the delta lobe is abandoned and undergoes rapid land subsidence, primarily due to sediment compaction. In part this process leads to burial and preservation of the delta deposits, as the marine environment reworks some of the available sands into transgressive barrier shorelines. Numerous external factors interrupt this natural process and accelerate shoreline loss: 1) global sea-level rise; 2) reduced Mississippi River sediment load; 3) sediment bypassing of the delta plain to the deep shelf, and; 4) human alteration of sediment transport processes through shoreline alteration and sediment diversion. This suite of factors, punctuated by periodic scour from hurricanes, contribute to the deterioration of the barrier-island systems that protect interior wetlands and human infrastructure from normal wave activity and tropical storms. To combat this rapid land-loss, abatement measures along sandy barrier islands include shoreline nourishment with sediments of similar composition, a rare commodity in the sand-starved environment of the delta plain. The discrete sandy deposits preserved along the inner shelf are the few suitable deposits available for coastal restoration efforts. This presentation provides a summary of the fluvial and marine stratigraphy along the inner shelf of Louisiana, and the preservation and resource potential of these deposits.

Implications
Shoreline restoration projects are common along the Louisiana coast, and numerous more are planned in the future to slow erosion along the barrier island and headland systems and protect the fragile interior wetlands from degradation. Identifying material suitable for shoreline stabilization is a difficult task in the predominantly muddy environment of the Mississippi River Delta Plain. "Blind" resource investigations have proven to be costly and minimally effective in locating the relatively small and widely dispersed sandy deposits. To properly identify the location and spatial extent of these deposits, it is necessary to first understand the depositional processes responsible for their development. The USGS and it's collaborators have been actively providing insight into the geologic framework of the Louisiana coastal zone for decades, and continue to provide valuable information to coastal managers in support of their efforts to provide shoreline stabilization.

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***2nd Place (tie) in the SOC Student Poster Contest** STUDENT

Are federal sandy shoals off Louisiana ecologically important?

Gelpi, G. Carey Jr.[1], Richard Condrey[1], John Fleeger[1], Mark Grippo[1], Stanislas Dubois[2], Greg Stone[1], Felix Jose[1]
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Based on our study of Ship, Trinity, and Tiger Shoals, we suggest that they perform at least three important ecosystem functions.

Oxygen refuge: Due to their shallow depth and microalgal oxygen production, these three shoals are oxygenated refuges within the "Gulf of Mexico dead zone". During our sampling of the shoals, we consistently found bottom water oxygen values above 2 mg O_2/l, high diversity and abundance of amphipods (known to be sensitive to hypoxic conditions), and ecosystems best characterized as less intensely/frequently disturbed.

Blue crab spawning ground hotspot: Ship and Trinity Shoals are currently nationally important, under-recognized blue-crab spawning grounds with an abundance of prey resources and adequate bottom water oxygen. During our study, we discovered unexpected concentrations of spawning blue crabs. Our analysis reveals that the abundance, condition factor, and fecundity of these crabs compares with other nationally recognized, 'healthy', blue crab spawning grounds. In addition, we find that these crabs are in a continuous spawning cycle, April-October, and are able to produce new batches of eggs every 21 days.

Macroinfauna stepping stones/biodiversity hotspot: When compared with the surrounding muddy benthic environment of the Mississippi-Atchafalaya River depositional plain, these three shoals support unique macroinfaunal assemblages, contribute greatly to Louisiana-shelf biodiversity, and function as important stepping stones for US GoM macroinfauna metapopulations. Our study greatly increased the recorded number of macroinfauna species for the Louisiana continental shelf, extending the documented range of species previously reported from the Florida and/or Texas shelfs. Approximately 90% of these individuals occurred on sandy habitat, suggesting that our sandy shoals are important connectors for northern GoM macroinfauna metapopulations via larval transport/settlement.

Implications
Ship, Trinity, and Tiger contribute a great deal to the biodiversity of the Louisiana continental shelf, and provide previously unknown oxygen refuges and spawning/foraging ground hotspots for commercially important female blue crabs. These blue crab populations contribute larvae that potentially benefit the ~$30,000,000 blue crab fishery. These shoals have been seen as the best source of sand for the temporary renourishment of barrier islands and coastal beaches. Based on the data and scientific interpretations of those data, we recommend that the State takes serious considerations of our findings regarding future dredging off the coast of Louisiana for coastal restoration.

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Louisiana Sand Resources Database - Compiling, Standardizing and Utilizing Geoscientific Data

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The Louisiana Office of Coastal Protection and Restoration (OCPR) developed the LouisianA SAnd Resource Database (LASARD) to manage geological, geophysical, and geotechnical data pertaining to offshore sand/sediment searches. LASARD was established as a result of a multiyear cooperative program with the Mineral Management Service (MMS) for geoscientific data management. The objective of LASARD is to centralize relevant data from various sources for better project coordination and to facilitate future planning for delineating and utilizing sand/sediment resources for restoration in coastal Louisiana. Relevant information consists predominantly of geophysical (seismic, sidescan sonar, magnetometer, and bathymetry) and geological (vibracore, jet probe, grab sample, isopach) data. Oil and gas infrastructural data are also incorporated as it affects the delineation of borrow area and subsequent dredging. The database will be of significant value to coastal planners, scientists, engineers, and others interested in the coastal restoration in the northern Gulf of Mexico once it is populated and is made available to all its intended users through internet.

In order to populate data from various sources and the use of the archival data, these data had to be standardized and converted into a format that could be displayed and analyzed online. Data guidelines were established by OCPR to ensure data integrity (Khalil, 2008). These guidelines were recently refined using data that was compiled for use in a sand and sediment search investigation of West Belle Pass, LA. Improvements to the data structure now allow users to make substantial qualitative assessments about these deposits, which will facilitate the management of Louisiana's limited sediment resources. This new information has been added to the data structure that can be used to assess potential sediment resources. This refined structure will allow users to determine various sediment types and its geometry. Queries will now be able to be made to identify key deposit types. This new functionality will greatly aid the State of Louisiana in identifying resources which can be used to develop strategy for Louisiana Sediment Management Plan.

Implications

Sand and sediment resources in Louisiana are limited but crucial for restoration. The availability of these resources is further reduced due to oil and gas infrastructure offsets requirements. Infrastructure related to alternative energy and oil and gas production have the potential to dramatically impact unidentified sand resources. As per the latest requirement by agencies like MMS, dredging of sediment/sand cannot occur within 1000ft of wells, pipelines, cables or other related structures. It is therefore imperative that as many sand resources as possible be immediately identified and delineated in order to avoid these impacts. This talk will show how data that has been populated using the LASARD database structure can be used to identify potential sand resources. Data use and functionality will be demonstrated and the implications to planning will be discussed.

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STUDENT

Long-Term Sediment Yields from Six Coastal Watersheds in the Northern Gulf of Mexico

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The Louisiana coast has experienced sea-level rise, land subsidence, and coastal erosion over the past century. Concurrently, river engineering and dam construction have decreased sediment supplies to the continental shelf of the Northern Gulf of Mexico. As a result, the Louisiana Gulf coast has been subject to the highest rate of relative sea-level rise of any region in the United States. Several studies have reported large land loss of Louisiana's low-lying delta plain since the 1930's, highlighting the importance of sediment in coastal Louisiana and the need for research. This study utilized 40-year USGS data on total suspended solids (TSS) and discharge recorded near the mouths of six major costal Louisiana rivers, the Sabine, Calcasieu, Mermentau, Vermilion, Bayou Teche, and Pearl rivers in order to quantify long-term sediment delivery, seasonal and interannual variability, and the relationships between sediment transport and hydrologic conditions of these six coastal rivers. A TSS - discharge rating curve was developed for each of the rivers. Daily, monthly, and annual TSS mass loadings were calculated. The results showed that on average the six rivers delivered a total of approximately one million metric tons/year of TSS into the Gulf of Mexico, and that the delivery rate was highly correlated with the rivers' discharge. The Pearl River showed the highest TSS yield (0.5 million tons/year), while the Bayou Teche had the lowest (0.02 million tons/year). TSS concentrations were highest in all rivers during the spring and early summer months and lowest during the late summer and fall. Discharge peaked during the winter months and was the lowest during the summer/fall.

Implications
The results of this study provide insights into riverine sediment resources in coastal Louisiana. Such information is helpful for state and regional agencies to develop better sediment management strategies. This will contribute to ongoing efforts to rebuild and stabilize coastal areas by helping to implement more comprehensive sediment management plans that use all of these basins in conjunction with the Mississippi and its distributaries.

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Effect of Externally Generated Turbulence on Sediment Transport

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The interaction at the interface of the sediment bed and fluid is one of the largest challenges still to be resolved in water resources. Our ability to predict sediment transport at large scales is limited by our understanding of the physics dominating sediment movement in a variety of complex forcing regimes. Traditionally, numerical models describe transport as a function of the applied excess shear at the bed. While the complexity of models has increased due to the availability of computation power, sediment transport calculations still rely on a combination of spatial and temporal averages. Additionally, processes such as externally generated turbulence and wave driven pressure gradients can increase transport significantly. For example, laboratory experiments performed in Denmark indicate that a 20% increase in local turbulence levels in the bed shear stress increased the bed load sediment transport rate by a factor of 6.
In this work, we examine two scales of turbulence, the resolvable vortex motions and the parameterized turbulent fluctuations, and their effect on the temporally- and spatially-dependent bed stress. The flow around a fixed cylinder at varying locations from a fixed bed will be numerically simulated with a detailed, three-dimensional computational fluid dynamics model. The turbulence in the system will be resolved by using a Large Eddy Simulation closure scheme. This will allow us to identify the larger-scale vortex motions, namely the vortices shed from the cylinder, as well as increased turbulence in the system due to the presence of the cylinder in the flow. Comparisons of predicted and observed mean velocity and turbulent kinetic energy profiles will be presented. The temporal and spatial variations of the bed shear stress will be examined and the adequacy of averaged models will be discussed.

Implications
The State of Louisiana faces serious challenges with coastal erosion and subsidence. Restoration efforts have been focused on the ability to use sediment available from the Mississippi River to increase land building in vulnerable wetland areas. This work will expand our understanding of the limitations of numerical models in the prediction of sediment transport at large temporal and spatial scales.

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Soils of Diversion

Concurrent Session I: Soils of Diversions

Consequences of Increased Nutrient Loading to Coastal Marshes Belowground
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The Impact of the Caernarvon Diversion and Atchafalaya River Discharge on Louisiana Marshes
John Day[1], Robert Lane[1], Matthew Moerschbaecher[1], Ron DeLaune[1], Robert Twilley[1], Irv Mendelssohn[1], Joseph Baustian[1]
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Restoration of Thin-Mat Flotant to Thick-Mat Flotant: Effects of Planting, Fertilizer, and Grazing
Charles E. Sasser[2], **Jenneke M. Visser**[1], and Guerry O. Holm[2].
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Biodegradation in Wetland Organic Soils
William Orem[1] and Christopher Swarzenski[2]
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Poster Presentations

Impacts of River Diversions on Coastal Marshes
Robert R. Lane[1], John W. Day, Jr.[1], Robert R. Twilley[1]
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Long-Term Monitoring Of Coastal Louisiana Marshes with An Emphasis On Discrete Sampling Of Soil Organic Matter And Porewater Quality
Christopher M. Swarzenski[1], Thomas W. Doyle[2]
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Consequences of Increased Nutrient Loading to Coastal Marshes Belowground

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Most plant production by emergent coastal marshes occurs belowground. This belowground production adds to the accumulation of organic matter sustaining salt marshes as sea level rises, thus preventing excessive flooding, eventual plant death, and habitat loss. The ubiquitous nutrient enrichment of coastal marshes stimulating aboveground plant growth may result in higher rates of inorganic matter accumulation that compensates for some of the marsh flooding caused by sea level rise. But will the soil system be compromised? We conducted field experiments and observations at a combination of geographically diverse and regionally-specific sampling of above- and belowground plant biomass in western Atlantic and Gulf of Mexico marshes to understand the belowground responses of the dominant salt and fresh marsh plants to N, P, and Fe additions. The results indicate that nutrient enrichment may lead to lower root and rhizome biomass, and belowground production, and organic accumulation. Phosphorus additions, more than nitrogen, seems to reduce root and rhizome biomass accumulation in salt marshes. Higher soil respiration and a lower Eh are anticipated additional soil property changes, revealing a loss of belowground carbon. Further, the soil strength is reduced below the rooting zone. Several examples will be shown to demonstrate that the cumulative effects of increased nutrient loadings may be to decrease soil elevation and to accelerate the conversion of emergent plant habitat to open water, particularly at the lower elevation range of the plant and during the occasional large storm.

Implications
Sustaining and restoring coastal emergent marshes is more likely if they receive a lower, not a higher, nutrient load. This conclusion is at odds with the rationale for river diversions and sewage treatment wetlands in unconfined natural marshes when wetland conservation or restoration is the management goal. The results are consistent with the high land loss post-Katrina/Rita in the Caernarvon outflow path, but not in the reference marsh. A quantitative evaluation of the relations between river diversions and wetland soil ecosystems is needed. The increased nutrient loading from the Mississippi River watershed this century has also driven the formation of the low oxygen zone (Dead Zone) that forms off the Louisiana-Texas shelf each summer. Restoring either offshore or estuarine ecosystems necessitates, therefore, improving water quality in the watershed.

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The impact of the Caernarvon diversion on above and belowground marsh biomass in the Breton Sound Estuary

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Above and belowground biomass, porewater nutrients (NO_x, NH_4, and PO_4), salinity, sulfide, and soil Eh were measured bimonthly at the Caernarvon diversion at near ($N_{1\&2}$), mid ($M_{1\&2}$), far ($F_{1\&2}$), and reference ($F_{1\&2}$) stations. Aboveground and belowground decomposition was estimated using litterbags and belowground using cotton strips. Aboveground productivity as measured by EOSL peak standing crop ranged from 423 g/m^2/yr at site M_2 to 1515 at F_1. Aboveground productivity was significantly greater at N_1 than at N_2, M_1, or M_2. Peak belowground biomass ranged from 8315 g/m^2/yr at R_2 to 17890 g/m^2/yr at N_1. Sulfide and PO_4 were related to belowground and aboveground biomass, respectively. The decomposition bag data did not indicate a strong impact, but cotton strip decomposition rates at the Ref site were lower through most of the depth profile, however this difference was only significant at the lowest measured depth. Vertical accretion was 0.49-1.25 cm/y at N_1; rates>RSLR.

Implications
Analysis of the results of short-term accretion compared to RSLR indicates that all Caernarvon sites are keeping pace with RSLR. Analysis of porewater parameters showed that stress on plants was low to moderate while nutrient concentrations were greatest at the Near sites. Belowground productivity at the measurement sites at Caernarvon area is among the highest reported in the literature. Decomposition was not strongly increased. The results indicate that marsh productivity and decomposition were not significantly negatively impacted. The study sites were streamside locations where there were strong inputs of freshwater, nutrients, and sediments. The results suggest that diversions should maximize sediment input and allow for drainage.

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Restoration of Thin-Mat Flotant to Thick-Mat Flotant: Effects of Planting, Fertilizer, and Grazing.

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Floating marshes historically were widely distributed in the freshwater areas of the Mississippi River Deltaic Plain, and their present distribution remains widespread. However, in some areas vegetation associations have changed from thick-mat maidencane (*Panicum hemitomon*) dominated marsh to thin-mat spikerush (*Eleocharis baldwinii*) dominated. The effect of planting, grazing, and fertilizer application were tested at four thin-mat sites in northwestern Terrebonne parish. Grazing by nutria was the crucial factor in the survival of *P. hemitomon* at all sites. Grazing protection coupled with *P. hemitomon* transplantation doubled the root standing stock compared to control conditions of the thin-mat community. Simple grazing protection of the natural community did not produce increases in live root standing stock. The natural nutrient availability at the sites was adequate for the growth of *P. hemitomon*. Although fertilization initially stimulated aboveground coverage of *P. hemitomon*, after four years there was no statistically significant difference in end-of-season biomass of above ground plant material in non-fertilized versus fertilized treatments. The re-introduction of *P. hemitomon* into the thin-mat floating marsh built a thicker and stronger marsh mat. Marsh soil strength and mat thickness were both increased by *P. hemitomon* growth coupled with grazing protection. Soil strength gains were observed in the upper 20 cm of the soil profile. An additional 10 cm of mat thickness was observed above that of control conditions. Protection from grazing of the existing thin-mat marsh plant community did not enhance soil strength or apparent root mat thickness.

Implications:
Control of nutria populations is essential for the restoration of thin-mat flotant, while addition of additional nutrients may not be required for *P. hemitomon* growth. Since *P. hemitomon* has very low seed viability, re-establishment has to be accomplished using vegetative methods. Planting large areas is extremely costly and alternative establishment techniques need to be developed.

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Biodegradation in Wetland Organic Soils

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Many wetland environments form organic matter-rich soils or peats. Waterlogged conditions in wetlands inhibit oxygen penetration into the soil, and organic matter degradation is dominated by anaerobic microbial processes. Peat accretes because wetland primary production exceeds anaerobic biodegradation, especially biodegradation of aromatic and aliphatic structural components of vascular plant. Anaerobic biodegradation in peats primarily involves a consortium of microorganisms that preferentially decompose oxygen-rich substances, such as cellulose from vascular wetland plants and complex carbohydrates from algae. This has been demonstrated by changes observed in the elemental composition and the ^{13}C nuclear magnetic resonance spectra of peat organic matter with increasing depth (e.g. over time). The anaerobic biodegradation process leaves the peat organic matter enriched in only slowly biodegraded and oxygen-poor aromatic (lignin) and aliphatic structures (waxes).

Anthropogenic activities impact natural peat accretion in many wetlands (e.g. south Louisiana, the Florida Everglades, and the Sacramento River Delta). Water allocation practices may cause drying, oxidation, and loss of peat mass. Chemical substances introduced into wetlands can also impact peat accretion and the physical integrity of peat deposits. Nutrient contamination has complex effects, stimulating both wetland plant growth and peat accretion, but also anaerobic biodegradation of peat. The introduction of electron acceptors, such as iron (III), nitrate, and sulfate also stimulates microbial populations and anaerobic biodegradation of the peat. Sulfate can enhance biodegradation by causing nutrient release from wetland soils (internal eutrophication), and by acting as an electron acceptor in microbial sulfate reduction. Preliminary studies in south Louisiana and the Everglades have demonstrate the potential of sulfate to enhance anaerobic biodegradation and destabilize peat accumulations.

Implications
In this presentation we review processes that control the degradation of soil organic matter. Factors affecting these processes have the potential to alter the organic structure of the peat and influence wetland stability.

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Impacts of River Diversions on Coastal Marshes

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The Mississippi River supplied water to broad areas of the deltaic plain during high river stage, stimulating primary and secondary production throughout the delta. Flood-control levees have now completely separated the delta from the river. River diversions that mimic flooding of the Mississippi River have been implemented under the assumption that reconnection would have positive effects, such as increased above- and belowground wetland productivity. Recent research, however, suggests that high nutrient loading (over 200 gN m^{-2} yr^{-1} and 10 gP m^{-2} yr^{-1}) can lead to reductions in belowground productivity and increased decomposition. There is concern that wetlands effected by river diversions are also experiencing decreased belowground productivity and increased decomposition, making them more susceptible to damage by hurricanes. Loading rates into wetlands from river diversions, however, are much lower than those found to be harmful. For example, loading rates from the Caernarvon river diversion into the Breton Sound estuary are on the order of 10 gN m^{-2} yr^{-1} and 1 gP m^{-2} yr^{-1}. It is likely that other factors are contributing to wetland decline, such as nutria, which are attracted to and are highly abundant at nutrient rich wetlands. Studies have shown that exclusion of nutria by fences dramatically increases both above and belowground marsh growth. We suggest that diversion of river water into marshes can have contrasting impacts on belowground productivity depending on a number of factors, such as the nutrient loading rate, nutria density, hydrological modifications, and wetland type.

Implications
The results of this research provide insights into the effects of large-scale river input into the coastal marshes. The implications are massive since millions of dollars are being spent on restoration efforts using river diversions. There are many assumptions regarding the effectiveness of river diversions, and there are many covariables that influence that effectiveness. This analysis attempts clarify these issues so that better decisions can be made in future restoration efforts.

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Long-Term Monitoring of Coastal Louisiana Marshes with an Emphasis on Discrete Sampling of Soil Organic Matter and Porewater Quality

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A successful long-term monitoring plan for coastal wetlands will reflect a close balance between the minimum information required to meet the stated objectives and the resources available to obtain and sustain the data collection. We discuss an approach that emphasizes the health of the wetland soil, specifically soil organic matter and porewater. The soil integrates rapidly fluctuating surface water conditions, over multiple years in the case of soil organic matter, and weeks or months for porewater. This integrative property of soils enables discrete sampling at infrequent intervals. It makes the routine sampling of additional constituents beyond salinity, temperature and water level possible. Moreover, discrete sampling enables data collection at multiple depths. The additional constituents provide essential and unique information on the health and trajectory of a given wetland.

We compare data from over 12 years of discrete and continuous monitoring in the most challenging coastal environment, the oligohaline marshes, and also in the simplest zone, the saline marshes, to illustrate the approach. A sampling frequency of 6-8 weeks appears to be sufficient to collect the porewater data essential to determining marsh health. Soil organic matter quality involves determining its degree of decomposition. Several techniques to measure this property will be presented.

Implications
The emphasis on discrete sampling of soils complements the Coastwide Reference Monitoring System currently in place for coastal Louisiana wetlands. CRMS emphasizes the measurement of pond salinity and water level to determine the optimum growing conditions for plant communities representative of a particular salinity environment. Substituting discrete sampling with numerous constituents for continuous data collection sondes with few parameters may reduce costs and enhance the information return for managing the resource when combined with the thoughtful use of nearby surface water data collection platforms.

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Lessons Learned

Concurrent Session II: Lessons Learned I

Construction Lessons from East Grand Terre and Chaland Headland Restoration Projects
Andrew Wycklendt[1], **Gordon Thomson[1]**, Shane Triche[2], Rachel Sweeney[3], Barry Richard[4], and David Swigler[1]
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The Geology and Geophysics of a Sediment Diversion: Results from West Bay
Alexander S. Kolker[1], Michael Miner[2], Valerie Cruz[1], Mead A. Allison[3], Ashley Barker [1,4]
[1]Louisiana Universities Marine Consortium, [2]Pontchartrain Institute for Environmental Studies, [3]Institute for Geophysics, University of Texas, [4]Louisiana State University

Neck Deep in Mud at the Rockefeller Refuge
Brett L. Geesey, Daniel J. Heilman, and T. Neil McLellan
HDR Engineering, Inc.

Concurrent Session VI: Lessons Learned II

A Case Study and Lessons Learned Overview on the Design and Construction of the Goose Point/Point Platte Marsh Creation Project
Rudy Simoneaux[1], Whitney Thompson[1], Dain Gillen[1], Kevin Roy[2],
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Do Sediment-Subsidies Restore the Ecological Structure and Function of Submerging Deltaic Wetlands?
Irv Mendelssohn[1], Camille Stagg[1], Angela Schrift[1], Sean Graham[1] Michael Materne[2], and Matthew Slocum[1].
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The Hammond Assimilation Wetlands: What Went Wrong and How to Fix It
Gary P. Shaffer[1], William B. Wood[1], John W. Day Jr.[2], and Christopher J. Lundberg[2]
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Poster Presentations

Louisiana Barrier Island Restoration: The Raccoon Island Success Story
Loland Broussard[1], Ron Boustany[1], Michael Carloss[2]
[1] USDA, Natural Resources Conservation Service, [2] La. Department of Wildlife and Fisheries

Design and Construction Methods for Coastal Ecosystem Restoration – What's in your Quiver?
Daniel J. Heilman[1], T. Neil McLellan[1], and Robert C. Thomas[1]
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Design, Construction and Lessons Learned for the Lake Borgne Shoreline Protection Project (PO-30)
Russ Joffrion[1], Shannon Haynes[1]
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Effects of Terraces on Marsh Vegetation, Coastal Waterbirds and Nekton
M.K. La Peyre[1], J.A. Nyman[2],
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The Good, the Bad, and the Bivalves: Lessons Learned During a Large-Scale Oyster Reef Restoration Project in Southeast Florida
Anne McCarthy[1], Lynwood Powell[1], David Spennacchio[1]
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Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration Project
Michael Poff[1], Rachel Sweeney[2], Barry Richard[3], Russ Joffrion[3]
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Six Successful Projects Restoring Louisiana Barrier Islands
Patricia A. Taylor[1], Jeanene Peckham[1], Brad Crawford[1], Brad Miller[2], Daniel Dearmond[2], Darin Lee[2]
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Planning to Restore a Coastal Cypress-Tupelo Swamp Forest: Progress and Hurdles at the Midpoint
Kenneth Teague[1], Russ Joffrion[2], Brad Miller[2], Patricia Taylor[1], Chris Williams[2], Timothy Landers [1,3] and David McQuiddy[1]
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Lessons Learned from Backfilling Canals to Restore the Coast
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Construction Lessons from East Grand Terre and Chaland Headland Restoration Projects

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Each barrier island restoration project provides different challenges. The location and condition of the island, construction access, surrounding oil infrastructure, the location and characteristics of the borrow area, fill density, need for marsh fill containment, breaches, and tidal currents are just a few of the elements that can be distinctly different, even for projects that are located only a few miles apart.

Chaland Headland was constructed between March 2006 and January 2007. It involved the placement of 1.8M cubic yards of beach fill and 950,000 cubic yards of marsh fill. The borrow area was located just 2.5 miles southwest of the project area and contained both the marsh fill and beach fill material. This required sidecasting of the marsh fill prior to constructing the beach. Construction access dredging was required, as was the dredging of an oil infrastructure access canal. The sand section of the borrow area had silt contents varying between 10 and 40%, which affected the submerged construction slope. During the project the Contractor requested a change in the construction slope due to offshore loss and overfilling of the toe of the template. Determination of an appropriate construction slope will be one of the main points of discussion in the presentation.

East Grand Terre is currently under construction with completion expected by June 2010. This project has separate beach and marsh fill borrow areas. The sand borrow area contains less fines (5-15%) than the Chaland Headland borrow area and the Contractor is struggling to fill the seaward toe of the template. These two projects provide an ideal opportunity for comparison of the effect of design features on construction given their proximity and the use of the same dredge to construct both projects.

Implications

Dredging costs have been steadily increasing. This has resulted in the scaling back of project size (volume) to stay within budgets, which negatively impacts project performance. There are several measures that can be incorporated into the plans and specifications that can limit the risk to the Contractor and thus help reduce project cost. One of the key items is the expected cut to fill ratio and more importantly, the cut to pay ratio. Construction slopes can affect the expected cut to pay ratio and thus the price.

Other items such as available project volume, pumping distances, borrow area characteristics, construction access, oil pipelines, over dredge allowance, etc can have an impact on the construction cost. Some of these items cannot be controlled but other items can be optimized to meet the project goals while minimizing construction cost. A discussion of these various items would be useful for project reviewers and design engineers alike.

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The Geology and Geophysics of a Sediment Diversion: Results from West Bay

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It is widely accepted that coastal management plans for Louisiana should focus on partially diverting the flow of the Mississippi River in a way that would reintroduce freshwater, nutrients, and sediment to degrading coastal wetlands and ultimately build new land in areas that are currently open water. Despite excellent studies on the ecological impact of these diversions and historical examples of land-building from quasi-natural diversions in the form of modern subdeltas, little is known about land-building potential under present Mississippi River sediment regime and flow conditions. Here we present preliminary results of an analysis quantifying and characterizing sedimentation trends associated with the West Bay Diversion, the largest operational diversion designed specifically to build new land. Chirp sonar subbottom profiles reveal a 5 to 25-cm thick horizontally-laminated seismic package covering an area of several km^2. Sediment cores indicate that the laminated seismic packages are characterized by interbedded silty clays and fine sands. Other areas of the bay are characterized by a scour surface that is actively incising into bay and relict subdelta deposits, indicating that depositional processes do not dominate all areas of West Bay. In order to determine seasonal sediment deposition rates, cores were collected in May2008, June2009, and September 2009 for ^{7}Be (a naturally occurring, particle reactive radionuclide with a half-life of 53 days) analysis. Preliminary results show that deposition rates during high-flow events can be an order of magnitude greater than times of lower discharge. Ongoing investigation into longer-term patterns of sediment accumulation using ^{137}Cs and ^{210}Pb (half-lives of 30 and 22.3 yr respectively), in combination with results from geophysical surveys, will help to constrain the contribution of high-flow events in the long-term sedimentation record and assess their preservation potential in West Bay.

Implications
Improved understanding of the early depositional-erosional response of receiving basins to introduction of fluvial sediment load and discharge is important for developing adaptive management plans for existing diversions, strategically selecting sites for new diversions, and quantifying the temporal and spatial land-building expectations of sediment diversions. Moreover, identifying and quantifying the controls on sediment deposition and retention rates over various timescales provides much needed information to help design and manage future diversions to efficiently achieve their maximum land-building potential and ensure that limited restoration funds are invested wisely.

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Neck Deep in Mud at the Rockefeller Refuge

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Currently, 25 to 35 square miles of wetlands are lost each year along coastal Louisiana. The reasons for the loss are many and complex and vary among different locations within the state. One of the most rapidly eroding portions of the Louisiana Gulf shoreline is at the Rockefeller Wildlife Refuge in Cameron Parish. Estimates of long-term shoreline retreat range from 30 to 40 ft/year (Byrnes et al. 1995). Severe storms such as Hurricane Ike in 2008 can cause more than 50 ft of erosion over a few days. To combat the direct loss of wetlands at the Rockefeller Refuge, the Louisiana Office of Coastal Protection and Restoration (OCPR) teamed with the National Marine Fisheries Service (NMFS) to implement the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18, CWPPRA Priority Project List 10). The project intent is to halt erosion along the 9.2 mile portion of the Refuge west of Joseph Harbor Bayou. Due to the challenges presented by extremely soft soils, requirement to protect the shoreline for up to hurricane conditions, and limited construction budget, a smaller demonstration project utilizing three alternative shoreline protection designs was proposed and constructed. This presentation will describe the overall project from the initial conceptual development through the construction of the demonstration portion of the project. The focus will be on the challenges of designing and constructing structures for hurricane conditions in soft soils along a Gulf-exposed portion of Louisiana's coast.

Implications
Due to the extremely challenging site conditions found within Louisiana's coastal areas, the use of conventional design and construction techniques can be impracticable for coastal protection and restoration projects. Throughout the design of the demonstration project, many alternative solutions were evaluated. Each alternative was evaluated not only for stability in the poor soil conditions and hydraulic stability, but to also be a cost efficient solution. This presentation will review the evaluation process and discuss how the alternatives eventually built were chosen. Some of the lessons learned throughout the construction process will also be discussed, as these lessons will need to be incorporated into the design of the full 9.2 mile project, as well as other protection projects located along the Louisiana Gulf coast.

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A Case Study and Lessons Learned Overview on the Design and Construction of the Three Benchmark Marsh Creation Projects

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Over the past two years the Office of Coastal Protection and Restoration (OCPR) has been responsible for the planning, design, and construction of three benchmark marsh creation projects: Goose Point/Point Platte Marsh Creation (PO-33), Dedicated Dredging on the Barataria Landbridge (BA-36), and the Mississippi River Sediment Delivery System at Bayou Dupont (BA-39). PO-33 is located in the Lake Pontchartrain Basin along the northern shoreline of Lake Pontchartrain. The project involved the creation of over 550 acres of marsh and was constructed with approximately 3.1 million cubic yards of hydraulically dredged sediment from Lake Pontchartrain. BA-36 is located in the Barataria Basin near the confluence of Bayou Perot and Bayou Rigolettes. The project involved the creation of over 2000 acres of marsh and was constructed with approximately 9.3 million cubic yards of hydraulically dredged sediment from Bayou Rigolettes. BA-39 is located in the Barataria Basin along the lower Mississippi River. The project involved the creation of 500 acres of marsh and was constructed with approximately 3.5 million cubic yards of hydraulically dredged sediment from the Mississippi River. The restoration technique involving wetland creation via hydraulically dredged sediment has been utilized for decades. However, OCPR engineers have advanced this practice by employing advanced settlement/consolidation estimation techniques, pioneering innovative slurry transport measures, and rethinking traditional fill site dewatering methods on these three projects.

While the design aspects may tend to appear somewhat simplistic, the underlying message to be conveyed during this presentation involves the numerous logistical challenges that each project team encountered throughout the development and construction of these projects. This Case Study includes a description of the techniques utilized throughout the engineering and design process, an overview of the modeling and tests that were performed, a summary of the data collected, the steps that were taken to ensure environmental compliance, and lessons that were learned once construction was initiated. The primary focus involves the challenges of using a slurry pipeline conveyance system, the behavior of dredge material slurry during construction (containment dike configuration, dewatering scheme), and predicting the long term marsh platform elevation of a marsh creation project (self-weight consolidation, long-term settlement).

Implications
Over the past decade hydraulically dredging and pumping dredged slurry to create marsh habitat has become one of the most effective and efficient restoration techniques utilized in Coastal Louisiana. This Case Study demonstrates the different challenges faced by OCPR Project Teams throughout design and construction of three distinct marsh creation projects and the practical steps that were taken to overcome numerous setbacks. Many of the same technical, logistical, and constructability issues may be encountered on projects dealing with dredged material slurry. Therefore, the information conveyed in this Case Study may be applicable to scientists, engineers, and project managers during the planning and design of future marsh creation projects.

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Do sediment-subsidies restore the ecological structure and function of submerging deltaic wetlands?

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Global changes in climate, sea level, hurricane activity and land-use have the potential to substantially affect the sustainability of deltaic ecosystems and to challenge restoration attempts. We have evaluated the potential for sediment-slurry restoration to restore and rehabilitate the ecological structure and function of coastal wetlands. The sediment subsidy provided by this restoration approach increases surface elevation, a result essential for the sustainability of salt marshes during periods of sea level rise. This presentation summarizes results from a series of individual studies at multiple sites that assessed plant ecological and soil physico-chemical responses to different intensities of sediment subsidy in salt marshes experiencing high rates of relative sea level rise. Sediments were hydraulically dredged with a high fluid to solids ratio and dispersed into coastal marshes. Sediment subsidies increased soil mineral matter, and, in turn, soil fertility and marsh elevation, and thereby reduced nutrient deficiency, flooding, and interstitial sulfide stresses. Positive effects of the sediment subsidy were still quantifiable at one restored marsh 15 years after sediment-addition. Evidence is provided that sediment subsidies promote the ecological integrity and longer-term sustainability of tidal wetlands via evaluations of system metabolism, organization, and resilience (the capacity of the system to recover from disturbance). Relative to system resilience, we found that sediment-slurry enrichment, not only increased salt marsh resilience in the near-term (8-years post sediment-addition), but that the positive effect of sediment-addition was still evident after 15 years. Salt marshes that received moderate intensities of sediment-slurry addition with elevations within the mid to high intertidal zone were more resilient than natural marshes in this submerging delta. Our research indicates that the ecological structure, function and resilience of deltaic wetlands are enhanced by appropriate intensities of sediment subsidy to subsiding deltaic wetlands, thereby, promoting their sustainability.

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The Hammond Assimilation Wetlands: What Went Wrong and How to Fix It

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Outfall of secondarily-treated wastewater into Four-Mile Marsh began fall, 2006. During the 2007 growing season, both herbaceous vegetation and baldcypress seedlings produced significantly greater aboveground biomass at the effluent site than in a nearby control marsh. Furthermore, the highest rates of production were proximal to the outfall area and vegetative production decreased linearly with distance from outfall. Nutria (*Myocaster coypus*), which are known to be attracted to high-quality vegetation, recruited to the area *en masse* and quickly devoured most of the vegetation. By spring 2008, much of the marsh had been converted to open water and the most extensive damage occurred closest to the outfall area. Despite killing over 2,000 nutria to date, much of the area remains as open water. However, mature baldcypress adjacent to the outfall are growing about 15 mm in diameter per year compared to 1-2 mm in the rest of the Maurepas swamp. Additionally, waterfowl use of Four-Mile Marsh has greatly increased.

To restore Four-Mile Marsh, a second outfall area needs to be established in the forests of Joyce Wildlife Management Area to the south, or a closer baldcypress – water tupelo forest to the east of the current outfall site. This would enable pulsing of the treated wastewater and periodic drawdown, which should enable reestablishment of a healthy herbaceous marsh and will greatly improve ecosystem function of the receiving forest. Adequate management of nutria populations will remain a challenge.

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Louisiana Barrier Island Restoration: The Raccoon Island Success Story

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The Isles Dernieres barrier island chain in Coastal Louisiana is experiencing some of the highest rates of erosion of any coastal region in the world. The rapid degradation of these islands has resulted in a decrease in the ability of the island chain to protect adjacent landward coastal marshes and swamps from the effects of storm surge, saltwater intrusion, increased tidal prism, and frequent storm waves. Raccoon Island, which is the westernmost island in the Isles Dernieres chain, is one of the few barrier islands with extensive mangrove habitat. As a result, the island is also host to a large colony of nesting seabirds, including the endangered brown pelican, which is increasingly vulnerable to the effects of storms as a result of the rapidly eroding shoreline. As part of a comprehensive barrier island restoration plan, the Raccoon Island Breakwaters Demonstration Project (TE-29) was initiated to examine the effectiveness and feasibility of using segmented breakwaters in mitigating shoreline erosion along Louisiana barrier islands, and to evaluate the potential use of breakwaters in future barrier island protection and restoration efforts. Eight segmented breakwaters were initially constructed in 1997. By 2004, it was estimated that the land mass protected by the breakwaters had a net gain of 9.6 acres. During the same period, the area not protected by the breakwaters suffered a net loss of approximately 28 acres, which is within the historic range of pre-project acreage loss. A U.S. Geological Survey analysis similarly estimated that the island had gained 10.8 acres in the protected area and lost 25.4 acres in the unprotected area during the period 1996 (preconstruction) to 2003. Because of the success of the project an additional eight breakwaters (TE-48) have been constructed to complete gulf side protection across the entire vegetated portion of the island.

Implications
The use of segmented breakwaters across the coast of Louisiana have proven they are an effective and cost-efficient means of protecting our shorelines. They provide ecological, environmental, and long term benefits to areas directly impacted by their presence. Indirect benefits are also evident by virtue of recreational opportunities afforded to birding and fishing enthusiast. Very few, if any, alternatives available to protect our shorelines and barrier islands have the potential to naturally rejuvenate and recover beach material that is traditionally lost during storm events frequently experienced by our Louisiana coastline. Coastal scientists and professionals agree that segmented breakwaters are not the all inclusive solution to solving Louisiana's retreating shoreline, however future restoration efforts should incorporate their use where applicable.

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Design and Construction Methods for Coastal Ecosystem Restoration – What's in your Quiver?

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Many complex variables must be considered and carefully assessed when developing approaches for restoring and protecting coastal habitat. Typical projects in these ecologically fragile areas must overcome difficult site conditions including soft foundation soils, shallow water, and exposure to hurricanes. In addition, limited project funding combined with a desire to restore or protect large areas often presents a challenge. This presentation will describe numerous habitat restoration and protection projects that have been constructed over the past fifteen years in Texas and Louisiana. These projects have included placement of dredged material, "scrape-down" techniques, mechanical placement of truck-hauled fill, and terracing, as well as constructing breakwaters and revetments using rock, geotextile tubes, and mattresses to protect both restored and existing habitat. Such projects require application of science, some trial and error, a good knowledge of both standard and specialized construction techniques, and a blending of engineering and biology. Questions that will be answered include: How high does a breakwater need to be to effectively protect marsh fringe from hurricanes? How should soil consolidation and settlement be addressed during wetlands design? What stage of marsh life development should be targeted when laying out a marsh configuration? The full presentation will include case studies of recent coastal restoration in Texas and Louisiana involving wetlands, bird islands, oyster reefs, and barrier islands. Lessons learned, unexpected results, and examples of how difficult site conditions can be overcome during design and construction will be included.

Implications
Because coastal ecosystem restoration is an evolving discipline, limited published guidance exists for design and construction techniques. This information gap often results in as much experimentation as engineering and science being applied to projects. The case studies and lessons learned in the full presentation will help carry forward experience from previous projects and hopefully improve success of future restoration efforts.

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Design, Construction and Lessons Learned for the Lake Borgne Shoreline Protection Project (PO-30)

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The Louisiana Office of Coastal Protection and Restoration (OCPR) in conjunction with various other local and federal sponsors have been responsible for the planning, design, and construction of shoreline protection projects located throughout the coast of Louisiana. The PO-30 project is located in the Lake Pontchartrain Basin along the southern shoreline of both lobes of Lake Borgne. It is a CWPPRA funded project whose federal sponsor is EPA Region VI. The goal of the project is to halt the erosion of approximately 3 miles of shoreline near Bayou Dupre and an additional 3 miles of shoreline near Old Shell Beach. Of particular concern was the extreme hydraulic conditions and erosion occurring at the confluence of Bayou Dupre, the Mississippi River Gulf Outlet and Lake Borgne. The shoreline erosion rates experienced in the project areas have historically ranged between 15 to 30 feet per year on average. This rate does not fully take into account extreme weather events. Due to Hurricane Katrina in 2005, the shoreline retreated to a distance equal to this annual rate of erosion within only a matter of a few hours.

During engineering design and entire suite of data was collected including bathymetric and topographic surveys and geotechnical borings, as well as searches for historical wind climate, water elevations, and imagery. This data was analyzed in order to quantify the wave environment and existing soil conditions necessary to perform the design. Numerous types of shoreline protection alternatives were then considered including segmented concrete panels, steel sheet piles, quarry stone, etc. These alternatives were subsequently evaluated and screened against factors such as cost, constructability, level of protection, maintenance, etc. in order to render a preferred alternative. Advanced measures were utilized in the design such as the evaluation of long term consolidation on multi soil layers, the segregation of breakwater reaches into weaker and stronger shear strengths, and optimization of the alignment through an extensive hydraulics analysis.

Many challenges were faced during construction of the project. Poor soil conditions combined with a high energy wave environment turned construction into a daunting task at times. As mentioned above, due to Hurricane Katrina, the final design had to be redeveloped to account for the vastly altered shoreline conditions across the entire project. To illustrate this fact, the mouth of Bayou Dupre nearly doubled in size and was scoured deeper by several feet.

The focus of this presentation will be on the creative methodologies utilized in the design and include an overview of lessons learned during construction. A brief follow up will also be provided on the upcoming maintenance event and future engineering monitoring.

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Effects of Terraces on Marsh Vegetation, Coastal Waterbirds and Nekton

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Various wetland restoration techniques are available and one popular method in eroding ponds is terraces. Terraces are constructed by dredging shallow open water areas and piling the dredged material to form an exposed surface. Unlike spoil banks, which are continuous and rise above normal tides, terraces are discontinuous and flood at high tide. The first terraces anywhere were constructed in the Chenier Plain during 1993 on Sabine National Wildlife Refuge. Since then, terraces have been constructed in coastal Louisiana and Texas. There are at least 200 km of terraces in coastal Louisiana and most are in the Chenier Plain. The popularity of terraces is based on the assumptions that (1) terraces initiate growth of emergent vegetation on the terraces, (2) terraces reduce wave energy that in turn slows erosion of adjacent marsh, (3) terraces increase the abundance of Submerged Aquatic Vegetation (SAV) in the pond by reducing wave energy and turbidity, and (4) terraces create valuable edge habitat for nekton (fish and crustaceans) and wildlife. Working with five graduate students, we studied the effects of terraces on submersed aquatic vegetation, nekton, and wildlife. Terraces generally increased the abundance of SAV, nekton, and waterbirds from that found in open water habitats to those found in natural marsh edge habitats. It is unclear if terraces help to reduce erosion of pond edges. However, the edge habitat created by terraces was not the same as that associated with natural marsh edges as indicated by differences in the nekton species assemblages and condition of some common nekton species between habitats.

Implications
This research is important in documenting the ability of the terraces to restore interior pond habitat, and in identifying its impacts of vegetation, nekton and waterbirds. Findings can be used to support changes in the design of terrace construction in order to maximize positive benefits, or minimize negative effects.

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The Good, the Bad, and the Bivalves: Lessons Learned During a Large-Scale Oyster Reef Restoration Project in Southeast Florida

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The St. Lucie Estuary (SLE) and Loxahatchee River System (LRS), which are located in Martin and Palm Beach Counties, Florida have lost 80% of their historic oyster reefs due to degraded water quality and depositions of silt and muck, leaving only a fraction of the total acreage of these once productive reefs. As part of the American Recovery and Reinvestment Act of 2009, the National Oceanic and Atmospheric Administration (NOAA) awarded Martin County over $4M for the *Recovery Act – St. Lucie and the Loxahatchee Rivers Oyster Reef Habitat Restoration Project* designed to restore more than 24 acres of habitat.

Martin County is uniquely qualified to coordinate this large-scale restoration project as they have been involved in similar projects in the SLE for over 10 years and successfully brought together multiple partners and harnessed local support. The project, comprising three phases (survey, restoration, and monitoring), serves to implement one goal of the Comprehensive Everglades Restoration Program; Indian River Lagoon – South Initiative. Construction began in August 2009, with each phase presenting its own set of challenges. The project team was required to adjust several aspects of the project, including the locations of the restoration areas due to muck depths and limited access, planned survey approaches, Federal and State permit submittals, the acquisition and use of oyster reef materials, equipment staging areas, budgetary considerations, and schedules.

This presentation will focus on the lessons learned and strategies applied in order to develop, fund, implement, and manage a large-scale oyster reef restoration project involving the use of public funds. As coastal restoration efforts continue to gain traction and attract funding sources, disseminating knowledge and experience gained from successful and unsuccessful projects is important to demonstrate an evolution and increased effectiveness of these types of programs.

Implications
This is one of the largest oyster reef restoration projects undertaken and much of the knowledge gained from the experience can be applied to projects in Louisiana. What was once historically viable oyster habitat was found to have deep muck layers during the survey phase, prohibiting placement of material in those locations. The team used practical solutions to identify suitable areas in shallow, murky water while keeping the project on schedule and cost-effective. Material availability during the planning and permitting was not a concern, but changes in the U.S. economy limited accessibility to necessary oyster cultch due to a reduction in mining. This unexpected hurdle required the project team to rapidly evaluate and locate alternate materials from various sources, indicating a need to consider and identify interchangeable materials and backup suppliers. Knowledge gained from these challenges and solutions is valuable and applicable for any large-scale coastal restoration project.

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Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration Project

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Project is located along the Bay Joe Wise Headland in Plaquemines Parish, Louisiana. Wetland, dune and marsh habitats within the Project area have undergone substantial loss due to oil and gas activities, subsidence, sea level rise, and storm erosion. Breaches in the barrier headland have resulted in fragmentary islands and inlet formation.

Coastal Engineering Consultants, Naples, Florida and SJB Group, Baton Rouge, Louisiana led the team for the Project (BA-35, CWPPRA Priority Project List 11). Federal and state sponsors were the National Marine Fisheries Service and Louisiana Office of Coastal Protection and Restoration (OCPR).

Project objective was to protect and preserve the structural integrity of the headland. The Project included construction of a 1,000 foot wide marsh platform and a beach-dune platform along the 2.7 mile gulf shoreline. Both the features will be vegetated. The area benefited by the marsh, beach, and dune creation is over 360 acres, predicted to maintain approximately 160 acres of habitats at year 20 of the design life.

Extensive modeling of sediment transport, circulation and water levels, and inlet stability was conducted to evaluate design alternatives. Results were evaluated to ensure the Project design did not greatly reduce flow, increase or decrease water velocities significantly, or cause significant changes to water elevations through the bay system.

Hurricane Katrina (2005) impacted the headland, necessitating a complete redesign of the fill template. A small breach in the headland enlarged dramatically, while Grand Bayou Pass at the eastern end filled in. Hurricanes Gustav and Ike (2007) both impacted the headland. Losses due to these hurricanes and the breach were measured at close to 1 million CY after the original design was completed.

Numerous other challenges occurred during construction, leading to redesign of both the island restoration template and the borrow area. The latter to locate sand to both close the breach and complete the beach/dune fill template. Constructing the marsh fill containment dikes near the breach posed another obstacle.

Implications
Implications relate to the need for: adaptability and flexibility in the face of changing conditions, more geophysical/geotechnical data, timely surveys and aerial photographs/observations, and stronger and more specific language in contract documents. Lessons learned will be a major focus of the presentation.

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Six Successful Projects Restoring Louisiana Barrier Islands

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Louisiana barrier islands are considered one of the most rapidly deteriorating barrier shorelines in the U.S. (McBride & Byrnes 1997). Over a ten year period, (1999 to 2009), EPA completed six barrier island restoration projects with resources from the Coastal Wetlands Planning, Protection and Restoration Act. Each project had unique design and construction issues, and slightly different restoration goals. The presentation will review the project features and post construction performance. Lessons learned will be shared to improve future projects and opportunities identified for future barrier island restoration efforts.

Implications
Adaptation to climate change should be considered in coastal restoration activities. Coastal Louisiana is vulnerable to major storm events and according to the fourth assessment report of the Intergovernmental Panel on Climate Change, future hurricanes are expected to become more intense (IPCC 2007). In the last ten years, construction costs have significantly increased and suitable borrow materials are limited, making strategic and sustainable restoration efforts more critical. The lessons learned from these six projects as well as the visual interpretation of the design performance and storm resiliency, should provide valuable information for fine tuning design and construction methodologies and planning future barrier island restoration initiatives.

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Planning to Restore a Coastal Cypress-Tupelo Swamp Forest: Progress and Hurdles at the Midpoint

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EPA and the State of Louisiana have been designing the restoration of the Maurepas Swamp since 2000. Maurepas Swamp is one of the four largest contiguous coastal cypress-tupelo swamp forests remaining in Louisiana. The swamp is "second-growth", having been extensively logged in the early 20th century. Currently, it is highly degraded, and without restoration is predicted to convert to fresh marsh and open water within 50 years. The swamp is degraded because its connection with the Mississippi River was severed in the early 1900s when it was leveed for flood control. As subsidence has continued with greatly reduced accretion rates unable to offset it, flooding in the swamps has doubled. In addition to greatly increased flooding, saltwater intrusion has severely impacted the swamp. Saltwater intrusion here partly results from the elimination of connectivity of the swamp with the Mississippi River, and (in the past) partly from the Mississippi River Gulf Outlet and the Inner Harbor Navigation Canal. The result of excessive flooding and saltwater intrusion has been reduced vegetative productivity, stressed and dying trees, and the elimination of regeneration of trees. Restoration is proposed via reintroduction of up to 2000 cfs of Mississippi River water and its associated sediment and nutrients, into the swamp, by constructing a gated diversion structure in the Mississippi River levee, a sedimentation basin, a diversion channel, and several minor "outfall management" features. The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) provides funding, first for a significant early feasibility study, and then for actual engineering and design and efforts to comply with the National Environmental Policy Act (NEPA). The project recently reached a critical milestone- 30% Design. We will present the status of the restoration project, the challenges to progress, and some possible alternatives for resolving them.

Implications
Mississippi River reintroduction into the Maurepas Swamps is critical to ensuring their long-term survival. The benefit potential, and many difficult challenges of this project, are instructive for future efforts to design other important Mississippi River reintroduction projects.

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Lessons Learned from Backfilling Canals to Restore the Coast

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We review the 30 year history of restoring coastal Louisiana wetlands by filling in canals with the remaining material of dredged residues lying parallel to the canal (spoil banks). Supplemental material may be added, and a plug built, but only in a minority of cases. This restoration method is called '*backfilling'* and there are enough successful examples to know the costs, effectiveness, and the time-line for success.

Thirty-backfilled canals have been followed over 20+ years, and a side-by-side comparison of two methods for restoring dredged canals to wetlands was examined at the Jean Lafitte National Historical Park and Preserve (JLNP) near New Orleans, LA. Both northern and southern canals at the JLNP had the remnant dredged spoil material returned to the canal, but the southern canal had additional sediment pumped in from a nearby lake. The water depth in the southern canal decreased from 1.2 to 0.4 m following backfilling and sediment addition, while the depth of the northern canal (which received no additional sediment) remained unchanged following backfilling (3 yrs). Neither site yet has complete soil restoration, but the former spoil areas of the northern canal showed greater restoration than the southern canal. The vegetation on the former spoil areas of the northern canal closely resembled that of the reference marsh, while the former spoil areas of the southern canal had species indicative of spoil banks and other elevated areas. After 3 years wetland vegetation was established on approximately 65% of the former spoil areas at both sites and 20–25% of the open water areas. Sediment addition to the southern canal raised costs by a factor of eight times compared to that of the northern canal.

Backfilling at the 30 older sites restored up to 90% of the organic matter, 92% of the bulk density, and 93% of the water content after twenty years at sites where spoil was properly removed. Canals backfilled in areas of intact marsh showed greater restoration success than canals backfilled in highly degraded marshes. Improving the completeness of spoil removal, coupled with appropriate site selection, could speed up the restoration process and enhance the success of future backfilling projects.

Implications
Backfilling is an attractive restoration option because it restores marsh, prevents future wetland loss, and is highly cost effective. It can be quickly implemented coastwide, and has virtually no negative consequences, but does have favorable and predictable outcomes. It directly addresses the main cause-and-effect driver of coastal wetland loss. The benefits of backfilling continue to increase over time, although complete restoration will take longer than twenty years. Improving the completeness of spoil removal, coupled with appropriate site selection, could speed up the restoration process and enhance the success of future backfilling projects. The increased success of backfilling over time illustrates how ecological processes often operate on longer timescales than those allowed for by restoration monitoring plans. The absence of a State/Federal backfilling program continues to be a missed opportunity.

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Storm Surge Modeling

Concurrent Session II: Storm Surge Modeling

Systems Approach to Coastal Storm Damage Reduction
Ty V. Wamsley[1], Mary A. Cialone[1], Jane M. Smith[1], Tate McAlpin[1] and Joannes J. Westerink[2]
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eSURF a Surge Level Prediction Model for Hurricanes
Maarten Kluyver[1], Mathijs van Ledden[1], Nancy Powell[2]
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Modeling Hurricane Waves and Storm Surge in Coastal Texas, Louisiana and Mississippi using Integrated Tightly Coupled Scalable Unstructured Mesh Computations
Joannes J. Westerink[1], Casey Dietrich[1], Andrew Kennedy[1], Seizo Tanaka[1], Mark Hope[1], Clint Dawson[2], Jane Smith[3], Robert Jensen[3]
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Poster Presentations

Biomechanics of Salt Marshes Applied to Wave and Surge Attenuation
James Chatagnier[1], Guoping Zhang[1], Q. Jim Chen[1], John Pardue[1] and Weiming Wu[2]
[1] Louisiana State University, [2] The University of Mississippi
STUDENT POSTER

Testing of Fully-Coupled Storm Surge and Wave Models for Coastal Louisiana
Kelin Hu[1], Q. Jim Chen[1], Joannes J. Westerink[2], J. Casey Dietrich[2], and Andrew B. Kennedy[2]
[1]Louisiana State University, [2]University of Notre Dame

Rapid-Response Measurements of Waves and Surge in Louisiana Coastal Marshes During 2009 Tropical Storm Ida
Ranjit Jadhav[1], Q. Jim Chen[1], B. Jason Kennedy[2], Andrew Kennedy[3], and Uriah Gravois[4]
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Hurricane Forerunner Surge in Louisiana and Texas
Andrew Kennedy[1], Joannes Westerink[1], Mark Hope[1], and Casey Dietrich[1]
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Evaluation of Two Parameterizations of WAM in the Gulf of Mexico Using Parallel Unstructured SWAN with Implications for Coastal Louisiana
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STUDENT POSTER

Nearshore Waves during Hurricane Gustav
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Systems Approach to Coastal Storm Damage Reduction

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Natural and man-made protection and buffering features like wetlands and barrier islands do not decrease the mass of water driven into the region by the hurricane winds (mass is conserved) but they do change the momentum and redistribute the storm surge. Therefore, changes in one part of a system can create unintended consequences somewhere else in the system. The potential for these unintended changes must be considered for effective coastal flood protection design. For these reasons, the effect of proposed project alternatives on storm surge levels and waves must be examined over large spatial and temporal scales, or systems approach. A high resolution numerical modeling system capable of representing complicated coastal landscapes and simulating all the primary relevant physical processes, including winds, air-sea momentum transfer, atmospheric pressure, wind-driven waves, riverine flows, tides, and friction due to land cover will be presented. The role of natural features in reducing surge and waves will be discussed. In addition, how the long-term effects of SLR can be incorporated in the modeling system will be demonstrated the impact of SLR on surge and waves analyzed.

Implications
The modeling system presented in capable of representing both natural and manmade features on a regional scale and includes the relevant physical processes for evaluating the role of wetlands and barrier islands in storm surge and wave reduction. The importance of taking a holistic systems approach to coastal flood protection and how the modeling system can identify unintended consequences is demonstrated. Results from the model can assist in prioritizing protection and restoration projects. The systems approach concepts and models presented are now being applied for developing flood damage reduction plans.

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eSURF a Surge Level Prediction Model for Hurricanes

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eSURF is a forecasting model that can predict surge levels caused by hurricanes in a matter of seconds for the New Orleans and vicinity area. eSURF stands for Experimental Surge Forecast. The model is based on data generated by the ADCIRC model for numerous hypothetical storms. The ADCIRC model is a system of computer programs for solving time dependent, free surface circulation and transport problems in two and three dimensions. For these hypothetical storms the model utilize the finite element method in space and incorporates all relevant physical aspects regarding hurricanes and storm surge to produce a 2D maximum water elevation surface for a storm. This however comes at a certain cost. For the high level of detail it requires a computer to do a significant amount of calculations, hence it takes a significant amount of time (order of hours) to finalize a single model run. Due to the changeable nature of these complicated weather systems a hurricane can already changed its size or path within the time to complete a run.

eSURF takes away the dependency of elaborate time consuming model calculations in the critical hours before a Hurricane makes landfall. eSURF can make a surge level prediction in seconds. The program uses an innovative algorithm to come up with fast and accurate predictions of surge levels. In essence eSURF is an innovative tool that quickly manages an enormous amount of data. At the base are the ADCIRC results from hypothetical storms for the Louisiana coast, the 2566 surge level prediction points, the parameters of the forecasted hurricane and the eSURF algorithm. In addition to this, eSURF can predict wave heights and wave periods and provide a risk classification based upon the forecasted hydraulic parameters in combination with known levee heights.

Implications
The availability of a fast prediction on surge levels prior to a hurricane making landfall can assist a number of authorities in a beneficiary way. For example Areas which are forecasted to be prone to greater flooding risk could be assisted first with temporary measures (e.g. sandbags). Furthermore evacuation orders, routes and the use of material could be planned effectively if areas of greater risk are identified early. Ultimately the model could be extended to include the entire Gulf Coast and provide the public with information on predicted surge levels with every public advisory from the NHC.

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Modeling Hurricane Waves and Storm Surge in Coastal Texas, Louisiana and Mississippi using Integrated Tightly Coupled Scalable Unstructured Mesh Computations

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Coastal Louisiana, Mississippi and Texas are characterized by tremendous complexity in their geography, topography, bathymetry, and surface roughness. The rapid evolution of data collection systems allows the physical system to be accurately defined, and the rapid evolution of unstructured grid computational models allows these characteristics and the resulting waves and flows to be numerically resolved. The SWAN+ADCIRC unstructured grid modeling system has been developed to simulate fully coupled hurricane winds, wind-waves, storm surge, tides and river flow in this complex region. This is accomplished by defining a domain and computational resolution appropriate for the relevant processes, specifying realistic boundary conditions, and implementing accurate, robust, and highly parallel unstructured grid algorithms for both the wind waves and the long wave current/storm surge/tide model. Basin to channel scale domains and high resolution grids which resolve features down to 30 meters and contain up to 4.2 million nodes have been developed. This modeling system is run on up to 16,384 processors and requires as little as 24 minutes of wall clock time per day of simulation.

Implications
The present modeling system shows a high level of skill for deep water and nearshore waves, high water levels and hydrographs. Hindcasts of Katrina, Rita, Gustav and Ike indicate that large domains and highly refined localized resolution is key. The system very closely couples wind waves and circulation. The system captures the effects of wave radiation stresses in wave transformation zones which drive additional coastal set up and currents and modifies bottom friction in the circulation model to account for the effects of energetic wave mixing. It also accounts for water levels and currents in the wave computations.

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Biomechanics of Salt Marshes Applied to Wave and Surge Attenuation

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Biomechanical properties of salt marshes, including bending stiffness and modulus of elasticity, were measured on two marshlands in Breton Sound and Terrebonne Bay, Louisiana, and are correlated with plant canopy height, stem height, stem diameter, plant stem density, and seasonal variations and botanical behavior. Two methods were employed, including direct stem bending and indirect board drop tests. The dataset is analyzed in depth to develop empirical equations of plant stiffness and compared with those found in the literature derived based on vegetation on river floodplains. Wave data collected by Jadhav et al. (2010) on the marshlands during storm events are used to correlate the hydrodynamics to biomechanics of salt marshes. These wave and surge measurements along with vegetation data are applicable to calibrating wave models that incorporate the reduction of energy due to wetland vegetation.

Implications
The mitigation of wave energy and storm surge is critical to the survival of Louisiana's wetlands and coastline. Salt marsh vegetation has the ability to mitigate the potential damage caused by storm surges and large waves. This study will improve our understanding of the role of vegetation in attenuating waves and storm surge and the accuracy of the parameterization of the vegetation effects in the-state-of-the-art wave models. The successful quantification of wave and surge attenuation by salt marshes will be a positive contribution to Louisiana hurricane protection and coastal restoration.

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Testing of Fully-Coupled Storm Surge and Wave Models for Coastal Louisiana

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The Louisiana coast is extremely susceptible to the impacts of frequent tropical storms and hurricanes. Severe coastal flooding, enormous property damage, and loss of life are ubiquitously associated with tropical cyclone landfalls, as demonstrated in the 2005 and 2008 hurricane seasons. Obviously, mitigating the impacts of hurricanes requires an accurate prediction of storm surge and hurricane-induced waves in deep and shallow waters, including the interaction of wave and surge in coastal regions.

Gustav (2008) and Ida (2009) are two new good test cases for the fully-coupled storm surge and hurricane wave models (Dietrich et al. 2009) because of the availability of high quality nearshore wave and surge observations. On an identical, unstructured mesh, new versions of SWAN for waves and ADCIRC for storm surge were tightly coupled through the exchange of water levels, currents and radiation stresses. An improved asymmetric hurricane wind model integrated with gulf-scale background winds was employed to generate wind fields. A large number of field observations, including winds, waves and water levels, were collected for model verification. Comparisons with field observations show that the model results generally agree well with the measurements. Further numerical experiments are carried out to quantify the influence of coastal landscapes. The effects of water level and currents on waves, and conversely, the effects of radiation stress on storm surge are studied quantitatively.

Implications
The continuing popularity of coastal areas and increased development along the coastlines put more people and property at risk from coastal hazards. This devastation was no more evident than during Hurricanes Katrina and Rita in 2005 and Gustav and Ike in 2008. The fully-coupled storm surge and hurricane wave models validated by field observations will provide more accurate predictions of both storm surge and wind waves, which will help mitigate the negative impacts of hurricanes.

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Rapid-Response Measurements of Waves and Surge in Louisiana Coastal Marshes During 2009 Tropical Storm Ida

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On November 9, 2009, ahead of Tropical Storm Ida's coming ashore, five wave and surge gages were deployed in the Breton Sound marsh, Louisiana. Based on the storm track, the deployment was mobilized just a day ahead of the predicted landfall. To capture open water waves a gage was deployed as far south as safely possible just beyond southernmost vegetated marsh. Three more gages were deployed northwards on the vegetated marsh to examine the effects of vegetation on the waves. The northernmost gage was deployed in Lake Lery. All the gages were retrieved after 10 days Recorded water levels along with the USGS tide gages in the vicinity were analyzed to examine the progression of the surge through the marsh. Recorded wind wave spectra were analyzed to quantify wave attenuation by vegetation. The result illustrates the role of wetlands and demonstrates the usefulness of this surge and wave monitoring technique for coastal Louisiana and beyond.

Implications

The past four years have shown the enormity of the devastation caused by hurricanes and resultant surges and waves to human life and property in coastal Louisiana. The traditional methods of hurricane protection using levees and floodgates can prove to be costly, unsustainable, and can cause unintended ecosystem consequences by disturbing the deltaic processes. Although it is generally believed that the coastal marsh dampens hurricane surge and waves, there is a lack of field measurements quantifying this benefit. Research is needed to provide field measurements of surge and wave attenuation by wetland vegetation. These data can be used to develop a more realistic and physically based parameter for the vegetation-dependent drag. This frictional coefficient is one of the key parameters in the current storm surge and wave models, which are increasingly employed for planning and management of coastal resources and restoration.

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Hurricane Forerunner Surge in Louisiana and Texas

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Large coastal surge beginning well over a day before landfall has been repeatedly observed on the Louisiana-Texas coast for large hurricanes. Here, we present measurements and modeling of this *forerunner* surge during Hurricane Ike. Surge magnitudes exceeded 7 feet at 15 hours before landfall, trapped people in low-lying areas, and contributed to the erosion of protective dunes and marshes before the arrival of the main surge. We show the form of the forerunner surge, its causes, and how it increased overall water levels both at the coast and in inland bays. The forerunner wave additionally forced a large coastal dome that traveled hundreds of miles along the coast and caused a large surge in areas distant from landfall. This was at some locations the largest surge observed throughout the storm. High resolution modeling demonstrates the surge dynamics and shows the strong influence of Coriolis forces. The wide and shallow shelf offshore of Louisiana strongly increased the forerunner magnitude over that which might be expected at other locations.

Although not well remembered, historical records also show this very large forerunner surge, and it must be considered to be a typical feature for large strong storms from Central Louisiana west into Texas.

Implications
The magnitude of the Hurricane Ike forerunner was unexpected and, because of this, increased the danger for coastal residents. It needs to be accounted for in future emergency management operations to increase safety.

Because forerunner surge increases strongly overall water levels in inland bays, it needs to be accurately represented in order to accurately assess risk levels. Effects of the forerunner on coastal erosion will also be significant and need to be assessed and accounted for.

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Evaluation of Two Parameterizations of WAM in the Gulf of Mexico Using Parallel Unstructured SWAN with Implications for Coastal Louisiana

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Third generation wave models are widely used in operational oceanography, in forecasting waves at different scales, from semi-enclosed seas to oceanic dimensions. There are several existing formulations for computing energy transfer from wind to wave and for wave energy dissipation.; Among theses, the WAM cycle 3 and WAM cycle 4 models are the two most common. In this study we have implemented SWAN, which is an open source phase-averaged wave model having the capability of using either WAM cycle 3 or WAM cycle 4. Since the latest iteration of SWAN can employ an unstructured triangular mesh (flexible mesh) instead of the traditional rectangular grid, it can be used to efficiently simulate the bulk wave parameters such as significant wave height, peak wave period, averaged wave period as well as the wave spectrum, using different parameterizations of wind energy transfer and wave dissipation. Moreover, SWAN supports parallel computing and its code is well-parallelized with almost linear speedup which in turn, significantly reduces the time needed to carry out the wave simulation. Taking advantage of the archived met-ocean data from NDBC buoys and WAVCIS stations, performance of SWAN has been evaluated for different WAM formulations during fair weather as well as severe weather such as cold fronts and Hurricanes.

Implications
In this study the most common formulations for wind energy transfer to waves and wave energy dissipation are evaluated. Skill assessment of SWAN simulations using different parameterizations can be used to compare the performance of the third generation wave models in hindcast or forecast of bulk wave parameters such as wave height and period, or wave spectra in fair or severe weather conditions. Moreover, either WAM cycle 3 formulations or WAM cycle 4 formulation has several tuning coefficients and the result of the calibration process in this study provides a good estimate for either formula for any future wave simulation study in the off the Louisiana coast and throughout the Gulf of Mexico. Therefore, this study a very important set of computational models utilization by scientists and engineers involved in coastal restoration along and off the Louisiana coast.

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Nearshore Waves during Hurricane Gustav

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During Hurricane Katrina, there were very few nearshore wave measurements to validate wave models for this extreme event. Hurricane Gustav came ashore in coastal Louisiana west of New Orleans in early September 2008. Preceding the storm, nearshore wave gauges were deployed in depths 5-15 m by Andrew Kennedy of the University of Notre Dame and six additional gauges were deployed in Biloxi and Terrebonne marshes by U.S. Army Engineer Research and Development Center Coastal and Hydraulic Laboratory. Wave heights exceeded 5 m in some nearshore areas. Wave and surge simulations were made using a suite of models, including WAM, STWAVE and ADICRC, to reproduce Hurricane Gustav waves and surge, and the gauge data are used to validate the wave models. Additionally, measurements of the vegetation in the Biloxi Marsh were taken after the storm to characterize the vegetation for specifying and improving the representation of vegetation in STWAVE.

Implications
Wave measurements are now available for more intensive validation of nearshore wave models for hurricanes, including wetland areas. The measurements confirm model results of large wave height reduction for moderate surge. Very short wave periods were observed in the wetlands, which indicates waves in the wetlands were locally generated. The implication of these results is the confirmation of the importance of wetlands in reducing wave energy and wave-driven surge in southeast Louisiana and the validation of numerical models for estimating these nearshore processes. Field measurements are a critical asset for understand hurricane wave processes and improving and validating nearshore wave models.

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Historical/Current Status

Concurrent Session II: Historical/Current Status

The Mississippi River's Last, Vast Natural Delta: Use the Record, or Lose the Coast
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Historical Changes in Wetland Area and Suspended Sediments in the Mississippi River Birdfoot Delta
Andrew Tweel[1] and R. Eugene Turner[1]
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Marsh Vertical Accretion in Coastal Louisiana: The State of Our Understanding after 30 Years of Research
J. Andrew Nyman, Ron D. DeLaune
Louisiana State University

Poster Presentations

Using Multiple Regression and Remote Sensing to Quantify Land Change in a Highly Dynamic Delta Region
Yvonne Allen[1], J. Barras[1]
[1] U.S. Army Corps of Engineers

Suspended Particulate Matter Dynamics along the Mississippi-Louisiana-Texas Coast from Satellite and Model Observations
Eurico D'Sa[1], Mitsuko Korobkin[1], Dong-Shan Ko[2], Harry Roberts[1]
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Modified Methodology for Projecting Coastal Louisiana Land Loss Changes Over the Next 50 Years
Steve B. Hartley[1]
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Quantifying Wetland Accretion and Fault Movement Rates in the Mississippi Delta with Optically-Stimulated Luminescence (OSL) Dating
Zhixiong Shen[1] and Torbjörn E. Törnqvist[1,2]
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Salinity Patterns in Marshes Influenced by the Houma Navigational Channel
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Saltmarsh Evolution as a Function of Relative Sea-level Rise, Sediment Supply, and Marsh Productivity: Case Studies in Louisiana, South Carolina, and Massachusetts

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The Mississippi River's last, vast natural delta: Use the record, or lose the coast

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The record: In the 1500s, Spain's conquest of the "New World' was accomplished with its Padrón Real – its secret, evolving, base-map of the world described in Alonso de Chaves' ca. 1537 rutter. Our analysis of Chaves suggests that the Spanish found two major distributaries of the Mississippi River, in which the Atchafalaya River-Bayou Plaquemine (*Atchafalaya*) was greater than the Mississippi River below Donaldsonville (*Mississippi*)

By 1680 -- seeking global domination -- France, England, and Spain raced to find the mouths of the Mississippi River. France was now the international leader in cartographic science and the scientific excellence of two Frenchmen (Iberville and de l'Isle) secured her claim. In 1698 Iberville correctly located the Mississippi (using Barotto's 1687 GoM survey) and in 1699 described its network of distributaries. In 1700-1730, de l'Isle (researching the authoritative French, Spanish, and English surveys) rewrote Europe's maps of this critical portion of the New World. Our analysis of this record suggests major shifts in the dominance of the Mississippi's distributaries.

In 1763/64, England surpassed France in naval power and ability to measure longitude at sea, and joined Spain in controlling and mapping Louisiana – as recorded in the authoritative coastal surveys of Gauld and Evia. Our analysis of this record reveals a vibrant coast advancing into the sea through three major outflows. Here huge drift trees, vast offshore oyster reefs, and an active sub-aerial delta at the mouth of Bayou Lafourche where important features of coastal advance/protection.

The pattern: These state-of-the-art surveys and their associated maps describe the last natural delta of the Mississippi River -- a vast, seaward-advancing arc beginning below Baton Rouge and extending in an east-west direction across the current parishes of St. Bernard to Iberia. This extensive system was characterized by four, shifting distributaries (*Atchafalaya, Mississippi*, Bayou Lafourche-Barataria Pass, and Bayou Manchac).

Implications
Failure to use this historic record has resulted in a continuing loss of Louisiana's cultural resources – ranging from its coast to the legacy of its Native Peoples. At a minimum, the largely unused historic record (1500-1800) contains desperately needed, scientifically valid, quantitative information on the dynamic nature and delta-building properties of the Mississippi River. If we do not begin to understand what the Mississippi was on the eve of European conquest/alteration, we cannot rationally address our current land loss crisis. Or more simply, we cannot restore what we do not understand.

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Historical Changes in Wetland Area and Suspended Sediments in the Mississippi River Birdfoot Delta

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A large proportion of the total wetland loss in Louisiana has occurred in the mineral-rich wetlands of the Mississippi River Birdfoot Delta. This deterioration started around 1950 and was preceded by a period of rapid deltaic expansion beginning in 1850. Around the same time, the area of cultivated land in the Mississippi River Basin increased rapidly, thereby increasing erosion and adding large volumes of sediment to the river. Sediment loads subsequently decreased considerably as soil conservation practices were established and as river bank revetments and dams were constructed. Historical surveys from 1778 to present were analyzed in a geographic information system to determine the spatial and temporal changes that occurred to the area of these deltaic wetlands. Historical suspended sediment records dating back to the 1840s were also analyzed to determine periods of increasing and decreasing sediment supply to the Birdfoot Delta. The rapid expansion, and subsequent areal decline, of the mineral-rich wetlands of the Mississippi River Birdfoot Delta will be discussed in relation to anthropogenically-influenced sediment regimes in the Mississippi River.

Implications
The results suggest that the amount of land in the 1930s era Birdfoot Delta, commonly used as the baseline condition against which many restoration targets are set, represents a peak following decades of increased sediment loading from land clearing in the Mississippi River watershed before the 1900s. Because land gains and losses in the Birdfoot Delta closely follow changes in suspended sediment loading in the river, whereas changes in wetland area in the deltaic plain do not, wetland gains and losses in these two systems are, therefore, governed by similar processes operating at different rates.

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Marsh vertical accretion in coastal Louisiana: the state of our understanding after 30 years of research

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Global sea-level rise and local subsidence will drown emergent vegetation and create new shallow open water areas if coastal wetlands vertically accrete too slowly. Marsh vertical accretion needs to be measured over long periods that include years of low and high sea level. We reviewed accretion studies based on either ^{137}Cs or ^{210}Pb dating, which estimate accretion since 1964 or during the last 80 years, respectively. The first measurements were published in 1978 based on 6 cores from southeastern Louisiana. Since then, over 150 cores have been collected and dated throughout coastal Louisiana by various researchers. Spatial patterns demonstrate that accretion accelerates in response to subsidence up to a limit. Beyond the limit, accretion is inadequate and marshes convert to shallow open water over several decades. The most rapid accretion every recorded, 9.8 mm/yr, was associated with rapid wetland loss southeast of Houma where subsidence combined with global sea level rise was measured at 13.8 mm/yr. Until the 1990s, it was widely assumed that coastal marshes worldwide depended upon mineral sediments to vertically accrete and that sediment starvation caused all inadequate vertical accretion. However, it is not clear that that many marshes, from tidal fresh to saline, from Louisiana to Canada, depend upon organic matter produced by emergent vegetation to vertically accrete. Roots, rather than stems and leaves, appear to control accretion via vegetative growth. No data are yet available to determine if slow production or rapid decomposition prevents accretion via vegetative growth from exceeding 9.8mm/yr, but the most likely cause is slow root production. Decades of marsh vertical accretion can be lost via soil oxidation if low water levels, such as during natural drought and managed drawdowns, are too persistent or frequent.

Implications
One implication of marsh vertical accretion via vegetative growth is that the effect freshwater diversions is not confined to the relatively small area where mineral sedimentation is enhanced, but extends to the larger area where diversions alter factors, such as nutrient availably, sulfate availability, and salinity, that may govern root growth or soil organic matter decomposition. Data are needed to determine the direction and magnitude of these effects, which also are relevant to salt water intrusion, hydrologic restoration, etc. Research also is needed to determine if fire affects accretion via vegetative growth because natural and managed fires are common in coastal Louisiana.

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Using Multiple Regression and Remote Sensing to Quantify Land Change in a Highly Dynamic Delta Region

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The Wax Lake Delta is an important model for gauging the potential effectiveness of coastal restoration through river diversions. Current models to estimate potential land gain in the Wax Lake Delta are, however, based on relatively limited ground or remotely sensed data. Varying river and tide levels can greatly affect any measurement of land change through time so explicit consideration of water levels at the time of measurement may offer a more accurate estimate of land change. We classified 77 Landsat images captured from 1983-2008 under a variety of tide and river conditions into categories of land and water. Tide, river level and date were used as independent variables in a multiple regression model to predict proportion of land in the Wax Lake Delta and in an adjacent marsh area. In the Wax Lake Delta date, tide and river levels were all significant predictors of land change. Coefficients of determination from regressions using water level and date as predictor variables were higher than those obtained using date alone to predict land change. Improvements were also noted when the data were divided by time period. Rates of delta growth in earlier years (1983-2002) were more rapid compared with more recent estimates (2002-2008). In the adjacent marsh, date and tide level were significant predictors of land change and coefficients of determination were higher when tide level and date were used to estimate land change. This analysis improves estimates of actual land change in a dynamic system and has multiple applications for coastal restoration. It also highlights the potential impacts that stressors such as hurricanes, reduced sediment supply and sea level rise may have in tempering expected results from restoration efforts.

Implications
Understanding the dynamic patterns and trends of land change in the Wax Lake Delta is critical to further understanding the potential benefit that may be expected from coastal restoration through river diversion. This study attempts to minimize the uncertainty associated with historical land change measurements and instead focus on the variable stressors that may be impacting land building. Such knowledge may inform the number and location of future coastal restoration projects.

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Suspended Particulate Matter Dynamics along the Mississippi-Louisiana-Texas Coast from Satellite and Model Observations

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Coastal waters such as those influenced by the Mississippi and Atchafalaya Rivers have high concentrations of suspended particulate matter (SPM) which may comprise of sediments or biogenic material such as detritus and algal matter. Remotely sensed ocean color data from the SeaWiFS sensor obtained between 1998 and 2008 were analyzed using a regional algorithm to examine both short and long-term trends in SPM in a region comprising coastal waters of Mississippi, Louisiana and part of Texas. SeaWiFS derived SPM in combination with winds from QuikSCAT satellite and the outputs of a high resolution (~ 2 km) 3-dimensional nested navy coastal ocean model (NCOM) examined during a frontal passage in March 2005 demonstrated the strong response of sea level and currents to wind forcing and the consequent effects on SPM along the coast. The backscattering spectral slope, a parameter sensitive to particle size distribution was used to examine particle size characteristics from satellite data during the frontal passage. Seasonal SPM distribution indicated strong linkage to river discharge in the plume region of the two rivers. We applied wavelet analysis to time-series satellite data to assess the dominant timescales of SPM variability across the Atchafalaya Bay. Preliminary analysis indicated a seasonal cycle in the timing of peak SPM variance that was likely associated with the winter frontal systems. A transport model based on NCOM Mississippi-Louisiana-Texas (MsLaTex) model outputs were applied to satellite derived SPM field of the Louisiana coast to assess the advection of SPM over time. The transport model applies a "thin-layer approximation" to extend surface 2D advection to 3D advection. Results of the transport model to satellite derived data suggests its potential application in predicting pollutants which often co-occur with sediments, and to obtain a better understanding of the SPM dynamics along the river dominated coastal margin.

Implications
A better understanding of the SPM dynamics along the Louisiana and adjacent coast is important as it plays an important role in water column light availability and thus primary productivity, as an indicator of pollutants, water quality and in carbon cycling studies. Along the Louisiana coast a large fraction of the SPM is comprised of suspended sediments, information that is important for coastal restoration. This study which was conducted as part of a NASA funded project to develop an integrated monitoring system for the region using NASA Earth science products and model outputs has the potential to be used in coastal restoration and water quality monitoring.

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Modified Methodology for Projecting Coastal Louisiana Land Loss Changes Over the Next 50 Years

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The coastal Louisiana landscape is continually undergoing geomorphologic changes (in particular, land loss); however, after the 2005 hurricane season, the changes were intensified because of Hurricanes Katrina and Rita. The amount of land loss caused by the 2005 hurricane season was 42 percent (562 km²) of the total land loss (1,329 km²) that was projected for the next 50 years in the Louisiana Coastal Area (LCA), Louisiana Ecosystem Restoration Study. The purpose of this study is to provide information on potential changes to coastal Louisiana by using a revised LCA study methodology.

In the revised methodology, we used classified Landsat TM satellite imagery from 1990, 2001, 2004, and 2006 to calculate the "background" or ambient land-water change rates but divided the Louisiana coastal area differently on the basis of (1) geographic regions ("subprovinces") and (2) specific homogeneous habitat types. Defining polygons by subprovinces (1, Pontchartrain Basin; 2, Barataria Basin; 3, Vermilion/Terrebonne Basins; and 4, the Chenier Plain area) allows for a specific erosion rate to be applied to that area. Further subdividing the provinces by habitat type allows for specific erosion rates for a particular vegetation type to be applied. Our modified methodology resulted in 24 polygons rather than the 183 that were used in the LCA study; further, actively managed areas and the CWPPRA areas were not masked out and dealt with separately as in the LCA study. This revised methodology assumes that erosion rates for habitat types by subprovince are under the influence of similar environmental conditions (sediment depletion, subsidence, and saltwater intrusion).

Background change rate for three time periods (1990–2001, 1990–2004, and 1990–2006) were calculated by taking the difference in water or land among each time period and dividing it by the time interval. This calculation gives an annual change rate for each polygon per time period. Change rates for each time period were then used to compute the projected change in each subprovince and habitat type over 50 years by using the same compound rate functions used in the LCA study. The resulting maps show projected land changes based on the revised methodology and inclusion of damage by Hurricanes Katrina and Rita. Comparison of projected land change values between the LCA study and this study shows that this revised methodology—that is, using a reduced polygon subset (reduced from 183 to 24) based on habitat type and subprovince—can be used as a quick projection of land loss.

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Quantifying Wetland Accretion and Fault Movement Rates in the Mississippi Delta with Optically-Stimulated Luminescence (OSL) Dating

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A reliable chronology for late Quaternary sedimentary strata in and near the Mississippi Delta is a key to quantifying deltaic processes such as wetland accretion and subsidence rates. Traditionally used ^{14}C dating is often limited by its age range (<40,000 years) and/or the lack of suitable organic matter. Optically-stimulated luminescence (OSL) dating involves the direct age measurement of depositional events with commonly available quartz and therefore provides a potentially appealing alternative. Two case studies are presented here to illustrate the usefulness of OSL dating: 1) wetland accretion rates in the Mississippi Delta, and 2) fault movements in the Baton Rouge Fault Zone (BRFZ).

In case one, we show that the Mississippi deltaic sediments are exceptionally suitable for OSL dating. OSL ages of crevasse-splay deposits along Bayou Lafourche show excellent stratigraphic consistency and agree well with independently obtained ^{14}C ages. The emerging OSL chronology suggests that wetland accretion rates can be as high as >3 cm/year at sites close to active river channels.

In case two, geomorphic evidence and stratigraphic correlation indicates that late Pleistocene fluvial and coastal strata have been vertically displaced in the BRFZ by up to 5 m. We are currently OSL dating the displaced strata to determine the long-term rates of fault movement in this area during the late Quaternary. Preliminary results of this work show that the vertical displacement occurred over at least 100,000 years, yielding long-term averaged rates of 0.05 mm/yr or less.

Implications
Crevasse-splay sediment accumulation rates of up to about an inch per year obtained from recent geological records confirm that wetland accretion can potentially keep up with high rates of relative sea-level rise, at least locally. Coastal restoration by means of river diversions that mimics crevasse breaching of natural levees therefore may have the potential of being successful, at least if preceded by a careful site selection.

Fault movements in the BRFZ over long timescales are very slow and therefore unlikely to be a main cause of the rapid subsidence in coastal Louisiana. However, detailed research to study fault activity at different spatial and temporal scales is required to further improve our understanding of this important process.

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Salinity Patterns in Marshes Influenced by the Houma Navigational Channel

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Salinity intrusion into historically fresher wetland areas has been identified as a likely cause of large-scale coastal wetland change. Previous studies, which focused on the broad scale coastwide salinity patterns and trends, showed no generalized pattern of increasing salinity. It is likely that saltwater intrusion is a localized occurrence. This present study investigated the nature of the salinity 'spikes' or 'pulses' at the local scale, in and near the Houma Navigation Channel (HNC).

Hourly salinity, water level, and discharge data for 2003 were obtained from stations along coastal-inland transects in the HNC and adjacent natural bayous. The water level patterns were typical for the Louisiana coast, with a tidal signal superimposed on other larger scale events. The inland water levels are driven by the coastal water levels. However, the salinity of the internal stations was not highly correlated with the salinity of the coastal waters. The result is that high coastal water levels result in high water levels throughout the system, where as high salinity at the coast does not always result in high salinity at the inland stations.

At ~40 k inland the HNC had significantly higher salinity pulses compared to salinity pulses in an adjacent natural bayou (5.5 ppt versus 1.8 ppt). The higher salinity waters associated with pulses remained longer in the natural bayou (7.3 days) than in the HNC(4.8 days). The HNC is connected to the Gulf Intracoastal Water Way (GIWW) allowing for freshwater from the GIWW to flush the HNC. Regression analysis indicates that discharge explains ~50% of the observed salinity pulses in the HNC. This result supports the study of saltwater intrusion in the HNC area by Wang (1988) who stated that the freshwater head, was one of the major driving forces influencing the intrusion of salt water in the channels.

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Saltmarsh Evolution as a Function of Relative Sea-level Rise, Sediment Supply, and Marsh Productivity: Case Studies in Louisiana, South Carolina, and Massachusetts

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Louisiana's coastal marshes are experiencing the highest rates of wetland loss in the U.S., in part due to subsidence-driven relative sea-level rise (RSLR). The response of the marsh to sea-level fluctuations is strongly related to RSLR rates, sediment supply, and marsh productivity. The relative importance of these factors is being explored in Louisiana, South Carolina, and Massachusetts marshes using historical imagery, topographic surveys, stratigraphic and geotechnical analysis of sediment cores, and long-term (decadal) sediment accumulation rates as determined from Pb-210 and Cs-137 radioisotopes. Results indicate that similar physical and ecophysical processes lead to shoreline retreat, expansion of tidal channel networks, and/or deflation of the marsh platform and ensuing submergence, depending on the RSLR rate, influx of inorganic sediment, marsh below ground biomass production, and tidal range. High rates of RSLR coupled with low sediment influx have caused a retreat of the Louisiana delta marshes and their submergence. The mesotidal range coast of the Santee Delta, South Carolina is responding differently to microtidal Louisiana. Here, increased flooding and draining of marshes and reduced sediment supply are resulting in an expansion of the tidal network. A third type of response is observed in the backbarrier saltmarshes of Plum Island, Massachusetts. These systems display interior ponding as seen in Louisiana, however, these water-filled depressions within the marsh platform are formed from enhanced decomposition of the organic substrata and are eventually drained by headward eroding creeks and ultimately recolonized by vegetation. Thus, the northern marshes are undergoing reworking, but have not yet begun to diminish in extent.

Implications
Analysis of processes occurring in deltaic regions experiencing high RSLR such as Louisiana and South Carolina are important as they can be used as a proxy for future marsh evolution in other coastal areas with expected accelerated sea-level rise. Understanding the processes of wetland deterioration is fundamental for mitigation of future marsh loss and the impact on local coastal communities and infrastructure, particularly in Louisiana. In addition, recognizing required organic and inorganic contributions to maintain a productive marsh are necessary to achieve sustainable saltmarsh systems with freshwater and sediment diversions and other mitigation efforts. Investigating saltmarsh processes along a continuum of tidal range and sediment supply broadens the applicability of individual studies, enhancing the understanding of complex marsh dynamics as they respond to sea level rise.

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Barrier Islands

Concurrent Session III: Barrier Islands
Moderator: Cheryl Brodnax, National Oceanic and Atmospheric Administration

Beach Topography/Bathymetry Changes to Segmented Breakers at Raccoon Island, Louisiana Over an Eight-Year Monitoring Period
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Geologic Controls On Island Evolution, Chandeleur Islands Louisiana
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A Cross-Shore Model of Barrier Island Migration over a Compressible Substrate and Importance for the Louisiana Coast
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Poster Presentations

Hydrodynamics Over Tiger and Trinity Shoals off the Louisiana Coast
Felix Jose[1], Gregory W. Stone[1] and Daijiro Kobashi[2]
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Reinforcement of Vegetated Sand Dune with Geotube® Containment Technology
Alan Juncker[1]
[1]TenCate Geosynthetics North America

Seed Production and Germination of *Uniola paniculata*
Carrie A. Knott[1], **Pheonah Nabukalu**[1], and Michael Materne[1]
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STUDENT POSTER

Applying Advanced Numerical (Delft3D) Modeling to Barrier Island Design
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Beach Topography/Bathymetry Changes to Segmented Breakers at Raccoon Island, Louisiana Over an Eight-Year Monitoring Period.

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In 1997 eight segmented breakwater structures were constructed along Raccoon Island, Louisiana as a Demonstration Project (TE-29). Post-construction beach topographic/bathymetric surveys were conducted from 1997 to 2005 by scientists in the Coastal Studies Institute at Louisiana State University in order to monitor the progressive response of the beach to these breakwaters. Dominant sediment accumulation occurred immediately after the completion of the project, during which the so-called "reverse salients" unexpected beach response was observed. During 2000–2002, general sediment loss occurred from the breaker-barrier system. During 2003–2004, beach morphology was characterized by a net sediment influx, which lasted until Hurricane Ivan impacted the study site in Fall 2004. Moreover, a downward trend of total sediment volume was observed until the end of the monitoring period. Over the eight years of the monitoring period, deposition occurred on the beach behind the breakwaters #3 to #6, while erosion took place in front of the breakwaters and along the western part of the island where there was no protection from breakwaters. Severe erosion occurred in the offshore area in front of the breakwaters, and especially along the unprotected segment of the island, farther west of the protected eastern zone. This situation was clearly apparent along the western section of the island when the coast was impacted by major hurricanes (Isidore, Lili, Bill, and Ivan), while negligible sediment loss occurred along the eastern portion of the island protected by the breakwater structures. There was no obvious seasonal beach changes although there were seasonal differences in coastal hydrodynamics associated with summer and winter seasons. Winter storms associated with the passage of cold fronts were frequent and were strong enough to resuspend and transport sediments. Encouraged by the success of this project, another eight segmented breakwaters have been constructed along the middle part of the island.

Implications
The data presented here will provide valuable information in terms of design criteria for future coastal restoration efforts, especially for constructing breakwaters, at other sites with similar physical and hydrodynamic conditions. Moreover, the extended period of data collected also have provided new insights into the complex interaction among sediment flux in the littoral zone, innershelf sediment sources, and anticipated responses along the adjacent beaches where breakwaters may be built to protect the delicate beach-barrier system.

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Geologic Controls On Island Evolution, Chandeleur Islands Louisiana

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The Chandeleur Islands and surrounding waters provide habitat for a variety of threatened wildlife species, a platform for human infrastructure and recreation, and storm protection for interior environments and human population. The islands formed about 2,000 years ago as sea level rose over the subsiding St. Bernard delta complex of the Mississippi River, reworking existing sandy material into a barrier lithosome that presently ranges in thickness from 1 to 9 m and covers an extent of 760 km^2. The islands are in a state of decline. The sandy sediments are continually scavenged by storms, reworked by prevailing wave climate, and inundated by a relative sea-level rise, resulting in a net loss of island area.

This presentation highlights results from geologic investigations conducted between 2007 and 2008 by a collaborative team of academic, state, and federal agencies. High-resolution seismic-reflection and bathymetric data, and sediment cores were collected to characterize depositional components of the stratigraphy underlying and surrounding the islands. The barrier-island lithosome, the primary deposit of interest, is a sandy marine-transgressive deposit that rests unconformably on mixed sand-mud facies of the older deltaic deposits. The dominant source of sand for the barrier platform is derived from wave-induced erosion of the distributary deposits (sand content 50-60%) within the relict delta sequence. Sediment is not distributed uniformly throughout the lithosome, and sand is mostly limited to the central section of the barrier system where littoral divergence occurs. Lithosome geometry is controlled by two dominant factors: accommodation space provided by the underlying geologic framework, and wave-driven littoral-transport conditions. The stratigraphic assessment indicates that the underlying deltaic deposits presently affected by wave action lack sufficient amounts of sandy material to maintain the islands as subaerial features.

Implication
In the event that shoreline renourishment becomes a viable option for island management, the results of this study will provide the physical information necessary to identify the location and quality of suitable sand resources around the islands. The study further demonstrates the collaborative capability of federal and state agencies to conduct complex environmental assessments in remote areas that are critical environmental habitats, but have low perceived commercial value.

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A Cross-Shore Model of Barrier Island Migration over a Compressible Substrate and Importance for the Louisiana Coast

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Barrier islands that overlie a compressible substrate such as deltaic sediment in Louisiana load and consolidate the underlying subsurface. Through time, the elevation and aerial extent of these islands are reduced, making them more susceptible to inundation and overwash. The result is an increase in island migration, breaching, and segmentation. Deltaic systems, because of their fragile, low-lying environments, comprise regions of the world that need the protection provided by barrier islands yet often these islands are rapidly reduced in subaerial extent and relief. Restoration of barrier islands fronting deltaic systems is complex due to regional sediment sources and sinks, environmental sensitivity in the ecological region, and the weight-bearing loading of restoration that further compresses the substrate.

This research determined the degree to which consolidation affects the evolution of barrier island systems overlying a poorly-consolidated substrate. A two-dimensional (cross-shore) mathematical model was developed, tested with field data, and applied to evaluate how a compressible substrate modifies long-term barrier island evolution. The implications of two strategies for restoring these islands (a one-time "Initial" large-scale infusion of sand from an external source versus traditional "Incremental" beach nourishment and subsequent smaller maintenance volumes) were tested.

Barrier islands overlying a compressible substrate are more likely to have reduced dune elevations due to consolidation, incur overall volumetric adjustment of the profile to fill in compressed regions outside the immediate footprint of the island, and experience increased overwash and migration when the dune reaches a critical elevation with respect to the prevalent storm conditions. Initial large-scale infusion of sand from an external source was found to be more effective at stabilizing the island as compared to the traditional Incremental approach.

Implications
Design of large-scale restoration projects for barrier islands in Louisiana must incorporate compression of the deltaic substrate because of the additional weight of the sediment. A one-time, large restoration is more effective in stabilizing the islands as compared to the traditional approach of initial nourishment with maintenance fills. This study points to the need for low-cost monitoring of barrier island restoration projects to improve design criteria and predictive methods.

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Hydrodynamics Over Tiger and Trinity Shoals off the Louisiana Coast

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Two oceanographic surveys were conducted at the Tiger-Trinity shoal complex in December 2008 and March-April 2009. Tripods equipped with ADCP, PCADP, ADV, OBS and pressure sensors were deployed along a transect for monitoring both wave and currents fields on the shoal and adjacent environment. During the 2008 deployment, which lasted for two weeks and with a single tripod deployed over Tiger shoal, three cold fronts crossed the study area and significantly influenced the hydrodynamics of the region. The maximum wind speed observed was 14.2 m/s while the maximum wave height recorded was less than 1 m. This substantial wave attenuation observed for Tiger Shoal can be attributed to the nature of the bottom sediments. The highly viscous bottom sediments dissipate incoming waves, a phenomenon confirmed by previous studies conducted along this coast. Also, associated with the winter storm events, a reduction in water level was observed which can be attributed to enhanced wind stress directed offshore. Except for a few instances,, the wave-induced shear stress at the bottom was strong enough to re-suspend sediment, during the entire deployment period. The data from the 2009 deployments are being analyzed and will also be discussed in the proposed presentation.

A suit of hydrodynamic models was also implemented, as a preliminary study, to estimate the effect of waves and currents on the shoal dynamics. MIKE 21 wave and Hydrodynamic models, developed by DHI Water and Environment®, were implemented for the Tiger and Trinity shoal system. A substantial reduction in wave height was observed seaward off Trinity Shoal. This can be attributed to rapid decrease in slope off Trinity Shoal. Also, our preliminary hydrodynamic model data demonstrated that strong currents existed over the shoal region, which are critical in the redistribution of sediment, although the precise patterns and magnitude are still to be quantified, especially during the winter storm period.

Implications
The deltaic coast of Louisiana is experiencing extremely high rates of coastal erosion and subsidence due to storm impacts, relative sea level rise, and anthropogenic influences. Federal and State agencies consider barrier island restoration to be a promising way to combat wetland loss; and the transgressive sandy shoals offshore have been identified as a viable source for executing this project. However, there are growing concerns with sand mining from the offshore sand bodies, particularly in terms of environmental impacts including hydrodynamics and sediment transport. The present study addresses these issues with extensive field measurements and numerical modeling. The study also considers the interaction of river-borne sediments with the shoals as during the post-frontal phase of cold fronts passages, the shoals are blanketed with fine-grained sediments debouched from the rivers. The study will ultimately come up recommendations for future sand mining from the region.

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Reinforcement of Vegetated Sand Dune with Geotube® Containment Technology

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Geotube ® containment technology provides a solution for providing protection for shorelines from erosion during storm events. The specially designed and fabricated container is hydraulically filled with sand and placed as the core of the sand dune. It holds sand and soil in place during storm events to prevent erosion and property damage.
Techniques used in the manufacture of the Geotube® containers will be presented as well as a review of installation techniques used to place and fill containers on this 31,000 linear foot project.

Implications
This presentation will offer information for the Science and Engineering theme as it relates to Risk Reduction Systems & Techniques. It will explore aspects of the successful manufacture and installation of 31,000 linear feet of Geotube® containment products on US Army Corps of Engineers Grand Isle & Vicinity Hurricane Protection Project along Grand Isle Beach in Jefferson Parish, Louisiana.

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Seed Production and Germination of *Uniola paniculata*

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The need for beach restoration in Louisiana has increased in recent years due to damage from numerous hurricanes and tropical storms. One plant used extensively throughout the Gulf of Mexico Basin for beach restoration is *Uniola paniculata* (sea oats). Sea oats is the dominant foredune grass of the Gulf Coast. In Louisiana vegetative propagation from rhizomes is the main source of sea oats plants for restoration projects. Vegetative propagation is very expensive and labor intensive. A cost effective and efficient alternative is seed-based plant production. To determine the utility of producing sea oats seeds in an artificial nursery, sea oats seeds were harvested from an artificial nursery at Aquaculture Research Station, Baton Rouge, LA; from experimental plots at Holly Beach, LA and Long Beach, MS; and a natural population at Grand Isle, LA. A total of 210 panicles were harvested from Baton Rouge, LA; and 10 panicles were harvested from Holly Beach, LA; Long Beach, MS; and Grand Isle, LA. Average seed yield panicle^{-1} was 483; 104; 56; and 86 for Aquaculture Research Station, Baton Rouge, LA; Holly Beach, LA; Long Beach, MS; and Grand Isle, LA, respectively. Percent germination was significantly higher for sea oats seeds harvested from Holly Beach, LA (60 %) than for seed harvested from Baton Rouge, LA (12%); Long Beach, MS (12%); and Grand Isle, LA (29%). To further investigate the utility of producing sea oats seeds in an artificial nursery, seeds from 7 experimental clones were harvested in 2009 at the artificial nursery, Baton Rouge, LA, and experimental plots at a natural beach, Gulfport, MS. Number of panicles, seed yield panicle^{-1}, seed weight, seed pathogens, percent germination and seedling survival are being determined. Differences between the artificial nursery and natural beach environment will also be examined.

Implications
This work presents the potential for producing sea oats seeds in artificial nurseries instead of harvesting seed and/or vegetative material from natural populations. This will allow the large-scale, commercial production of sea oats plants without disturbing natural ecosystems. Seed-based propagation also produces a genetically diverse population that is able to adapt to various locations and more likely to withstand environmental stresses than vegetatively propagated clones. The ability to produce seed in an artificial environment also provides the opportunity for unlimited supply of seed to test and eventually select genetically unique lines for specific traits, such as high seed yield, resistance to disease and adaptability to various environmental stresses. Results from this study will be used to recommend seed production protocols for coastal restoration practitioners.

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Applying Advanced Numerical (Delft3D) Modeling to Barrier Island Design

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The evolution of advanced numerical coastal models, such as Delft3D and Mike21, provides coastal engineers additional insight into complex coastal processes over large model domains. Delft3D and Mike 21 are better able to model and integrate complex processes, such as sand/silt interaction, relative sea level rise, tidal currents, storm surge, and island breaching, than previous models (GENESIS, SBeach, and AdCirc). While the output from these three latter models has to be interpreted and integrated by the engineer, Delft3D incorporates these processes within one package. The West Belle Pass Barrier Headland Restoration Project (TE-52) will be used as a case study.

The design for the West Belle Pass Barrier Headland Restoration Project incorporated analytic design and numerical modeling techniques. The analytic design evaluated shoreline changes and separated the changes into component parts of longshore, offshore, RSLR, and overwash. SBeach modeling was performed to determine a design cross-section, estimate overtopping, and predict future retreat rates at a few specific points in time. However, two critical elements of project design, the potential for breaching and western growth of the spit, could not be modeled using SBeach or GENESIS. However, Delft3D could model both of these processes as well as modeling the project over the entire 20-year project life.

Delft3D was instrumental in comparing project alternatives. The model was used to evaluate the effectiveness of a terminal groin and breakwater. The model was also used to evaluate numerous beach fill and marsh fill configurations. The Delft3D model assisted the project team in determining that raising the marsh an additional 0.5 feet was cost effective and reduced the potential for breaching. Acreages for various target years could be extracted directly from the model and applied in the Wetland Value Assessment benefits analysis. The model output plots were useful during the 30% and 95% design CWPPRA meetings to visually demonstrate the expected difference between the 6 alternatives.

Implications
Since more advanced numerical models, such as Delft3D and Mike 21, are better able to incorporate complex processes, they can help provide more accurate predictions of project performance than earlier models, such as SBeach, GENESIS and AdCirc. Design engineers can use these models to optimize projects and better evaluate project alternatives. Furthermore, variables such as island composition, marsh and beach elevation, marsh and beach width, and structures can be better evaluated.

The model results provide decision makers with additional insight when choosing between project alternatives and then between various projects. The application of more advanced numerical models should therefore lead to better project designs and more confident allocation of limited funding resources. The more complex (and more expensive) models benefit the design and decision making processes and should be highlighted and discussed.

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Fauna

Concurrent Session III: Fauna
Moderator: Mike Carloss, Louisiana Department of Wildlife and Fisheries

Climate Change, Energy Scarcity, Fisheries Resources and Mississippi Delta Restoration
James H. Cowan, Jr.[1], John Day[1] and Kim De Mutsert[1]
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Understanding Colony Site Selection of Seabirds on Isles Dernieres Barrier Island Refuge
Cecilia Leumas[1], Frank Rohwer[1], Aaron Pierce[2], and Edward Raynor[2]
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*Deepwater Horizon Oil Spill: Impacts to Coastal Louisiana's Wildlife and Habitat
Mike Carloss
Louisiana Department of Wildlife and Fisheries
Replacement Presentation (No Abstract Available)

Poster Presentations

If We Want the Sand, We Need to Study the Crabs
Richard Condrey[1], Felix Jose[1], Gregory Stone[1], Carey Gelpi[1], Stanislas Dubois[2], Roger Amato[3]
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*The original presenter, John Supan, was unable to present the topic described in the conference program. The session moderator, Mike Carloss, instead gave a presentation titled "Deepwater Horizon Oil Spill: Impacts to Coastal Louisiana's Wildlife and Habitat"

Climate change, energy scarcity, fisheries resources and Mississippi delta restoration

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The deterioration of the Mississippi delta in the 20th century is evidenced by high rates of coastal wetland loss and widespread water quality deterioration. The wetland loss was primarily the result of levees that resulted in elimination of riverine input to the delta and pervasive hydrologic alteration of the deltaic plain. These changes resulted in saltwater intrusion, reduction of sheet flow hydrology, increased flooding of wetlands, and reduction of sediment input to marshes. Fisheries have changed due to high fuel prices and cheap imports, but there is little evidence of effects of hypoxia. Climate change in coming decades will include accelerated sea level rise, more frequent drought, increased river flow, and more hurricanes. Energy will become more expensive and scarce as the world passes through peak oil production.

Implications
Recognition of the severity of the wetland loss and other problems led to a growing effort to restore the delta. Initially, restoration efforts were small and often unrelated. We now recognize that restoration must be a comprehensive and integrated, and focused on ecosystem function via massive reintroductions of river water. Reversing or slowing land loss will become more challenging due to climate change but options will be limited due to energy shortages. Hypoxia may become less severe because of increasing fertilizer costs and use of wetland buffers in the basin. Fisheries have not been strongly impacted but may cross a threshold due to habitat loss and other cumulative insults. We infer that large-scale river diversions back into degraded areas could begin the delta cycle anew and facilitate the "resetting" of prior conditions. This premise also infers that to delay restoration efforts could significantly diminish the likelihood of ecosystem recovery.

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Understanding colony site selection of seabirds on Isles Dernieres Barrier Island Refuge

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Colonial nesting seabirds face a variety of threats, including habitat loss and degradation, human disturbance, and predation. Louisiana contains large breeding colonies of many of these birds, and several species of conservation concern concentrate high percentages of their total U.S. populations here. However, some restored areas with apparently suitable nesting habitat do not host colonies. We studied the assemblage of seabirds, including Royal Terns, Sandwich Terns, and Black Skimmers, nesting on Isles Dernieres barrier islands in Terrebonne Parish, Louisiana. These islands have been the focus of many expensive restoration projects, and ideally they should be valuable for wildlife as well as for coastal protection. Two of the four islands in this chain host extensive seabird colonies and two do not. Our objective is to better understand what factors limit the use of available habitat on barrier islands.

We used an experimental approach to test two hypotheses that may explain seabird preference for one island over another. We used decoys and call broadcast to test the hypothesis that social facilitation is required for these species to form new colonies. To test the hypothesis that disturbance by potential predators prevents new colony formation, we erected fences around half of our experimental plots, and conducted predator surveys on all four islands. Only one pair of seabirds was induced to nest by our social facilitation, although behavioral observations indicate that seabirds showed more interest in decoy than in control plots, and that sound enhanced the attractiveness of the decoys. We were unable to test disturbance without nests; however, predator surveys revealed the presence of raccoons, rats, and coyotes on non-colony islands, and no mammalian predators on colony islands.

Implications
Many bird species of conservation concern in Louisiana are dependent on coastal habitats. Coastal restoration and protection efforts that are aimed at helping the human populations of south Louisiana should therefore aim to benefit wildlife as well. Seabirds, which tend to nest in very large, dense colonies, are especially vulnerable to loss of important breeding areas, and might increase reproductive output by nesting in more places. In the case of barrier islands, we had hoped that seabirds could be drawn to nest on restored areas via social facilitation, a technique that has been successful elsewhere in closely related species. We found that although seabirds were attracted to the decoys and sounds, they were not induced to nest in large numbers, suggesting that other factors prevented colony formation. Predator presence or absence seems to be important, and predator control on restored islands might benefit multiple seabird species of concern.

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If We Want the Sand, We Need to Study the Crabs

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Sandy shoals in the U.S.-Louisiana Continental Shelf are rare, under-studied, and critical sand sources for Louisiana's coastal restoration efforts. In recent MMS/DNR-supported studies, we have found that Ship and Trinity Shoals, potentially important sand-mining sites for replenishing the rapidly diminishing island chains nearby, are also important blue crab (*Callinectes sapidus)* spawning grounds.

Blue-crab larvae hatched on these shoals may contribute to the current stability of the Louisiana blue-crab fishery and/or benefit the genetic diversity of a GoM metapopulation. Questions regarding larval transport mechanisms are inherent in all MMS-related sand mining studies. These questions cannot be addressed with two- dimensional models where passive transport of inert particles is assumed. Rather three-dimensional (3D) hydrodynamic models coupled with particle tracking algorithm are required so that larval behavior can be considered.

We discuss the need for a universally applicable 3D hydrodynamic Advanced Circulation model (ADCIRC) for larval transport, using blue crab as the example. We will show how the model can be coupled with a Lagrangian particle tracking algorithm, to simulate the potential dispersal trajectories of larvae released from two differing areas (Louisiana shoals and estuarine waters) during prime spawning periods, testing the comparative ability of larvae released from these two different areas (shoals and estuaries) to recruit to nurseries with the help of prevailing wind, current, and tidal forcing and a series of realistic larval behaviors. And we will show how flow vectors and sea surface elevation computed using the model can be validated using met-ocean data from the Wave Current Surge Information System (WAVCIS), implemented for the Louisiana coast. We conclude with a simple demonstration of the sustainable-fishery implications of our considerations.

Implications
Louisiana requires the use of federal sand deposits for some of its most critical coastal restoration efforts. Federal permission to use these sands is contingent upon a careful consideration of the ecological and economic impacts. Our studies have discovered the critical role some of these shoals play in the spawning success of the economically and ecologically important blue crab. A careful consideration of blue crab larval recruitment patterns is required to assess the roles these shoal-produce larvae play in the stability of the Louisiana and/or GoM blue crab fishery, considerations which should be addressed before these areas are mined for sand.

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Dutch Perspective

Concurrent Session III: Fauna
Moderator: Natalie Snider, Coalition to Restore Coastal Louisiana

*The Multiple Lines of Defense Approach: Lessons Learned from Louisiana and the Netherlands
Natalie Snider
Coalition to Restore Coastal Louisiana
Replacement Presentation (No Abstract Available)

Dutch Lessons Learned and Eco-Engineering Protection Systems
Yvo Provoost[1], Mindert de Vries[2]
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The Risk of Flooding: In Control
Hans van der Sande
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*The original presenter, Linda Mathies, was unable to present the topic described in the conference program. The session moderator, Natalie Snider, instead gave the lead-in presentation of the session, titled "The Multiple Lines of Defense Approach: Lessons Learned from Louisiana and the Netherlands."

Dutch Lessons Learned and Eco-Engineering Protection Systems

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In 1953 a disaster struck the South West of the Netherlands. Large areas were flooded and many people drowned. As soon as possible the Dutch started the Delta Works. The main item: shortening the coastline. The engineers closed several sea arms of the Southern Sea and the Eastern Scheldt. Now we know what impacts occur to a closed system like the Dutch delta: a Markermeer where nothing lives, an Eastern Scheldt with ´sand hunger´ and algae's in fresh water lakes.

In 1996 a large project was started in the South West of the Netherlands: engineers started to replace the old revetments along the dikes. According to the law, nature was important. But during the project, pilots like 'Riche Dike' and 'Building with Nature' were started. Today engineers and biologists are talking about eco-engineering while reinforcing dikes.

This project, Sea Defense, is under high pressure of time and money in a surrounding of ecosystems, environmental aspects and political issues. In spite of this difficult environment the project, over halfway done, is right on schedule. The clue: listening, looking and acting according to the environment. Safety first, but flora and fauna are right behind and where possible needs of parties interested are fulfilled.

Safety first, but many effort is put into research and innovation. Research and innovation are embedded in the project because it always offers improvements to the project whether it is on safety, nature, environment, time or even on finance. Research and innovation occurs not only on technical issues but also on ecological issues. Therefore there is a good cooperation with, for example, nature reservists. Together with engineering offices and industry the project is making the dikes as safe and eco-friendly as possible.

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The Risk of Flooding in the Netherlands: In Control

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In the Netherlands with a very high standard of safety against flooding caused by stormsurges (in Zeeland: resist a storm that occur 1 time each 4000 years), the focus is laying on preventing: www.stateofthecoast.org State of the Coast 33 make sure the flood defense is strong enough to resist that storm. In order to fullfill this obligation, since 1996 there is a flood protecting law in which is arranged to report every 5 years about the strength of your flood defenses. The first time was in 2000, the second in 2005 en this year we are preparing the report for the third time. This process of verifying has become more and more professional. In the first round there was a lack of (digital) data of strength and most of the waterboards only systematically reported on the mechanism 'wave overtopping and flooding ' and 'dune erosion'. A couple of defense were obvious to weak and measurements were prepared. During the second round the focus was laying on gathering of data (archive and field). Almost all mechanism has been analyzed and reported and again some measurements were acknowledged. But more investigations are needed in order to give a definitive answer : insufficient or good . The third time the results of the investigations will be incorporated. A Digital standard has been developed and all waterboards has to use this standard to report. It's expected that the fourth round will lead to a complete image of safety with a proposal of some measurements
.
After a period of 20 years the risk of flooding is finally in control. Long but comparable with a big project such as the replacement of all the revetment in Zeeland (1997-2015). Maintenance is the other important issue to remain the safety on the agreed level. The history tells us that not the most severe stormsurges has caused the greatest disasters but a lack of maintenance (during and after a war or recession) has been responsible for the magnitude of the disaster.

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Mississippi/Atchafalaya Rivers

Concurrent Session IV: Mississippi/Atchafalaya Rivers
Moderator: Angelina Freeman, Environmental Defense Fund

One-Dimensional Sedimentation Modeling of the Lower Mississippi River Response to the West Bay Diversion
Ronald E. Heath[1], Jeremy A. Sharp[1], and C. Fred Pinkard, Jr. [2]
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Recent Progress to Quantify Nitrate and Carbon Export from the Atchafalaya River
April BryantMason[1], Y. Jun Xu[1], and Mark Altabet[2]
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Wetlands in the Labranche Basin and the Bonnet Carre Spillway: The Importance of Large Crevasses
Day, Jr.[1,2], J.W., **R.G. Hunter**[1,2], R.D. DeLaune[1], R. Keim[1], J.W. J.N. Day[2], and M.G. Hunter[2]
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Poster Presentations

An Improved Adcirc Model of the Lower Mississippi River
Hugh Roberts[1], John Atkinson[1], Rose Martyr[2], Casey Dietrich[2], Dr. Joannes Westerink[2], Hans Westerink[2], Lee Westerink[2] and Hasan Pourtaheri[3]
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Estimating the Role of the Atchafalaya River Basin in Reducing Nutrient Discharge to the Gulf of Mexico
Amy E. Scaroni[1], J.A. Nyman[1], C.W. Lindau[2], R.F. Keim[1], R.D. DeLaune[2]
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STUDENT POSTER

One-dimensional Sedimentation Modeling of the Lower Mississippi River Response to the West Bay Diversion

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The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), West Bay Sediment Diversion Project is located on the west bank of the Mississippi River, in Plaquemines Parish, Louisiana at River Mile 4.7 above Head of Passes. The project was designed to restore and maintain approximately 9,831 acres of fresh to intermediate marsh in the West Bay area by diverting fresh water and sediment from the Mississippi River over the 20-year project life. The project included the excavation of an uncontrolled diversion channel through the bank of the Mississippi River. Construction was completed in November 2003.

In theory, the diversion of water and sediment increases the potential for induced sediment deposition in the main channel downstream of the diversion unless the diverted bed material sediment load to water ratio is greater than that of the primary river. This is a critical issue on the Mississippi River where increased sediment deposition can have an adverse impact on other project purposes such as commercial navigation and flood control. Concerns about increased sediment deposition and resulting increased dredging prompted the CWPPRA Task Force to authorize a multi-faceted study to evaluate the impacts of the West Bay Diversion on sediment deposition and dredging within the navigation channel and adjacent anchorage area. This paper addresses the 1-D modeling effort.

One-dimensional (1D) sediment routing modeling provides the opportunity of evaluating long-term channel changes and delivery of sediments at a regional spatial scale and provides boundary condition input for related multi-dimensional modeling. The HEC-6T, Sedimentation In Stream Networks, software package was used to conduct 50-year simulations with and without the West Bay Diversion to compare long term sediment deposition trends within the navigation channel and anchorage area.

Implications
Model simulations of the behavior of the West Bay Diversion and the associated response of the Lower Mississippi River will increase our understanding of critical sedimentation processes that must be considered in the design and operation of proposed future diversions. Ultimately, the results of this 1-D model investigation integrated with results from the associated field investigation, geomorphic assessment, and the multi-dimensional model investigations will provide the CWPPRA Task Force with the technical information needed to make decisions on the future operation and management of the West Bay Diversion.

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Recent Progress to Quantify Nitrate and Carbon Export from the Atchafalaya River

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Riverine wetlands have the capacity to reduce nutrients and organic matter through assimilation and for nitrogen, denitrification. Paired isotope technique can be more informative than examining nutrient concentration alone since isotopes lend insight into nutrient processing, source, and age. In this study, we used paired isotope technique to investigate nitrate and organic carbon transport in the Atchafalaya River. Water samples were collected biweekly-monthly at five sites along the Atchafalaya (Simmesport, Melville, Butte La Rose, and outlets, Morgan City and Wax Lake), and at two sites along the Mississippi (Angola and Baton Rouge). The samples were analyzed for nitrate, nitrite, dissolved organic and inorganic carbon concentrations, as well as isotopic changes in δ^{15}N-NO_3 and δ^{18}O-NO_3. In situ a series of water quality parameters were recorded, including temperature, dissolved oxygen, pH and specific conductivity. We found distinct seasonal trends of water temperature and dissolved oxygen and a closely reversed relationship of the parameters. Additionally, all sites had similar water temperature (about 18^{o}C) except Morgan City that showed a significantly higher water temperature (19.3^{o}C). Morgan City likely received backwater from riverine swamps, which may have contributed to the elevated temperatures. River waters collected from all sites showed similar δ^{18}O (4.58$^o/_{oo}$-4.81$^o/_{oo}$) and were significantly different from rain samples (66.1$^o/_{oo}$), indicating that atmospheric nitrate was not a major nitrate source. Although there was little variation in δ^{15}N-NO_3 between the sites, average δ^{15}N in the Mississippi's water at Baton Rouge (7.71$^o/_{oo}$) was significantly higher than the outlet of Atchafalaya River (6.99$^o/_{oo}$). The relatively small difference (0.72$^o/_{oo}$) in δ^{15}N reflects a similar source, but may reflect a higher influence of the Red River, an agricultural tributary to the Atchafalaya River or a constant delivery of organic nitrogen and ammonium within the basin which is quickly converted to nitrate with limited fractionation, resulting in a lower δ^{15}N signal.

Implications
This study reflects the basin may be a key role in reducing organic nitrogen. The dynamics in the basin is much more complex than originally believed. The potential importance of the backwater areas within the basin where water velocity is reduced and there is more interaction with soils may be key to denitrification. It is important that coastal planners consider the relationship with backwater areas and levee interaction flow paths. Simply increasing the amount of water diverted at the Old River Control Structure is not the solution. Further research is needed in the backwater areas as well as possible groundwater interaction. This study also demonstrates that utilizing isotopes in water quality research can supply a range of additional information otherwise unavailable in mass balance approaches.

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Wetlands in the Labranche Basin and the Bonnet Carre Spillway: The Importance of Large Crevasses

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Sediment accretion and long-term growth rates of baldcypress were compared in three wetland sites in the Labranche basin (LB) and the BC Spillway (BCS). The floodgates of the BCS have been opened nine times since 1930, approximately once every decade, with flows ranging from 3100 to 9000 m^3/s. Wetlands north of the railroad in the LB receive regular re-suspended sediments while those to the south do not. South of Airline highway, elevations in BSC reach almost 2m. In the LB elevation north of the railroad is about 30 cm and to the south elevation is near sea level. ^{137}Cs accretion in BCS, LB north of the railroad, and LB south of the railroad were 2.0, 1.0, and 0.3 cm/yr, respectively. Cypress growth rates in BCS were twice as high as those in LB. Wetland loss in LB has been caused by inadequate accretion, saltwater intrusion and hydrologic alterations that reduce sediment and freshwater input. Prolonged inundation limits cypress regeneration in the LB and leads to wetland loss.

Implications
Previous research has shown that small river diversions in coastal Louisiana can increase marsh primary production, wetland surface elevation, and vertical accretion. However, there is contention that these diversions are so small compared to the pre-levee flooding of the Mississippi River that they are not making a significant contribution to coastal restoration. Even at its lowest discharge, water flow through the Bonnet Carre Spillway is about 150 times the size of water flow from the Caernarvon or West Pointe a la Hache structures, and more than 700 times the size of water flow from the Violet siphon. These results indicate that infrequent (once a decade) large diversions can sustain wetlands, even with accelerated sea level rise.

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A Foundation for Comprehensive Delta Planning: The SL16 ADCIRC Model of the Lower Mississippi River

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A new ADCIRC finite element model has been constructed, validated, and implemented for the lower Mississippi river. A very high resolution representation of topography, bathymetry, and frictional roughness between the river levees and within the lower distributaries has been built into an existing southern Louisiana model, known as the SL15 model. The SL15 model contains the Gulf of Mexico and the western north Atlantic basin, and has formed the basis of many modeling studies by FEMA and USACE for evaluating levee design, flood risk, and natural system response to hurricane storm surge. The addition of the highly resolved Mississippi river represents the next generation of southern Louisiana ADCIRC models: the SL16 model. Despite the success of the SL15, the SL16 is better able to capture the stage-discharge relationship for a wide range of riverine flow rates. Highlighted are the ADCIRC mesh improvements of the small scale features within the river channel, as well as improved accuracy of the SL16 model for capturing riverine flood events, the tidal signal, and Hurricane Katrina storm surge.

Implications
Experience gained during construction and testing of this numerical model has revealed the importance of accurately representing small scale topographic and frictional details for capturing the low energy tidal exchanges and the daily riverine flows. Understanding how these small details influence the numerical models will guide data collection and model building for many modeling applications along the Louisiana coast. In addition, the availability of the more accurate SL16 model for Southern Louisiana provides an important existing condition model upon which to base detailed modeling within the context of future planning studies in the region.

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STUDENT

Estimating the Role of the Atchafalaya River Basin in Reducing Nutrient Discharge to the Gulf of Mexico.

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The Mississippi and Atchafalaya Rivers are the major sources of freshwater and nutrients to the Gulf of Mexico. Increased nutrient loads from these rivers, primarily in the form of nitrate, have caused increased eutrophication in the Gulf. Large river floodplains, such as the Atchafalaya Basin, have the potential to ameliorate eutrophication through their ability to remove and sequester nutrients. However, the historical extent of many floodplains has been reduced by levees and other hydrologic alterations. Even smaller floodplains remain dynamic, and natural succession leading to habitat change can also isolate areas from river flow. Limiting contact between floodwaters and floodplain sediments likely affects the ability of floodplains to improve water quality. As sedimentation associated with the Atchafalaya River fills in lake habitat, lakes transition to baldcypress swamps, and ultimately to bottomland hardwood forests. This succession may change the capacity of the Basin to remove nutrients. We recently initiated studies to quantify nutrient removal in the Atchafalaya Basin based on storage in the soil and biomass, and via denitrification in the three distinct habitat types: lake, cypress swamp, and bottomland hardwood forest. Preliminary results indicate that removal rates differ throughout the basin, and this difference can be explained by habitat type. Evidence suggests that hydrologic conditions partially determine the capacity for nutrient removal.

Implications
Upstream wetland creation is often touted as a means of improving downstream water quality. Existing as the largest distributary of the Mississippi River, the Atchafalaya River and associated floodplain are positioned in an ideal location to mitigate excess nutrient loading. However, it is difficult to predict nutrient removal rates in the Atchafalaya Basin as habitats are transitioning over time. A change in wetland area will limit sites available for nutrient storage and the denitrification process. Quantifying removal rates in the Basin will not only establish a baseline for nutrient removal in specific habitats, but it will also allow us to model how removal rates will change in light of habitat change. The ability to predict nutrient removal, or lack thereof, will allow coastal managers to compare how different hydrologic management regimes will ultimately affect nutrient discharge into coastal waters.

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Social and Economic Risk

Concurrent Session VI: Lessons Learned II
Moderator: Rex Caffey, Louisiana State University

Mapping Social Vulnerability to Climate Change in Louisiana
Jasmine Waddell, PhD, Mark Hambrick
Oxfam America

The Third Element - Building a Complete System of Community Resiliency and Protection
Brian Jackson[1], Maura Wood[2], Ann Yoachim[3]
[1] Environmental Defense Fund, [2] National Wildlife Federation, [3] Tulane Institute on Water Resources Law and Policy

CNREP 2010 Conference Overview
Rex H. Caffey[1]
[1]LSU AgCenter and Louisiana Sea Grant College Program

Poster Presentations

The Buoyant Foundation Project: A Strategy for Flood-Resilient Housing
Elizabeth English[1]
[1]Bouyant Foundation Project

Developing the Water Management Industry
Scott Kirkpatrick[1]
[1]Coast Builders Coalition

ASCE 24 and Its Importance to Coastal Construction
David Minton[1], Michael Slovensky[1]
[1]Lonnie G. Harper and Associates, Inc.

Florida Communities Plan for Post-Disaster Redevelopment
Lincoln Walther[1], Tara McCaw[1], Sandy Meyer[2]
[1]CSA International, Inc., [2] Florida Division of Emergency Management

The Social / Science / Policy Nexus: Stakeholder Uncertainty, Data Gaps, and Adaptive Management
Maura Wood[1] and Juanita Constible[1]
[1]National Wildlife Federation

Mapping Social Vulnerability to Climate Change in Louisiana

Jasmine Waddell, PhD, Mark Hambrick
Oxfam America

Oxfam America worked with the Hazards and Vulnerability Research Institute at the University of South Carolina to produce a series of social vulnerability maps for thirteen states in the US South. In the Oxfam-commissioned report, *Exposed: Social Vulnerability and Climate Change in the U.S. Southeast*, 75% of the variance for social vulnerability to four hazards associated with climate change--drought, flooding, hurricane force winds, and sea level rise--was explained by eight variables: wealth, age, race, ethnicity, rural, special needs populations, gender and employment. The overlay of social vulnerability, a static demographic assessment, with the dynamic potential for hazards associated with climate change is crucial information for emergency preparedness and regional planning. The presence of 'black spots' on the overlaid maps indicates that there is a high incidence of disasters historically and that there is high social vulnerability as defined by the social vulnerability index, SoVI. The 'black spots' are concentrated on the southern coast and MS delta region of Louisiana which indicates both a high incidence of social vulnerability and climate change related hazards here. In order for effectively manage the living people resources in these geographic areas, federal state and local policies must be developed which respond to vulnerability in addition to resiliency. Vulnerability and resiliency are not two sides of the same coin, and both are critical for effective coastal policy.

Implications
The implications of this knowledge about social vulnerability to hazards associated with climate change are very practical. This information is designed to create systems which can respond to the specific needs which result from a disaster. The needs of a community with low social vulnerability are different than those for a community with high social vulnerability and the systems developed and supported by public money should reflect this. The information from this report focuses on people, and not property value; therefore, the information can be used to develop systems for people-focused emergency management in the face of climate related disaster.

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The Third Element - Building a Complete System of Community Resiliency and Protection

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The term "Non-structural" refers to a number of measures that help reduce risk and damage from storms and flooding - better zoning laws, land use regulations, or building codes; infrastructure improvements such as floodproofing power lines and other utlities; elevation; storm-resistant architecture or design; shuttering, reinforcement, or dryproofing of individual structures; storage or interior planning for protecting valuables; insurance; landscaping; and evacuation planning. These comprise the third set of elements that are an essential part of a complete system of protection, along with levees and restoring a robust coastal wetland buffer. Yet these measures tend to be overlooked and undervalued for their important contribution to community resiliency and cultural continuity. In this session, we will examine the role that "non-structural" elements can play in increasing community protection and resiliency. We will discuss the "How Safe, How Soon" collaboration, which provided resources to three coastal Louisiana communities to assess their level of risk and determine what measures the community as a whole could take to reduce risk. Finally, we will talk about the status and utilization of non-structural funding and policies through several state and federal agencies that can contribute to a resilient coastal Louisiana.

Implications
A complete system of community protection in coastal Louisiana must rely on many "lines of defense" to reduce risks and damage from storm surge and flooding. These include restored coastal wetlands, levees to protect densely populated areas, and non-structural measures that protect life and property - and have the advantage of rapid deployment. Without all three elements, the system of protection is not complete, and communities are less resilient in the event of hurricanes and flooding. A robust non-structural program will help reduce flood risk and protect communities far in advance of levee construction. When looked at in conjunction with levees and coastal restoration, either greater levels of protection may be achieved, or plans for levees may be adjusted, creating more opportunities for coastal restoration.

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CNREP 2010 Conference Overview

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The economic importance of natural capital is now widely acknowledged, and nowhere is this more clearly demonstrated than in the coastal areas of the United States. Catastrophic damage from hurricanes, threats from sea level rise and subsidence, and the inexorable degradation associated with development and industrial activity all threaten coastal environments, but they also provide opportunities and demand for socioeconomic research. To provide a national forum for this work, the LSU Center for Natural Resource Economics & Policy (CNREP) initiated a national conference in 2004 that focuses on the status and challenges of socioeconomic research in coastal systems. A second conference was held in 2007 and attracted more than 160 researchers to Louisiana in the wake of Hurricanes Katrina 40 State of the Coast *www.stateofthecoast.org* and Rita. On May 26-28, 2010, more than 200 social scientists will meet in New Orleans for: *Challenges of Natural Resource Economics & Policy (CNREP 2010) the 3rd National Forum on Socioeconomic Research in Coastal Systems.* This presentation will draw on the triennial CNREP forums to describe the evolving research agenda for natural resource and environmental economics in coastal Louisiana. Primary review topics include: emerging applications of ecosystem valuation and benefit-cost analyses; indexing coastal community resiliency; and reconciling fisheries management with coastal restoration. Additional information will be provided on the status of resource damage assessments related to the Deepwater Horizon oil spill incident in the Gulf of Mexico.

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The Buoyant Foundation Project: A Strategy for Flood-Resilient Housing

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Amphibious foundations are a cost-effective, resident-friendly alternative to permanent static elevation for housing in areas where rising flood waters are not accompanied by high water flow speeds. There is growing awareness that homeowners in established neighborhoods are resistant to elevation strategies that disrupt a neighborhood's appearance and cause the daily inconvenience of climbing long flights of stairs, with no assurance of providing sufficient protection in an extreme flood event. Amphibious foundation systems retain a home's relationship to the street by resting close to the earth most of the time but floating the house to a level as high as necessary to remain safely above the water whenever flooding may occur.

Successful amphibious foundation systems have been functioning for over thirty years in Raccourci Old River, Louisiana, where they provide more reliable and more convenient flood protection than can be obtained from permanent static elevation. In the last decade, the Netherlands has built amphibious housing in the Maasbommel region along the Maas River, which has a long history of severe flooding. Most recently, the Make It Right Foundation announced the completion of the FLOAT House, an amphibious house designed by Morphosis Architects for New Orleans' Lower 9th Ward. An amphibious house constructed in the Lakeview neighborhood of New Orleans in 2007 is close to receiving its occupancy permit.

In urban areas, amphibious foundations can encourage the preservation of established neighborhoods, leaving intact their architectural character and traditional close relationship between house and street. The Buoyant Foundation Project has developed an amphibious foundation system for retrofitting traditional New Orleans elevated wooden "shotgun" houses, so that former residents who are still displaced will feel that it is safe to return home without having to elevate their houses high above the street, which for many is an unacceptable alternative but until recently the only strategy fully approved by FEMA. A buoyant foundation retrofitted to a traditional south Louisiana elevated wooden house is considerably less expensive than permanent static elevation and provides superior flood protection in extreme conditions. In 2007, the Buoyant Foundation Project constructed a full-scale partial prototype of a buoyant foundation system, surrounded it with a temporary floodwall, and conducted a series of tests to demonstrate its successful flotation and stability under a variety of load conditions.

How does a buoyant foundation work? It basically works like a floating dock. A structural frame that secures the flotation blocks is attached to the underside of the house. There are four "vertical guidance" posts not far from the corners of the house. The tops of the posts are attached to short extensions of the structural frame that protrude from underneath the house. The posts telescope out of the ground, allowing the house to move up and down with the level of floodwater. Utility lines must have either self-sealing "breakaway" connections or long, coiled "umbilical" lines. When flooding occurs, the flotation blocks lift the house, with the structural frame transferring the forces between the house and the blocks. The vertical guidance posts keep the house from going anywhere except straight up and down on top of the water. The entire system works completely passively, requiring no preparations or interventions to perform safely in a case of catastrophic flooding.

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Developing the Water Management Industry

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The restoration and protection challenges presented by the Louisiana coast have led to the development of a substantial industry presence in Louisiana focused on providing and implementing solutions to achieve a sustainable coast. The continued growth of knowledge and experience in this area is not only important to the efficient and effective implementation of a master plan for a sustainable coast, but is an important consideration in economic development opportunities for Louisiana.

A survey of similar important public sector projects such as the Japanese shipbuilding industry in the 1950s and the Dutch water management industry in the 1960s and 70s shows how the proper program and policies can ensure a successful implementation and lead to the development of an important industry sector for the region.

A successful implementation plan for Louisiana should ensure the timely acquisition of knowledge and experience to plan a system of protection and restoration along with policies and procedures that allow the water management efforts to evolve into an important commodity for state businesses.

Implications
If the restoration and protection program is unable to timely develop the knowledge expertise required, the coast will endure additional deterioration, expose citizens and assets to additional risk and/or the project implemented will not be optimal.

If the program is funded and run in a sporadic, unclear manner, then industry will not be able to respond efficiently and will not develop comprehensive knowledge and expertise centered in Louisiana that they are able to export.

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ASCE 24 and Its Importance to Coastal Construction

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I recent years, coastal Louisiana has been taught a very important lesson regarding the design construction of structures located in Special Flood Hazard Areas (SFHA) across coastal parishes due to the impacts of Hurricanes Katrina, Rita, Gustav, and Ike: Structures must be built above the flood level, as well as strong enough to withstand the wind and all possible flood loads that will impact the structure. Many structures including residential, commercial, and public facilities that were not designed to sustain this unique loading situation were severely damaged or completely destroyed by the recent hurricanes

In 2005 the ASCE published the ASCE 24-05 manual dictating implicit construction guidance of structures located in the Special Flood Hazard Area (SFHA). The guidance in this manual has proven invaluable through the risk reduction associated with the design of structures that were built in Southwest Louisiana after Hurricane Rita and survived the impacts of Hurricane Ike less than four (4) years later.

Many design professionals are unaware of this document, and it is the intention of Lonnie G. Harper and Associates, Inc. to spread the knowledge and basic understanding of this document to both the general public and the design professional. Understanding that construction in the coastal region *will* continue, as an engineer it is our responsibility to not only design structures in a manner that protects the health, safety, and welfare of a community, but also pass on this knowledge so that other professionals may do so as well. Through reducing the risk associated with occupying coastal areas by building safer and stronger, development can occur in a safe manner.

Implications
It has been seen that construction in accordance with the building code will minimize, if not negate damage to a structure during a flood event. There has been much expansion on knowledge in the field of coastal construction in the recent past with regard to water and wave loads applied on a structure. With proper design and construction practices, facilities *can* be built in the SFHA which *will* withstand the loads incurred during a hurricane. It is our hope that through furthering the understanding of this document, structures will be properly designed such that the occupants will be able to come back to a minimally damaged structure after a hurricane.

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Florida Communities Plan for Post-Disaster Redevelopment

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The Florida Department of Community Affairs (DCA) and Florida Division of Emergency Management assisted by CSA International, Inc. are currently completing a 3-phase post-disaster redevelopment planning initiative that will culminate in a handbook that can be used by local governments to guide them in developing a Post-Disaster Redevelopment Plan (PDRP) for their community. All 203 of Florida's coastal counties and municipalities are required to adopt a PDRP, however, guidance on what a PDRP should address and how pre-disaster planning for post-disaster redevelopment can best be accomplished is not readily available. In addition, inland communities are also encouraged under Florida Statutes to prepare PDRPs.

A post-disaster redevelopment plan identifies policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of the community after a disaster. The plan emphasizes seizing opportunities for hazard mitigation and community improvement consistent with the goals of the local comprehensive plan and with full participation of the citizens. Recovery topics addressed in the plan should include business resumption and economic redevelopment, housing repair and reconstruction, infrastructure restoration and mitigation, short-term recovery actions that affect long-term redevelopment, sustainable land use, environmental restoration, and financial considerations as well as other long-term recovery issues identified by the community.
The initiative is being conducted in three phases:

1) **Drafting guidelines** for developing long-term, post-disaster redevelopment plans before a disaster occurs. These guidelines are based on an extensive literature review, assessment of existing PDRPs, and focus group input.

2) **Testing guidelines** on six pilot communities – Hillsborough, Manatee, Nassau, Polk, and Sarasota Counties and Panama City. This phase is critical to the initiative, as it tests the guidelines' effectiveness in assisting various types of communities in determining the appropriate planning process and plan content for their unique post-disaster redevelopment needs.

3) **Providing an objective analysis of the draft guidelines** to be incorporated into the final PDRP Guidebook as well as recommendations for legislative changes to clarify the minimum requirements of a PDRP for those communities who are required to develop a plan.

Implications
Louisiana along with the other Gulf coastal states are extremely vulnerable to major hurricanes, some reaching catastrophic proportions. Louisiana has been impacted by Hurricane Katrina and Hurricane Rita in 2005 and Hurricanes Gustav and Ike in 2008. Florida has been extremely active in implementing a number of disaster planning initiatives. These efforts have

transferability to Louisiana and the other Gulf Coast states. The value of the Florida PDRP handbook to Louisiana and its coastal restoration and protection efforts include:

- A planning process that can be used to prepare a PDRP;
- That **pre-disaster planning** for long-term, post disaster redevelopment is essential in creating more resilient communities and enabling them to recover more rapidly;
- A compendium of relevant post-disaster issues that need to be considered in the development of a PDRP;
- Emphasizing the importance of pre-identifying an organizational structure that can be activated immediately following a major disaster.

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The Social / Science / Policy Nexus: Stakeholder Uncertainty, Data Gaps, and Adaptive Management

Maura Wood[1] and Juanita Constible[1]
[1]National Wildlife Federation

Stakeholder opposition can be a critical obstacle to implementing landscape-scale restoration projects, including the new generation of sediment-rich, land-building diversions currently in design. National Wildlife Federation has conducted interviews with six categories of stakeholder groups to: (1) characterize the impacts each group expects from sediment diversions; and (2) gather stakeholder-identified solutions to perceived negative impacts. The interviews reveal uncertainty among stakeholders about the potential positive and negative effects of sediment diversions. Furthermore, the interviews reveal a sense among stakeholders that there are few opportunities to make "unsuccessful" projects better. In our efforts to address stakeholder concerns, we have identified significant gaps in data that may be hindering coastal restoration efforts.

Implications
The urgency of the land loss crisis and the reality of increasingly tight state and federal budgets makes it more important than ever to meaningfully address stakeholder concerns and ensure that projects are meeting performance targets. Baseline and monitoring data contribute to the success of coastal restoration efforts by preparing project managers and policy makers to acknowledge and address stakeholder concerns before, during, and after project construction. Further, such data collection efforts are a critical component of meaningful adaptive management plans, which should include clear, quantitative targets. By filling critical data gaps, we can address stakeholder concerns more efficiently and fairly, move more rapidly toward project construction, and protect the investment we make in each coastal project.

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Innovative Tools

Concurrent Session IV: Innovative Tools
Moderator: Rick Raynie, Office of Coastal Protection and Restoration

Louisiana's Coastal Wetland Forest: Ecotourism/Recreation Magnet and Tropical Storm Protector or Disappearing Ecosystem?
Jim L. Chambers, Richard F. Keim and John A. Nyman,
School of Renewable Natural Resources, LSU AgCenter

The Use of Artificially Induced Oyster Reefs in Coastal Restoration
Mark Gagliano[1], Spencer Varnado [1], and Cheryl Brodnax [2]
[1] Coastal Environments, Inc., [2] National Oceanic and Atmospheric Administration (NOAA)

More Submersed Aquatic Vegetation (SAV) Species Biology Needs To Be Incorporate into SAV Restoration Strategies for Different Louisiana Salinity Zones and Landscapes
Michael A. Poirrier[1], Elizabeth A. Spalding[2] and Carol D. Franze[3]
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Poster Presentations

Genetic Diversity of Selected Sea Oats(*Uniola paniculata L.*) lines
Carrie Knott[1], **Sarah Bertrand[1]**, Niranjan Baisakh[1], Michael Materne[1], and Prasanta Subudhi[1]
[1]Louisiana State University Agricultural Center
STUDENT POSTER

Oyster Reefs as a Restoration Tool: Do Reef Structure, Physicochemical Conditions, and Wave Energy Environment Affect Reef Sustainability?
Sandra M. Casas[1], Jerome F. La Peyre[1], Megan La Peyre[2]
[1] Louisiana State University Agricultural Center, [2] U.S. Geological Survey, Louisiana Fish and Wildlife Cooperative Research Unit, School of Renewable Natural Resources, Louisiana State University Agricultural Center

Utilizing GIS in Ocean Observation and Forecasting Systems with Emphasis on the WAVCIS System and its Application to the Louisiana Coast
Yuliang Chen[1], Gregory W. Stone[1]
[1]Louisiana State University

Using the Floristic Quality Index to Assess Wetland Condition in Coastal Louisiana
Kari F. Cretini[1], Jenneke M. Visser[2], Ken W. Krauss[1], and Gregory D. Steyer[1]
[1] USGS National Wetlands Research Center, [2] University of Louisiana Lafayette

Enhancing Louisiana's Coastal Sustainability with Biologically Dominated Engineered Reefs: Carbon Sequestration Implications
Daniel Dehon[1], Steven G. Hall[1]**,** Mike Turley[2], Tyler Ortego[3], Matt Campbell[4], Bob Beine[3], William Shockey[1], Brian Thompson[1]
[1] Louisiana State University, [2]Wayfarertech, [3]Oratechnologies, [4]Coast and Harbor Engineering
STUDENT POSTER

Soil Amendments May Improve Establishment of *Baccharis halimifolia* at Coastal Restoration Sites
Michael J. Dupuis[1], Mark W. Hester[1]
[1]University of Louisiana, Lafayette
STUDENT POSTER

Development of Germination Protocols for *Schoenoplectus californicus* Seeds
Carrie Knott[1], **Audrey Hall**[1], Michael Materne[1], and Herry Utomo[1]
[1]Louisiana State University Agricultural Center
STUDENT POSTER

Refinement of Black Mangrove's Restoration Template in Coastal Louisiana
Lauren K. Alleman, **Mark W. Hester**
Coastal Plant Ecology Laboratory, Department of Biology, University of Louisiana, Lafayette

Improving the Multiple Lines of Defense for the Chenier Plain
Stanley L. Klemetson
Department of Engineering, McNeese State University, Lake Charles, LA

Development of Techniques for Commercial Production of Sea Oats (*Uniola paniculata*)
Carrie Knott, **Lina Kruth**, and Michael Materne
Louisiana State University Agricultural Center-School of Plant, Environmental and Soil Sciences, Baton Rouge, LA, USA

Post Katrina Bottomland Hardwood Reforestation
Amy LeGaux[1], Natalie Snider[2], PJ Marshall[3]
[1]Audubon Nature Institute, [2]Coalition to Restore Coastal Louisiana, [3]RPM Ecosystems LLC

Improved Planting Techniques for Coastal Restoration
Aaron Pierce
Ecological Restoration Services

Utilization of Ferrate (Iron +6) for Wastewater Disinfection, Reuse, and Wetland Restoration
Brady K. Skaggs[1], Robert S. Reimers[1], Andrew J. Englande, Jr.[1], and Gordon C. Austin[2]
[1]Tulane University, [2]Sewerage and Water Board of New Orleans

Reduction of Endocrine Disrupting Compounds (EDCs) in Municipal Wastewater by Ferrate (Iron VI) Oxidation
Ponsawat Srisawat[1], Robert S. Reimers[1], Andrew J. Englande, Jr.[1], Thomas Wiese[2], Deborah Barbeau[1]
[1]Tulane University, [2]Xavier University

WAVCIS: A Metocean Observing Network for Supporting Coastal Restoration and Science along the Louisiana Coast
Gregory W. Stone[1,2], Yixin Luo[1,3], William J. Gibson[1], Yuliang Chen[1], Seyed M. SiadatMousavi[1,2], Baozhu Liu[1,2], Amy L. Spaziani[1,2], Mohammed N. Allahdadi[1,2] and Felix Jose[1]
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Using Chemical Analysis of Marsh Grass to Improve Coastal Restoration
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STUDENT POSTER

Transplant Canister and Aerial Seeding Applications of *Spartina alterniflora:* Revegetation Tools for Large-Scale Coastal Marsh Creation and Restoration
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Evaluating Hydrologic Restoration of Coastal Wetlands in Louisiana: A Plant Centric Approach
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Mercury Concentrations in the Soils and Vegetation of the Lake Maurepas Wetlands and Potential Responses to Increased Nutrient Loading
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Louisiana's Coastal Wetland Forest: Ecotourism/Recreation Magnet and Tropical Storm Protector or Disappearing Ecosystem?

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Coastal Louisiana was once rich with highly productive cypress-tupelo wetlands. New forests of this type were built as the major rivers changed channels. Even as some cypress-tupelo wetlands were disappearing, new ones were once being naturally created to take their place. But as levees were built areas were drained and developed, and exploration for oil and gas boomed, coastal wetland forests began to disappear. Timber harvesting, transportation, and development began to eat away at the fiber of our coastal wetlands, and storms took their toll as well. Harvesting of coastal forest was not the main cause of loss because most sites regenerated, but in certain areas harvesting worked along with other events to decrease forest area and continues to do so. Although there was some recognition of coastal forest losses by the early 20th century, only in the early 1980s were declines quantified with scientific data. In 2004 the Governor's Office of Coastal Activities created a Science Working Group (SWG) to study the coastal forest and make recommendations about policies to reverse losses and degradation. The SWG concluded that these coastal forests and especially the dominant cypress-tupelo forests are a tremendous asset to the state, but that some forests areas have disappeared and the functions and ecosystem services provided by others are threatened. The SWG made a series of recommendations to alter the demise of our coastal forest. This talk summarizes what has taken place since the SWG completed its report and what is currently being accomplished to protect our wetland forest.

Implications
Our coastal wetland forest is a large part of Louisiana's coastal wetland ecosystem that provides valuable services but has received relatively little restoration attention. New data and policies are needed to account for different threats and opportunities facing landowners and governmental agencies that own or manage coastal wetland forest. These needs extend beyond the current legally defined coastal zone.

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The Use of Artificially Induced Oyster Reefs in Coastal Restoration

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There are approximately 30,000 miles of land-water interface within the Louisiana coastal zone that are soft, muddy, and eroding. Erosion of coastal marshes is exacerbated by lowland soils being composed largely of clays and organic peats generally devoid of beach-forming, sand-sized particles. One problem in implementing traditional coastal erosion barriers in the past has been the inability of these barriers, or breakwaters, to be installed directly adjacent to the shoreline. Traditional rip-rap rock barriers require deployment in deep water. This results in placement far from shore, or bottom dredging to allow for the navigation of barges used in installation. This increased distance from the shoreline often results in an area of water between the structure and the shoreline with turbidity and wave energy not entirely dissimilar from that outside the breakwaters.

Coastal Environments, Inc. (CEI) has developed a method of shoreline protection that can not only be implemented in water as shallow as 12 inches, but is a living, self maintaining structure. By growing oysters in an interlocked, anchored structure designed for maximum wave reduction, several projects have shown that the bio-engineered structure is an effective tool for shoreline stabilization as well as restoration. Production of calcium carbonate by shellfish is one of the few natural ways in which coarse granular material is introduced into the deltaic plain ecosystem**.** When CEI's reef structure is aligned with the existing shoreline the patented design reduces wave energy and allows sediment from the water column to fallout foreshore of the structure along with coarse particulate matter that naturally sloughs off the structure. The result is an area favorable for accretion of sediment. Project sponsors to date include the National Oceanic and Atmospheric Administration (NOAA), The Nature Conservancy, The Galveston Bay Foundation, and The United States Fish and Wildlife Service (USFWS).

Implications
CEI's system is deployed parallel to the existing shoreline in a configuration that maximizes wave reduction and allows for sediment fallout foreshore. The design allows for placement in shallow, remote waters where traditional shoreline stabilization methods are not practicable. Construction of all components of the system takes place on land and then transported via shallow-draft vessel to the project site. Aside from shoreline protection, the system provides a solid substrate suspended in the water column favorable for new oyster recruitment that is less susceptible to predation while growing oysters at a faster rate than natural reefs. Completed projects can be seen on Mad Island Nature Preserve, TX, Galveston Bay, TX, Bay Rambo in Lafourche Parish, LA and Lake Barre in Terrebonne Parish, LA. Currently projects are being constructed in Caminada Bay in Jefferson Parish, LA, Lake Fortuna in St. Benard Parish, LA, and Mobile Bay, AL.

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More Submersed Aquatic Vegetation (SAV) Species Biology Needs To Be Incorporated into SAV Restoration Strategies for Different Louisiana Salinity Zones and Wetland Landscapes

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Submersed aquatic vegetation (SAV) refers to rooted, flowering plants that grow underwater. Despite their food and habitat value for fish and wildlife, what little is know about Louisiana SAV biology has not been incorporated into restoration efforts. Discrete SAV associations occur in coastal salinity zones ranging from diverse freshwater species that tolerate some brackish water, to a few intermediate salinity species, to high salinity seagrasses. In addition to salinity, factors such as light, water level, nutrients, and growth form need to be considered.

Light generally begins to significantly limit growth at depths greater than one meter, and maximum depth of SAV occurrence is controlled by decreasing light with increasing depth. The minimal depth of occurrence is controlled by low water events that expose SAV to drying and damaging waves. With nutrient loading, SAV is generally replaced by algae due to shading by epiphytes and dense phytoplankton. However, particularly in freshwater habitats, the abundance of algal grazers, high growth rates, formation of persistent, near-surface canopies and the ability of exotic species to engineer a more suitable SAV habitat can negate nutrient effects. Species with high underground biomass generally have stable populations, while others have variable seasonal populations.

Implications
For sustained restoration to prosper, different monitoring, management and restoration strategies need to be developed for different salinity zones and coastal landscapes. Disregard for SAV species biology can result in SAV loss due to algal overgrowth or nuisance growth of undesirable native and exotic species resulting in negative habitat value. Using SAV cover to monitor restoration success needs to include species-specific seasonal variation. Long-term population cycles and alternate stable community states also occur and potential habitat models and dispersal from source populations need to be considered. Restoration by transplanting only works if environmental quality is restored first. Native SAV needs to be maintained and exotic species controlled to maintain long-term habitat integrity.

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STUDENT

Genetic Diversity of Selected Sea Oats (*Uniola paniculata* L.) Lines

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Sea oats (*Uniola paniculata* L.) is a perennial dune grass native to the Gulf and Atlantic Coasts of the United States. Sea oats is ideal for building and stabilizing sand dunes because its extensive rhizome system stabilizes sand while its shoots act as a windbreak to collect windblown sand. It is important because low profile dunes leave the Louisiana coastline vulnerable to storm and hurricane destruction. Sea oats preserve and restore beaches which act as a buffer for coastal communities by decreasing storm surge. With the development and utilization of well-adapted sea oats lines, it is possible that beaches would be able to rebuild dunes naturally after major hurricanes rather than requiring repeated restoration. Native sea oats populations no longer exist in Louisiana, mostly likely due to the extreme beach conditions including low profile dunes and saturated beaches. Therefore, The LSU AgCenter's Coastal Plant Breeding Program, the first and only program of its kind in the United States, is utilizing traditional plant breeding methodologies to develop genetically diverse sea oats lines that tolerate Louisiana's extraordinary beach conditions and are adapted to the western Gulf of Mexico Basin. In 2001, seeds from 380 sea oats plants were collected from eight states. These seeds were germinated and approximately 1500 plants were transplanted to Holly Beach, LA and Long Beach, MS for evaluation. Based upon survival, plant vigor, and spread, 158 lines representing five states (North Carolina, Florida, Alabama, Louisiana, and Texas) were selected. The objective of this study was to determine the genetic relatedness of the selected lines using Amplified Fragment Length Polymorphism (AFLP). Preliminary analyses of 32 lines indicate a high level of similarity (86%) from 330 loci.

Implications
Genetically unique sea oats lines that perform well in Louisiana's natural beach environments are essential for successful coastal restoration projects. This is because genetically diverse lines are capable of adapting to environmental changes, which promotes beach growth and longevity. The use of molecular genetics methodologies, such as AFLPs, make it possible to determine the genetic relatedness of experimental breeding lines. This will ensure that parental lines chosen for controlled crosses within the breeding program maintain a high level of genetic diversity. This information will also be helpful in developing Marker Assisted Selection (MAS) tools that will increase the efficiency of the sea oats breeding program.

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Oyster Reefs as a Restoration Tool: Do Reef Structure, Physicochemical Conditions, and Wave Energy Environment Affect Reef Sustainability?

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Reefs created by the eastern oyster, *Crassostrea virginica*, provide a variety of ecological services including habitat creation, water quality maintenance, and shoreline stabilization. For coastal protection, reefs located near marshes have been suggested to act as natural breakwaters, absorbing wave energy and slowing shoreline erosion, and may provide an additional tool to aid in coastal restoration efforts. However, few data exist to support managers in determining where reefs may be most sustainable, and ultimately, where reefs may be successfully used as a tool to help with shoreline protection. This project examined the effects of reef structure (narrow: 25 x 0.7 x 1.5 m, and wide: 25 x 0.7 x 3 m) and energy environment (low and medium) on reef sustainability at three locations, with locations used as a proxy for different physicochemical conditions (salinity, total suspended solids, chlorophyll a availability). In February 2009, nine oyster reefs were created in Sister (Caillou) Lake, LA, using oyster shell. During the first year, all reefs experienced spat settlement (> 1000/m^2), good spat and oyster survival (>50%), and growth By December 2009 live oysters on the reefs reached densities of up to 7,000 individuals/m^2 and sizes of 35 mm; however, large differences were found between reefs based on energy, and location but not by structure. In general, oyster density was higher on the medium energy reefs as compared to the low energy reefs, and oyster density was higher at reefs closest to the Gulf of Mexico along the south side of Sister Lake. Long-term sustainability will continue to be monitored to determine how oyster size distribution and recruitment vary over years which will help in defining the parameters that can be used for managers in deciding when and where to use oyster reefs as a tool for shoreline protection.

Implications
Several scientific studies have shown that oyster reefs can reduce shoreline erosion. In order to act as a natural breakwater, and to provide this service over the long-term, the reef needs to be self-maintaining through high spat settlement and survival rates. This research suggests that such parameters as wave energy and some basic physicochemical data can be used to help identify where oyster reefs would provide a useful and sustainable tool for coastal restoration.

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Utilizing GIS in Ocean Observation and Forecasting Systems with Emphasis on the WAVCIS System and its Application to the Louisiana Coast

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GIS has widely been applied in coastal research, especially for visualizing complex multi-dimensional outputs from wave and hydrodynamic models. As in WAVCIS (Wave-Current-Surge Information System) – a regional ocean observation and forecasting system along the southeastern United States coast, GIS plays a critical role in conducting raw data processing, data visualization, and data analysis. The real-time data and model output broadcast on the World Wide Web are processed and integrated by WebGIS. The latest research in WebGIS helps to integrate animations from ocean numerical models with other data assessment/data analysis functions.

While animation is one of the important representations or output of oceanographic models, traditional GIS lacks of mature functional support for it. In WAVCIS, a feasible solution is developed to support forecast animations on the web. As animations are the main function of the system, other functions are integrated to provide more services, such as real time met-ocean data access, forecast/hindcast data validation, etc. The system provides wave and current forecasts for 60 to 84 hours from several models, viz., Mike21, Wave Watch 3, SWAN, HYCOM. Met-ocean data from six offshore stations along the Louisiana coast are updated every one hour and can be visualized up to 1 month. All the information are archived and can be easily accessed by simple queries. Access can also be obtained using an ID and Password. In this presentation we expound the GIS infrastructure as it pertains to the Gulf of Mexico and in particular, the Louisiana coast and inner shelf.

Implications
By utilizing GIS, WAVCIS operates as a platform to provide comprehensive and reliable operational data/information from in situ measurements and forecast data for the Gulf of Mexico, in various spatial scales, from high resolution coastal forecasts to Gulf-wide met-ocean forecasting. Information necessary for emergency response is provided online to the concerned agencies which would help them making critical decisions during storms or oil spill and other emergency cases offshore or in the bays. During the past hurricane seasons this system has worked efficiently and provided much needed, high quality information to the end user, academic, emergency operations in addition to Federal, State agencies and the private sector. With the flexible design and implementation, this emerging technology and system can be extended to other ocean/coastal research systems for ocean observation and forecasting and engineering design.

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Using the Floristic Quality Index to Assess Wetland Condition in Coastal Louisiana

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The Floristic Quality Index (FQI) has been developed for several regions throughout the United States to provide an objective assessment of the vegetative quality or biological integrity of wetland plant communities. We have developed a modified FQI (FQI_{mod}) for coastal Louisiana wetlands to assess the status of coastal wetlands and the effectiveness of restoration and protection projects. Vegetation data to support the index development were derived from vegetation monitoring stations that are situated within active restoration projects and reference areas. These stations are distributed across swamp forests and fresh, intermediate, brackish, and saline marshes in coastal Louisiana. A comprehensive list of 809 coastal Louisiana wetland plant species was developed and distributed to a group of 40 local plant experts. The panel of experts assigned Coefficients of Conservatism (CC) values from 0 – 10 to each species according to that species' tolerance to disturbance and to the species' fidelity to Louisiana coastal wetlands. A subpanel of eight local experts met to combine the scores and to resolve inconsistencies in scoring from the larger group. Several groups of plants including floating or submerged aquatics and non-rooting, parasitic plants were excluded from the analysis and thus were not assigned a CC score. Non-native species were assigned a score of zero. FQI_{mod} incorporated yearly measures of species percent cover from monitoring stations. Vegetation data collected over 12 years from the East Mud Lake Hydrologic Restoration Project were used to test FQI_{mod} and to demonstrate the utility of the index over time. Results suggest that the incorporation of quantitative cover data into the FQI provided a useful ecological indicator of condition. FQI_{mod} will be used in conjunction with other indices developed for hydrology, soils, and landscape in order to collectively assess coastal wetland restoration and protection efforts in Louisiana.

Implications
There is a critical need to develop scientifically credible indices for assessing the effectiveness of restoration projects and programs in Louisiana. The FQI shows promise as a useful indicator of vegetation condition. However, the use of indicators in assessment requires identification of restoration targets (desired conditions), which have not been clearly defined for coastal Louisiana at the project or program level. The Coastwide Reference Monitoring System (CRMS) is providing reference data that can be used by the restoration and management community to establish a range of condition as a target. Agreement upon a set of targets against which progress can be assessed can assist in determining an ecosystem condition that provides optimal structural and functional characteristics, resilience to disturbances and self-maintenance.

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STUDENT

Enhancing Louisiana's Coastal Sustainability with Biologically Dominated Engineered Reefs: Carbon Sequestration Implications

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Bioengineered reefs have been used to enhance and encourage growth of oysters and other organisms in coastal restoration projects. These devices have advantages over largely non-biological devices such as rock breakwaters, requiring less material and growing to new water heights, but do not initially reduce wave energy as much as rock breakwaters. However, after 1-3 years of growth, these devices actually reduce waves better and are more sustainable over time, growing into appropriate spaces, even as they sink slowly (1-2 cm/year) into the soft coastal muds.

Three areas of interest are linked to carbon dioxide: 1) carbon sequestration in oyster shells and biomass; 2) ocean acidification and potential decalcification or slowed growth rates; and 3) rising sea levels due to melting of glaciers. Greatly increased levels of atmospheric carbon dioxide are predicted to lead to approximately 1 meter in global ocean level over the next 100 years. Coastal structures must be adapted, or grow to a new level. These devices can grow vertically 3-5 cm/year. Ocean acidification due to absorption of atmospheric carbon dioxide is expected to shift pH by 0.1 pH point. Oysters have been shown to be minimally affected up to about 0.5 pH points, while some corals and other species may be dramatically affected by this shift. Finally, long term, we need to not only slow the production of carbon dioxide but find ways to reverse it by sequestering carbon in biological, chemical or even mechanical ways. This paper will detail rates at which carbon is sequestered in these natural bioenhanced structures.

Implications
Biologically dominated coastal structures change over time, making some people uncomfortable. However, they require less initial material, can grow vertically to make up for subsidence and sea level rise, provide habitat, and, due to lower mass density, can be emplaced more easily.

Oyster dominated structures could also provide food and/or spat for the oyster industry. Two limitations are: 1) they take some time (usually 1-3 years) to reach "maturity"; and 2) water quality (and salinity) will affect where structures will grow well. We identify an "oyster zone" and review recent and ongoing projects and practical implications.

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Soil Amendments May Improve Establishment of *Baccharis halimifolia* at Coastal Restoration Sites

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Development of techniques that enhance the establishment of vegetation plantings at coastal and barrier island restoration sites are important to project success and sustainability. Barrier island restoration projects may benefit the most from the development of soil amendment protocols since sediments at these sites are typically dredged offshore sands. These sediments can create a stressful environment for plant establishment because they are low in nutrients and organic matter content. Both humic acid and hydromulch are two amendments that may improve establishment success, but are not yet widely utilized in coastal restoration. An ideal plant species for supratidal woody habitat restoration on barrier islands is *Baccharis halimifolia*. *Baccharis halimifolia* is a common constituent of Louisiana barrier island plant communities that has high seed production, is salt tolerant, and provides faunal habitat. The purpose of this study is to investigate ways of enhancing establishment of *B. halimifolia* by seed while improving sediment conditions for subsequent vigorous growth. We conducted three experiments: the first determined the benefit of organic matter, hydromulch, and humic acid treatments on *B. halimifolia* seed germination under two precipitation regimes; the second evaluated a range of applied humic acid amendments on seedling growth; the third focused on optimizing humic acid dosage and potential synergy with fertilizer application. Results from the first study show a significant benefit of hydromulch on germination in sediment with low organic matter. In the absence of hydromulch, sediment organic matter content was positively associated with germination success. Results to date from the humic acid studies suggest that humic acid amendments are not as effective as traditional fertilizer application rates in enhancing growth of *B. halimifolia*. However, humic acid has been reported to function similarly to a slow release fertilizer. Therefore, potential benefits of humic acid amendment may not be evident until later in the study.

Implications
Healthy plant communities are an essential part of the success of barrier island restoration projects. Vigorously growing plants aid in trapping and binding sands, thus enhancing barrier island sustainability. Hydromulch and humic acid show promise in potentially enhancing the establishment of vegetation in stressful environments, such as recently created supratidal barrier island habitats. Our studies have demonstrated that hydromulch is effective in retaining sediment moisture, thereby improving *Baccharis halimifolia* germination success especially in sediments with low organic matter content. Although humic acid studies are ongoing, it appears that humic acid has the potential to benefit barrier island plant establishment as an organic amendment that also functions as a natural slow-release nitrogen source.

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Development of Germination Protocols for *Schoenoplectus californicus* Seeds

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Louisiana is experiencing detrimental coastal land loss. To reduce the rate of land loss, many saltwater and brackish marsh restoration projects have begun using native plant species that are able to withstand the extreme conditions of these environments. In Louisiana, salt tolerant California bulwhip (*Schoenoplectus californicus)* is a plant species used in restoration projects. California bulwhip is a perennial, deep-water plant that forms extensive networks of rhizomes and above-ground tissue. It is suitable for restoration and stabilization of eroding areas with high wave energy. Seeds and above-ground plant material provide food and shelter for many wildlife species, which accelerates ecosystem development in restored areas. Currently, genetically identical bulwhip clones are being used in restoration projects. Producing and transplanting mature clones is very expensive, and genetically identical clones cannot adapt to environmental changes. One method of efficiently and economically produce genetically diverse plants is seed based propagation techniques. Unfortunately, California bulwhip seed is documented to have a low germination potential. To develop protocols that will enhance California bulwhip germination potential, seeds harvested in 2008 from 20 salt-tolerant California bulwhip ecotypes were scarified with two techniques and germinated in four environments. The seeds were mechanically scarified with a scalpel or paddle thresher. Four growth chambers were used to obtain the following environments: 35°C (7 hrs)/ 18.3°C (17 hrs); 29°C (16 hrs)/ 19°C (8 hrs); 20°C (14 hrs)/ 10°C (10 hrs); and 25°C (24 hrs). After 90 days, the range of germination was 1 - 6% for non-scarified and 0.67- 11% for scarified seeds. Seeds scarified with a scalpel and germinated at 25°C (24 hrs) had the highest percent germination at 11 %. To determine the cause of low California bulwhip seed germination, growth hormones and additional scarification treatments and germination environments are being investigated; this data will be presented.

Implications:
Implementing a seed based propagation technique would greatly increase the efficiency of California bulwhip plant production, reduce the cost of establishing plants at restoration sites, and increase the genetic diversity of plant material used in restoration projects.

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Refinement of Black Mangrove's Restoration Template in Coastal Louisiana

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Black mangrove (*Avicennia germinans*) grows at the northern latitudinal limit of its North American range in Louisiana's coastal salt marshes. Black mangrove are especially valuable in back-barrier island salt marshes, where they provide critical woody habitat for species such as the endangered brown pelican, as well aid in trapping and binding sediments, thereby contributing to the sustainability of barrier islands. Barrier islands are recognized as being the first line of defense against tropical storms and hurricanes, buffering storm surge intensity to the landward shorelines and marshes. Effectively establishing vegetation, such as black mangrove, in barrier island restoration designs requires a thorough understanding of tolerance limits to environmental gradients present within a restoration design template. Hydrogeomorphic setting is an important modulator of wetland plant performance. In Louisiana, consideration of the limiting effect of a micro-tidal tide range on compressing the amount of suitable created inter-tidal habitat is crucial: small changes in elevation translate into large differences in amount of habitat created within a given plant species' tolerance limits. To more clearly define the restoration 'space' in which black mangrove seedlings can be successfully established and vigorously grow, we conducted a series of experiments that manipulated environmental variables often present at barrier island salt marsh restoration sites: water-level, salinity level, and sand burial and determined the responses of different age classes of black mangrove seedlings to these environmental and stress factor gradients. Seedling growth response displayed non-linear trends with optimal responses occurring at intermediate levels of stress or disturbance as follows: 24 to 48 ppt salinity, 0 to 10 cm burial, and marsh surface elevations of 5 to 30 cm above mean water level. Seedling age classes displayed similar tolerances and responses; however, older seedlings may confer a slight restoration advantage due to greater total biomass and reserves, most notably in response to burial.

Implications
Uncertainties remain in designing optimal restoration templates in back-barrier salt marsh creation/restoration projects. Black mangrove is a key component of barrier island salt marshes because of the valuable ecosystem services that it provides. Our research has shown that elevation and salinity gradients have profound effects on the successful establishment and growth response of black mangrove seedlings. Seedling response to post-establishment environmental effects, such as sand burial, which may occur via aeolian transport or overwash, further constrains optimal restoration template space. Our study provides clear guidance on how this refinement of black mangrove seedling tolerance to environmental gradients and stressors in micro-tidal environments can be utilized to better inform the design of optimal templates for habitat restoration and sustainability on Louisiana's back-barrier salt marshes.

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Preservation of Lines of Defense for the Chenier Plain

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Multiple Lines of Defense are needed to preserve the coastal communities on the Gulf of Mexico. The Chenier Plain is a major part of that defense in Southwest Louisiana and the surrounding areas, but many of these areas are being destroyed by physical erosion. While protection is provided by highways and other barriers; Highway 82, one of the principal barriers, has been damaged by recent storm events. Unless we take action to make the highways and other barriers more resistant to erosion we will experience greater damage to the Chenier Plain due to erosion. In addition, Highway 82 is a primary access and emergency escape route for the coastal communities and lands. The loss of the highway means significant economic impact and safety impact to the area. McNeese State University has been evaluating methods for making the highway more resistant to erosion damage through replacement of highway shoulder materials. These materials are being evaluated by field and laboratory analysis methods.

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Development of Techniques for Commercial Production of Sea Oats (*Uniola paniculata*)

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Coastal erosion is a growing, pervasive problem affecting the entire United States, particularly Louisiana. To reduce coastal erosion, native plant species are being incorporated into coastal restoration projects. Sea oats, *Uniola paniculata*, is an invaluable plant species for building sand dunes along the Atlantic and Gulf of Mexico coasts. It is a perennial dune grass that thrives in sandy areas such as beaches and barrier islands. Sea oats are able to withstand harsh environmental conditions and are capable of mitigating and reversing coastal erosion. Therefore, they are used extensively in restoration projects. Florida has a successful commercial sea oats industry that supports restoration efforts. However, purchasing and transporting sea oats from Florida to other states is costly and methodologies for commercial sea oats production are not publically available. In Louisiana, the size and number of restoration projects incorporating sea oats is limited by the high cost of commercial plant production. To determine efficient methods of commercial sea oats production, we have investigated various seed production, seed germination, and plant production methods. Preliminary tests indicate that large numbers of sea oats seeds can be produced in artificial nurseries as far north as Baton Rouge, LA: seeds cut prior to planting increased germination by up to 72%, and plants grown hydroponically in a greenhouse survived six times better than seeds germinated in a laboratory and transplanted to a greenhouse. These data indicate the potential for increasing the efficiency of commercial sea oats production in Louisiana. In December 2009, a study to determine the effect of seed scarification and various aspects of hydroponic production such as water type, fertilization, and aeration was initiated. Percent germination, seedling survival, and seedling vigor will be measured. Seedlings will also be transplanted to natural beach environments where survival, vigor, and plant spread will be evaluated.

Implications
This project will establish publically available techniques for commercial sea oats production. These methodologies will be more efficient and cost-effective than current methodologies, thus allowing the size and number of restoration projects that utilize sea oats to increase.

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Post Katrina Bottomland Hardwood Reforestation

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Bottomland hardwoods serve a critical role in the watershed by reducing the risk and severity of flooding to downstream communities by providing areas to store floodwater. In addition, these wetlands improve water quality by filtering and flushing nutrients, processing organic wastes, and reducing sediment before it reaches open water.[4] Bottomland hardwoods grow on natural ridges and in broad flood plans and can play an important role in Louisiana's multiple lines of defense strategy. State-wide, bottomland hardwood forest loss is estimated to be 50 to 75 % of the original presettlement acreage.[5]

Post storm seed settlement and an open canopy, led to a rapidly developing monoculture of invasive Chinese Tallow *Sapium sebiferum* in Audubon Louisiana Nature Center's 86 acre bottomland hardwood forest. After consultation with numerous local, state and federal agencies an invasive species removal and reforestation plan was formulated. The Coalition to Restore Coastal Louisiana in partnership with Entergy Corporation, and Restore America's Estuaries came to the aide of Audubon Nature Institute providing volunteers, clearing costs, equipment and trees. Two and a half of the ten acres cleared and replanted to date were reforested with trees donated by RPM Ecosystems LLC. RPM trees are grown with the patented, all natural (non-GMO) Root Production Method producing high performance native trees from Louisiana gulf coast seed stock.[6] Through its not for profit, The Restoration Tree Trust, RPM is donating 10,000 trees toward the **complete restoration** of the Nature Center's forested wetlands which were totally devastated by Hurricane Katrina.

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Improved Planting Techniques for Coastal Restoration

Aaron Pierce
Ecological Restoration Services

Due to the overwhelming land loss in Louisiana, there is a great need to rebuild our coast. One of the key factors that is sometimes overlooked is vegetative planting on coastal restoration projects. Although it is usually the last work to be done on restoration projects, such planting is a vital component of land creation. Vegetative planting plays a key role in holding the soil in place to help fight erosion and provides a key habitat for wildlife. There is always going to be a need for vegetative planting when rebuilding coastal Louisiana.

Ecological Restoration Services is striving to improve planting techniques, which will aid in bringing down the cost and also provide faster plantings. Ecological Restoration Services poster will show new ideas for planting bitter panicum and seashore paspalum and show how vegetative plugs can be planted in wet conditions with a mechanical planter. Ecological Restoration Services is using all of the release varieties from the NRCS Golden Meadow Plant Material Center at our nursery in Point Au Chien.

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Utilization of Ferrate (Iron +6) for Wastewater Disinfection, Reuse, and Wetland Restoration

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Current wastewater disinfection practices for New Orleans utilize chlorination and discharge to the Mississippi river, a system that contributes to the dead zone in the Gulf of Mexico. In an effort to mitigate cypress wetlands loss in the New Orleans area, Tulane University researchers have evaluated municipal wastewater reuse by disinfecting wastewater with ferrate ion, or iron (VI), and subsequently discharging to the wetlands. Ferrate (FeO_4^{2-}) is a green oxidant, which produces a micronutrient for vegetation and chemical coagulant (ferric hydroxide). Bench-scale testing has been utilized to test ferrate's efficacy to disinfect for fecal coliform, *E. coli*, *Enterococci,* and somatic bateriophage microbial indicators. Reduction of estrogenic hormonal activity by a bioluminescent assay has also been observed. Disinfection assays utilizing ferrate indicate 3-log reduction in microbes, or 99.9% inactivation. Ferrate will oxidize endocrine disrupting compounds to inactivate their biological and hormonal activity. This research elucidates the efficacy of ferrate for disinfection by determining minimal contact time, reaction kinetics, and dose for disinfection as applied to municipal wastewater effluent. The specific advantages of ferrate over chlorine are:

1. Produce a pathogen free effluent with respect to *E. coli, enterococci,* and somatic bacteriophage.
2. Current disinfection processes tend to produce potential problem by-products, while iron VI will not produce these chlorinated by-products.
3. With the current concerns of EDCs and PPCPs in wastewater effluents, ferrate will oxidize these refractory organics to inactivate their biological and hormonal activity.

Implications
Integration of ferrate technology into New Orleans' existing wastewater treatment facility can produce an effluent discharge that can be used to mitigate wetlands loss by displacing salinity intrusion, providing organics and iron for plant growth, reducing pathogens released into the environment, and minimizing the release of disinfection byproducts and hormonally active compounds into environmental media. Furthermore, this iron species does not produce the disinfection by-products commonly associated with chlorination practices. Its resulting oxidative by-products are non-biocidal and non-carcinogic, which could lessen the impacts to human health and the environment.

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Reduction of Endocrine Disrupting Compounds (EDCs) in Municipal Wastewater by Ferrate (Iron VI) Oxidation

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Endocrine disrupting compounds (EDCs) in wastewater present an emerging category of pollutants that have the potential to adversely interfere with the reproduction and development of humans and wildlife. Conventional wastewater treatment plants are not designed to remove EDCs. The purpose of this study was to evaluate effectiveness of ferrate in the removal of estrogenic activity from New Orleans wastewater treatment plant (WWTP) effluent.

Raw wastewater influent, pre-chlorination effluent and post-chlorination effluents were collected from the treatment plant. Pre-chlorination effluent was treated with varying doses of ferrate (0-12 mg/L). Each wastewater sample was filtered to remove suspended solids. EDCs were extracted from both the solid phase and the liquid phase using methanol and methylene chloride. Extracted samples were evaporated to dryness and reconstituted in ethanol. The estrogenic activity in wastewater sample was measured using the MVLN bioassay which compared to the activity of 17-β-estradiol (E2) at 10^{-9} M and expressed as equivalents E2/L sample.

The estrogenic activity of WWTP influent was 219.5µg E2 equivalents/L. Following activated sludge treatment, the estrogenic activity was 119µg E2 equivalents/L; a 46 % decrease. Following chlorination, the estrogenic activity increased to 173.2 µg E2 equivalents/L, a 46% increase from pre-chlorination effluent. Following disinfection with ferrate, the estrogenic activity of the secondary wastewater effluent decreased further; the optimal dose for estrogenic activity reduction was 6 mg/L. The reduction of estrogenic activity was dependent on organic content of the wastewater; 66.6% reduction was observed at low organic contents while 23.7% reduction was observed at higher organic.Because of its ability to reduce the estrogenic activity in wastewater, Ferrate provides an attractive alternative to chlorine in wastewater treatment.

Implications
The wetlands of coastal Louisiana are a highly productive ecosystem and provide an important barrier of protection from storm surges; yet they are disappearing at an alarming rate.Wastewater effluents and sludges are a potential source of nutrients and fresh water to assist in the restoration, but they must be treated adequately to prevent adverse effects on the environment and public health. Concerns exist over the potential adverse effects on aquatic life posed by emerging pollutants, such as endocrine disrupting compounds (EDCs).

This study investigates the potential reuse of activated sludge treated wastewater for wetlands restoration in Orleans and St, Bernard parishes, Louisiana. A “green” disinfection/oxidant, Ferrate, is used as an alternative to chlorine disinfection. In bench studies, Ferrate has been shown to reduce estrogenic activity in wastewater effluents generated during activated sludge treatment. Furthermore, its oxidation by-product, ferric hydroxide, is a micronutrient beneficial to wetland rehabilitation.

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WAVCIS: A Metocean Observing Network for Supporting Coastal Restoration and Science along the Louisiana Coast

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The Wave-current-surge information system (WAVCIS) is a comprehensive ocean observing and forecasting network implemented for the northern Gulf of Mexico and has been operational since 1998. CSI 16, off Breton Sound, is the latest addition to this network of offshore observation stations, which currently encompasses 6 fully functional platforms distributed along the Louisiana coast and inner shelf. The offshore stations are equipped with state-of-the-art met-ocean equipment that measure oceanographic and meteorological information; these data are available on an hourly basis and the data can be secured on the web (www.wavcis.lsu.edu). The marine data products include time series of bulk wave parameters, tide, current speed and direction, salinity, SST, dissolved oxygen etc. Meteorological data consist of wind speed and direction, air temperature, atmospheric pressure, visibility, humidity etc. Taking advantage of the observational capabilities of Acoustic Doppler Current Profilers (ADCP), vertical profiles of current speed and direction are continuously monitored. Also, directional wave spectra and spectral evolution are computed from the ADCP measurements.

The meteorological instruments are mounted on oil platforms and marine instruments are affixed to the rig legs and are connected to the computers located on-site. Care has been taken to configure the instrument location with minimal data contamination from interference with the platform structure. Data gathered offshore are transmitted by satellite communication to a base station in the WAVCIS data processing laboratory at Louisiana State University's Coastal Studies Institute. The entire WAVCIS operation-beginning from *in situ* data collection, on board pre-processing, data communication, QA/QC and data archiving and rapid dissemination online-have been automated. Also, met-ocean forecasting for the Gulf of Mexico and Atlantic coast, at various spatial scales, are also provided at the site. Third generation wave models provide 84-hour forecasts and the models are skill assessed using near-real time bulk wave data collected offshore.

Implications
WAVCIS has proven its importance on numerous occasions, especially during the landfall of major hurricanes as well as when occasional oil spills occurred offshore. The ADCP's installed at the stations will detect long period swells while the tropical cyclones are preparing to enter the southern boundary of the GoM, thereby providing valuable data for emergency decision makers, numerical modelers and citizens of the State of Louisiana Additionally, these data are used extensively by scientists and engineers to fine-tune coastal restoration projects.. Salinity, temperature, chlorophyll concentration and dissolved oxygen data, collected at variable water depths (depth profiles) at WAVCIS stations, assist in monitoring the migration of Hypoxia along the coast. Also, real time met-ocean data from CSI 09 are now displayed on an LCD screen erected at the main thoroughfare on Grand Isle for recreational use by locals and visitors to the

island in addition availability on portable devices. WAVCIS archives have become a data mine for academicians, graduate students, federal and state agencies involved in coastal restoration and management, as well as for the oil and gas industry.

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STUDENT

Using Chemical Analysis of Marsh Grass to Improve Coastal Restoration

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Reducing loss of remaining marsh is an important goal for Louisiana. A primary concern in managing coastal marshes is increasing productivity of marsh grasses to improve marsh stability. To increase productivity, managers need tools to diagnose the causes of limited production and to test whether management actions address these causes. Currently, however, the tools available to diagnose the causes of limited production in marshes are expensive because either they require specialized equipment or they are very time consuming.

A common and inexpensive tool used to diagnose causes of limited production in agricultural crops is plant tissue analysis. Using tissue analysis requires clipping only a few grams of leaf tissue and submitting it to an agricultural extension office, such as the LSU AgCenter's Soil Testing and Plant Analysis Lab. Tissue analysis provides concentrations of elements in the plant tissue, which can be used to inform decisions about management regimes when compared to critical values of each element. Critical values are published by agricultural extension offices and are often provided with tissue analysis results.

To apply this tool to marsh management, we developed critical values for *Spartina patens* (marsh hay, cordgrass). We focus on *S. patens* because it is the most common plant in Louisiana's coastal marshes. We found that elemental concentrations and ratios in *S. patens* can be used to identify three common causes of limited production in Louisiana's marshes: C:N indicates nitrogen starvation, [Na] indicates salinity stress, and [Mn] indicates flooding stress. We are also developing a fourth indicator, [Ca], which will diagnose the overall degree to which production is limited.

Implications
Without inexpensive and widely available tools to diagnose the causes of limited production in marshes, restoration and management strategies must have large budgets to diagnose limitation or take a trial and error approach to planning. The results of our research will improve how managers, restoration professionals, funding agencies, and policy makers make decisions about restoration and management of Louisiana's coastal marshes. Managers and restoration professionals can use information about which factors limit production to tailor management plans to address the sources of limitation in their marshes. Managers can also use this information to inform adaptive management plans by using the results of tissue testing to adjust their management strategies. Funding agencies and policy makers can use information about which factors limit production in marshes to implement only projects that are most likely to remedy the causes of limitation at the proposed site.

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Transplant Canister and Aerial Seeding Applications of *Spartina alterniflora*: Revegetation Tools for Large-Scale Coastal Marsh Creation and Restoration

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Louisiana coastal marshes suffer from a catastrophic land loss of 40 square miles annually. Based on long-term predictive model of geological trends, global sea level rise, and decreased natural supply of sediment, maintaining the current land mass is very challenging. Constructions of new wetlands, terraces, and barrier islands or modification of hydrology through river diversions are current efforts to slow down the land loss and could serve as a foundation of future coastal wetland systems. While physical structures are important, resiliency of native plants will determine the productivity of future estuaries. Preserving a full functionality of the entire coastal marsh system is crucial to support both wildlife and the life and culture of many people who depend on this ecosystem.

Superior seed producing lines of smooth cordgrass (*Spartina alterniflora*), PolyC15, were developed from Louisiana native populations to facilitate production of seed that can be applied in large-scale revegetation efforts. Seed can provide economical and rapid revegetation to stabilize newly constructed marshes or rejuvenate degraded salt marshes. Seed-based system will provide necessary means for maintaining the health and productivity of the coastal plant ecosystem.

Two planting systems, transplant canister and aerial seeding of smooth cordgrass, are being evaluated for their potential use in a large-scale planting. Aerial seeding can provide a way to overcome remote and highly degraded areas difficult to reach by other means. The seed can be used to develop vegetation to stabilize newly constructed terraces or created wetlands much faster than natural recolonization by volunteer plants from the adjacent wetlands. While aerial seeding is suitable for low energy areas, transplant canister is targeted for high energy areas. Research findings from aerial seeding at Bayou Dupont – Belle Chase, simulated aerial seeding at Rockefeller site, and applications of transplant canister will be presented and discussed.

Implications
Seed-based propagation system provides more versatile approaches in conducting erosion control and habitat restoration. It will help restoration agencies develop strategies for large-scale efforts. Seed can also be used to mass produce transplant canister, plugs, and potted plants more efficiently and will benefit the coastal plant nurseries.

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Evaluating Hydrologic Restoration of Coastal Wetlands in Louisiana: A Plant Centric Approach.

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Hydrologic restoration (HR) has been one of the most common wetland restoration techniques used by the Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA) Task Force in coastal Louisiana. As of January 2006, there were 16 HR projects constructed, 4 HR projects were under construction, and 8 HR projects were in the Engineering and Design Phase. The general goal for hydrologic restoration projects is to restore a more natural hydrologic regime to wetland areas that have experienced human alterations to the hydrology primarily through the addition of channels. These projects are monitored, but reference areas are not always available. However, 5 HR projects for which construction was completed between 1999 and 2001 had sufficient data for a complete BACI Analysis. Due to the large number of observations in hydrologic data, biologically insignificant differences among mean water level and salinity inside and outside of a restoration project are often statistically significant. Therefore, the hydrologic data was summarized into plant stress indices for each year before analysis. None of the projects evaluated significantly affected plant stress indices. In general, all sites were much more influenced by the large impact of a regional drought around 2000 that reduced flooding stress and increased salinity stress, than by the human manipulation of hydrology.

Implications
More knowledge on the effect of variable hydrology on coastal plant growth is needed. The concept of stress indices needs to be tested with plant growth data. Design of hydrologic restoration projects needs to evaluate the ability of structures to significantly alter hydrologic parameters that are based on the target vegetation.

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Mercury Concentrations in the Soils and Vegetation of the Lake Maurepas Wetlands and Potential Responses to Increased Nutrient Loading

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The presence of mercury in aquatic environments is of serious concern for both managers and users of these habitats. Mercury is especially worrisome because of its ability to bioaccumulate in aquatic food chains and eventually be consumed by humans. Many sport fish in Louisiana waterways have been shown to have levels of mercury above advisory limits, suggesting that further investigations into local mercury cycling would be beneficial. To this end, we conducted a field determination of mercury concentrations in the soil and vegetation of the wetlands surrounding Lake Maurepas, along with ancillary biogeochemical data. Further, we performed a soil core amendment study to elucidate the effects of surface water eutrophication (nitrogen and phosphorus) on methyl mercury production in soils. Our field study was performed in 2007 and early 2008 during which water levels at our field sites were unusually depressed, and likely responsible for the surprisingly low soil methyl mercury concentrations detected. Soil redox potentials at both 1 and 15 cm depths were high, and in conjunction with a near total lack of detectable pore water sulfides at a 15-cm depth, suggest that soils were relatively oxidized during this time. Thus, it is unlikely that microbial sulfate reduction, thought to be the primary source of methyl mercury in aquatic environments, was favored in these habitats during the study period. Importantly, total mercury concentrations in soils, as well as in aboveground and belowground components of vegetation, were consistently low and within a typical range for an uncontaminated wetland. This indicates that mercury influx into the Maurepas wetlands likely occurs primarily through normal atmospheric deposition. However, other researchers working in this region during more typical hydrologic conditions found higher soil methyl mercury concentrations. Results of the soil core amendment study suggest that, although the introduction of elevated nitrogen and phosphorus may impact various biogeochemical processes, soil methyl mercury concentration will likely not be affected in the short term. This is consistent with the findings of other researchers who suggest that altered nutrient loads may primarily affect mercury methylation by enhancing plant growth and stimulating microbial productivity through the provision of labile carbon.

Implications

Mercury is an insidious environmental threat as its release into the environment occurs as a by-product of various industrial and energy-related endeavors, such as the combustion of fossil fuels. Further, substantial atmospheric transport can result in the contamination of habitats that do not have apparent point sources of this pollutant. Our studies did not detect anomalously high levels of mercury; however, this appears to be a result of unusually low water levels during the study period. Researchers conducting similar studies did find substantially higher soil mercury concentrations during more typical hydrologic conditions, revealing the importance of understanding the environment being assessed when drawing conclusions concerning mercury cycling. Surface water eutrophication does not appear to directly alter soil methyl mercury concentration in the short-term, but longer studies to assess indirect impacts mediated through vegetation are needed.

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Sea Level Rise

Concurrent Session V: Sea Level Rise
Moderator: James Pahl, Office of Coastal Protection and Restoration

*Sea-Level Rise Impacting Louisiana Coastal Protection and Restoration: Knowns and Uncertainties
James Pahl
Louisiana Office of Coastal Protection and Restoration
Replacement Presentation (No Abstract Available)

Accelerated Sea-Level Rise and Coastal Subsidence: A Dual Threat for Louisiana and the Adjacent US Gulf Coast
Torbjörn E. Törnqvist[1,2], Shiyong Yu[1], Juan L. González[3], Ping Hu[1]
[1]Tulane University, [2]Tulane/Xavier Center for Bioenvironmental Research, [3]University of Texas

Assessing the Vulnerability of Coastal Louisiana Habitats to Accelerating Sea-Level Rise
Patty Glick[1]
[1]National Wildlife Federation

Poster Presentations

Integrating Global Trends in Coastal Restoration Planning for Louisiana
John Day[1]**,** Doug Daigle[2]
[1]Louisiana State University, [2]CREST Program

Determining Rates of SeaLevel Change From Historic Data Around a "Migrating Lighthouse" (Ship Shoal, Louisiana)
D. Elaine Evers[1], Richard Condrey[1] and John Anderson[2]
[1] Department of Oceanography and Coastal Science, School of the Coast and Environment, Louisiana State University, [2] Department of Geography and Anthropology, Louisiana State University

Assessing the Potential for Submergence at CRMS Sites Using Elevation Change, Accretion, and Sea-Level Rise Estimates
Thomas McGinnis[1], Leigh Anne Sharp[1], and Troy Barrilleaux[1]
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*The original presenters, Tim Osborn and Jonathan Brazell, were unable to present the topic described in the conference program. The session moderator, Jim Pahl, instead gave the lead-in presentation of the session, titled "Sea-Level Rise Impacting Louisiana Coastal Protection and Restoration: Knowns and Uncertainties."

Accelerated sea-level rise and coastal subsidence: A dual threat for Louisiana and the adjacent US Gulf Coast

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Sea-level rise and subsidence combine to pose an ongoing and increasing threat for the US Gulf Coast in general, and coastal Louisiana in particular. This presentation reviews the progress that has been made over the past decade in understanding these phenomena, both in terms of processes and rates. Comparison of detailed reconstructions of Holocene relative sea-level (RSL) rise from southwest and southeast Louisiana (the Chenier Plain and the Mississippi Delta, respectively) shows differential crustal motions of Pleistocene and deeper strata of ~0.15 mm/yr. This difference can be explained by the effect of sediment accumulation in the delta and the resulting depression of the underlying lithosphere. Reconstruction of RSL rise during the past millennium yields a pre-industrial rate for the central US Gulf Coast of ~0.4 mm/yr, primarily due to glacial isostatic adjustment (forebulge collapse) associated with the melting of the Laurentide Ice Sheet that affects the entire region. RSL rise as measured from tide-gauge records for the past century shows rates of 2 mm/yr or more, indicating a dramatic increase, echoing what is observed worldwide. Tide gauges in the Mississippi Delta show rates of RSL rise on the order of 10 mm/yr and sometimes higher. Given the relatively slow subsidence rates of the deeper subsurface, this indicates that subsidence occurs primarily in the shallower and more recent deposits. Studies of the deformation of deltaic strata have confirmed that subsidence rates due to sediment compaction (primarily due to loading resulting from clastic sediment accumulation) can be as high as 5 mm/yr over millennial timescales, and likely higher over decades to centuries. Projections for the future within the context of climate change suggest that sea-level rise may progressively overtake subsidence as the main threat to coastal Louisiana.

Implications
Comparison of rates of sea-level rise over various timescales highlights the impact of global warming on the US Gulf Coast by means of a rapid acceleration, with rates of sea-level rise about five times higher during the 20th century compared to the previous (pre-industrial) millennium. This is augmented in coastal Louisiana by high subsidence rates, thus providing one of the conditions that have contributed to the rapid loss of coastal wetlands. An analysis of subsidence mechanisms and rates brings both good and bad news. Since most subsidence occurs in relatively shallow deposits (uppermost 50-100 feet), infrastructure anchored in the Pleistocene substrate is generally relatively stable. On the other hand, the high sensitivity of shallow deltaic deposits to compaction demands caution in the selection of target areas for river diversion projects. These things said, the primary threat for coastal Louisiana remains the further acceleration of sea-level rise due to climate change.

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Assessing the Vulnerability of Coastal Louisiana Habitats to Accelerating Sea-level Rise

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NWF is working with Warren Pinnacle Consulting to apply the Sea Level Affecting Marshes Model (SLAMM). SLAMM was designed to simulate the dominant processes involved in shoreline modification and the conversion of one wetland type to another under long-term sea-level rise. The SLAMM model, which has been in development for the past two decades, provides a highly accessible tool to assess how rising seas may impact coastal habitats. As with all models, SLAMM is not a crystal ball. It is not intended to forecast what *will* happen to the region's habitats in the future; rather, it is a tool to offer a picture of possible outcomes under a range of scenarios.

NWF's study highlights and incorporates the results of additional research and modeling through a review of the recent literature and input from a team of expert advisors. Based on the results of this assessment, we highlight how current and potential management options in the region might help safeguard coastal habitats and communities under these future scenarios of sea-level rise.

Implications
The National Wildlife Federation (NWF) has initiated a study to identify some of the potential impacts of sea-level rise on Louisiana's already-sinking coastline. An accelerating rate of sea-level rise due to climate change is a tremendous added stressor to other factors contributing to coastal land loss. However, sea-level rise has not been factored into projected land loss trends until recently. It is critical for sea-level rise to be incorporated in the design and implementation of coastal restoration and protection strategies so our coastal investments will endure for future generations. The study will help communities and decision-makers develop the most effective coastal restoration and protection measures possible.

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Integrating Global Trends in Coastal Restoration Planning for Louisiana

John Day[1], Doug Daigle[2]
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Among the questions to be considered:

What are the implications of climate projections for coastal Louisiana on the time-line used by the United Nations IPCC Panel? How do these compare with the timelines estimated for restoration/protection actions and projects in the 2007 Louisiana *Master Plan*?

What are the likely energy needs for restoration and protection, both near and long-term, and how should we plan for them? If, as the International Energy Agency (IEA) asserts, global oil production will peak by 2020, at what stage are Louisiana's coastal programs projected to be then?

There are case studies in Louisiana that can provide useful information on how to plan for these trends: the "brown marsh" event of a few years ago, the impacts of high diesel prices on restoration projects in 2008, and the hurricanes of 2005 and 2008. Finally, are there local energy sources that can help in planning, such as the natural energy of the Mississippi and Atchafalaya Rivers, both for freshwater diversions and in utilizing for hydrokinetic river turbines?

Implications
Global trends such as climate change and energy scarcity have serious implications for coastal Louisiana. Their economic and environmental effects are complex and manifested in fluctuations (weather events, prices, etc.) rather than a process of steady change. A key challenge, then, is how to integrate such trends into planning for coastal management, protection, and restoration.

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Determining rates of sea level change from historic data around a “migrating lighthouse” (Ship Shoal, Louisiana)

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Ship Shoal is declining in height (relative to sea surface), migrating, and/or dispersing. The rate of its decline is difficult to measure given incompatibilities of the hydrographic survey data collected since 1853. These incompatibilities include differences in vertical and horizontal data resolution and manipulation, and use/location of offshore landmarks. We present a novel method using GIS technology of assessing the rate at which the distance between sea surface and substrate surface has been increasing over a 150 year period in an offshore area expected to have been affected by erosion, subsidence, and sea level rise. Since our method used historical materials available locally at LSU, these resources will be described.

Implications
Many of the ecosystem functions of Ship Shoal are depth-related. In addition to its interactions with the alongshore currents and storm fronts, these functions include its roles as a hotspot of macroinfaunal biodiversity, refuge from hypoxia, and spawning ground for blue crabs, *Callinectes sapidus*. The association of ecosystem function and depth are disturbing. All of the area surrounding the shoal has been identified as being hypoxic during parts of the year. If the trend of declining height of the shoal continues, the shoal itself will also become hypoxic and the crabs will no longer have this area for spawning.

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Assessing the potential for submergence at CRMS sites using elevation change, accretion, and sea-level rise estimates

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Rates of surface elevation change and vertical accretion combined with estimates of sea level rise will be used to assess the potential for submergence and shallow subsidence across the coastal zone of Louisiana. Elevation change and accretion data are available from many of the 392 Coastwide Reference Monitoring System – *Wetlands* (CRMS) sites from as early as fall 2006.

At each site, surface elevation is measured from a permanent location over time with an rSET (surface elevation table) while vertical accretion, sediment (organic and mineral) accumulation, is measured over maker horizons (typically feldspar clay) over time. Rates of change from these techniques are combined to calculate the shallow subsidence of the marsh surface. These site specific rates (surface elevation and subsidence) are compared to regional rates of sea-level rise to estimate submergence rates (relative sea-level rise). GIS layers of subsidence and submergence rates are added to a base map of CRMS sites to locate potential "hotspots" of subsidence and submergence. To date, the estimates are preliminary, as they will improve over time with additional data. However, elevation change and submergence estimates will have large future implications as they identify areas in danger of submerging and should be used to focus restoration efforts. The relationship between rates of elevation change, accretion, and shallow subsidence and landscape factors including dominant vegetation and soil type will be explored. Because much of the marsh loss in the coastal zone of Louisiana is attributable to marsh submergence, this application will be a beneficial tool for determining where restoration is most needed. Combining the elevation change/submergence information from this application with hydrologic (water level and salinity) and vegetative (percent coverage, floristic quality, and community type) information will not only identify where restoration is needed but also what type of restoration would best suit areas to be restored.

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Designing Diversions

Concurrent Session V: Sea Level Rise
Moderator: Barb Kleiss, US Army Corps of Engineers

Description and Analysis of Legacy Diversion Structures in Coastal Louisiana
John A. Lopez[1], and Rebecca Green[1]
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Hydrodynamics and Sediment Transport in Lower Mississippi River Meander Bends (Louisiana): Implications for Large Sediment Diversions
M.A. Allison[1], **Ehab A. Meselhe**[2], J.A. McCorquodale[3], I. Georgiou[3]
[1]University of Texas Institute for Geophysics, [2]University of Louisiana, Lafayette, [3]University of New Orleans

Simulating the Change in the Sediment Carrying Capacity of a Hypothetical Diversion Under Projected Future Sea Level Rise Using ADH
Erol Karadogan[1] and Clint Willson[1]
[1] Louisiana State University

Poster Presentations

Hydrodynamic and Salinity Numerical Modeling of the Caernarvon Diversion
Gaurav Savant, Jennifer N. Tate and Tate O. McAlpin
US Army Corps of Engineers

Small-Scale Mississippi River Reintroduction: An Important Ecological Restoration Tool in the Mississippi River Deltaic Plain
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Description and Analysis of Legacy Diversion Structures in Coastal Louisiana

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Legacy diversion structures are defined as: *Artificial hydrologic conveyance features which redirect river flow outside of or into its natural channel either incidentally or by intentional design, e.g. river diversions, spillways, new channel outlets, navigation channels or significant modifications to natural channels.* Approximately 24 legacy diversion structures have been identified and included in a database. The following characteristics have been catalogued for most structures: Discharge, Date of Construction, Operator, Constructor, Original Purpose, Current Purpose, Conveyance Characteristics, Operational Status, Original Construction Cost, River Source, Structure Type, Discharge Controls, Pictures, References /Web Links. Legacy structure designs have crude corollaries to natural deltaic hydrology and can be considered "artificial bayous", "artificial crevasses" or "artificial distributary channels". The legacy structures cumulatively represent several hundred years of operation in the Louisiana coast. Focus is currently on understanding the environmental effects of the diversions.

Implications

The concept of reintroducing Mississippi River water into the wetlands in coastal Louisiana dates back at least a century to when the problem was first created by river levees. Diversions are included in all modern coastal restoration plans for Louisiana. Nevertheless, there is great uncertainty regarding the design and impact of proposed diversions. The body of data for the legacy structures represents an untapped source of information that may be critical in predicting the response to future diversion projects. Although possibly designed for flood protection, navigation and other purposes, these structures have introduced river water into the coastal estuary and, either intentionally or not, have affected coastal wetlands, in spite of their design for other purposes. These legacy structures should be viewed critically in light of restoration needs so that they may be modified or operated more appropriately, but also as a basis for designing a new generation of structures with a new priority on re-building and sustaining coastal wetlands.

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Hydrodynamics and Sediment Transport in Lower Mississippi River Meander Bends (Louisiana): Implications for Large Sediment Diversions

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Field data collection and numerical modeling is being conducted in the lower Mississippi River in the region of a meander bend at Myrtle Grove, LA (river km 96 above Head of Passes) in support of a proposed large water and sediment diversion (1,130 – 2,830cms) for coastal wetland restoration. Field studies in October 2008, April and May 2009, at discharges ranging from 11,000-21,000 cms, examined the role of bend dynamics on sediment transport through this reach relative to control sites further downriver and USGS monitoring stations upriver. Suspended loads and grain size character measured by ADCP (velocities and backscatter), isokinetic point sampler (P-63), and optical sensors (LISST, OBS, transmissometer) indicate that during the rising-to-high discharge phase, sand lifting off from the downstream edge of the lateral bar upriver of the bend augments that carried from further upriver, and is entrained in the upper 10-25m of the water column. This excess suspended sand is advected around the bend before concentrations are reduced to background levels over the lateral bar downstream of the bend. Bedload transport rates measured by repeat swath bathymetric mapping of migrating dunes are comparable upstream of the bend, downstream, and in the control sites. However, no bedforms are observed in the bend thalweg (up to 60 m deep) supporting the dominance of suspended sand transport in the bend. Both 1D (HEC-RAS and HEC6-T) and 3D (Flow3D) numerical hydrodynamic and sediment transport modeling is underway to simulate this process and the large-scale eddy present in the bend that generates upriver transport along the inside of the meander bend at all observed discharges. Our preliminary results suggest that the outside of meander bends might be an appropriate site for sediment diversions that draw near-surface water from this sediment-rich layer.

Implications:
This work focuses on examining the use and possible implications of sediment and water diversions in the lower Mississippi River as a tool for coastal restoration. This comes at a time when post-Katrina master plans for coastal protection and restoration have been prepared by the State and U.S. Army Corps of Engineers. Although both plans make reference to large diversions, and suggest sites for construction, no consensus has been reached on whether they should be used for coastal restoration (given complicating environmental and socio-economic factors), and where they should be located. This effort is an examination of the issues surrounding large diversions in general, as well as investigating the implications of constructing large diversion at an authorized site for a smaller diversion at Myrtle Grove. We also outline critical gaps in our understanding that need to be addressed prior to constructing large diversions.

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Simulating the Change in the Sediment Carrying Capacity of a Hypothetical Diversion Under Projected Future Sea Level Rise Using ADH

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The rate of coastal land loss in Louisiana has reached catastrophic proportions. Within the last 50 years, land loss rates have exceeded 40 square miles per year, and in the 1990's the rate has been estimated to be between 25 and 35 square miles each year. A number of freshwater diversion structures are projected to serve as the conduits for freshwater, with sediment and nutrients, to pass through river levees and into the Louisiana coastal marshes to make them vertically accrete through the accumulation of both organic matter and mineral sediment and keep pace with the relative sea level rise.

ADH (Adaptive Hydraulics) is the modern, multi-dimensional, finite element hydraulic modeling program in development by the Coastal Hydraulics Laboratory of the U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC). The 2D Shallow Water Module of ADH coupled to its Sediment Transport Module (SEDLIB) is being used to model sediment transport over a 130 mile stretch of the Mississippi River (from Carrollton to the Gulf of Mexico). The model has been calibrated and verified under several different flow and tidal conditions using stage data collected from 14 stations and recent discharge observation data obtained from USACE New Orleans District published reports and databases for the Mississippi River, distributaries and passes in the study reach. Results will be presented to demonstrate the performance of ADH in modeling a hypothetical diversion located around River Mile 70 connecting the river to the adjacent wetlands. Performance and sediment carrying capacity of the hypothetical diversion will be tested under current and several projected future sea level conditions.

Implications
Standard off-the-shelf numerical models can provide some assistance in diversion design projects. However, the dynamic and spatially variable processes associated with river flow and sediment diversions and the size of the domain require state-of-the-art computational modeling and high-performance computing. Complex and accurate numerical models with sufficient spatial and temporary resolution are necessary for design and management of the Lower Mississippi River Delta system, i.e. providing quantitative insights and details for designing future structural features, assessing their impacts on the River, and understanding the processes that influence the decay and growth of sub-deltas. Results from these tests are being used to evaluate coastal restoration scenarios and define further research questions.

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Hydrodynamic and Salinity Numerical Modeling of the Caernarvon Diversion

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The Caernarvon Diversion is a feature of the Mississippi Delta Region Project, and is located approximately 15 miles downstream of the city of New Orleans. The controlled discharge structure diverts fresh water from the Mississippi River the Breton Sound Basin. The project was established to increase fish productivity and reduce adverse salinity effects.

The System Wide Water Resources Program (SWWRP) of the US Army Corps of Engineers in conjunction with the New Orleans District is presently conducting research into the effects of freshwater introduction into the basin on the hydrodynamics and salinity behavior of the Breton Sound Basin. An Adaptive Hydraulics (ADH) numerical model has been created to ascertain these impacts. The simulation area encompasses the entire Mississippi River from Reserve Louisiana to approximately 50 miles downstream of the Birds Foot Delta, and extends East-West from Gulfport, MS to Port Fourchon, LA.

The numerical model was validated for post-Katrina conditions (Year 2008) for hydrodynamics and salinity. Results from the validated ADH simulations for hydrodynamics and salinity will be presented.

Implications
The loss of Louisiana coastal wetlands and the associated wildlife productivity has become a cause for national concern. The numerical model to be presented will provide a valuable tool in understanding the hydrodynamic and salinity effects of the Caernarvon Diversion on the overall behavior of the system.

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Small-Scale Mississippi River Reintroduction: An Important Ecological Restoration Tool in the Mississippi River Deltaic Plain

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Perhaps EPA's most-preferred approach to coastal restoration in Louisiana, is reintroduction of Mississippi River water, otherwise known as *diversion*. EPA has long-supported this tool, but only since 2000, has EPA actually sponsored these kinds of projects in the Louisiana Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA) program. Beginning in 2000, EPA began obtaining approval to design several small Mississippi River reintroduction projects, four to date. While we recognize that it is primarily the much larger reintroductions that are critically-needed to begin to restore the Mississippi River Deltaic Plain in a very significant way, we also recognize the significant benefits of these small reintroductions. With few exceptions, most Mississippi River reintroduction projects funded by CWPPRA have been small. The EPA-sponsored projects are in various stages of planning. In spite of their significant benefits and small size, these projects are complex and raise questions that many other project types do not. We will discuss the benefits and challenges of small Mississippi River reintroduction projects.

Implications
EPA Region 6 believes that Mississippi River reintroduction is the single-most important technique for restoring coastal Louisiana wetlands. While small reintroductions do not have the massive potential that larger ones do, they do have significant wetlands benefits, and reflect harnessing of the fundamental deltaic processes and riverine resources of the Mississippi River. They help to demonstrate what is possible with larger reintroductions. That said, reintroductions large and small involve unique and difficult challenges.

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Policy and Planning

Concurrent Session V: Sea Level Rise
Moderator: Karen Gautreaux, The Nature Conservancy

The West Bay Sediment Diversion on the Lower Mississippi River
Cherie Price
U.S. Army Corps of Engineers

The Coastal Project Planning Process – A Difficult Path to Authorization for Dual Purpose Studies
Norwyn Johnson
Louisiana Office of Coastal Protection and Restoration

Quantification of Potential Carbon Sequestration Rates in Louisiana Wetlands
Sarah K. Mack[1], John W. Day[2,3], and Robert R. Lane[2,3], Tiffany M. Potter[4]
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Poster Presentations

Restoring Bayou Lafourche - Benefits for Coastal Louisiana
Robert Routon[1], **Tom Cancienne**[2], Michelle Robert[2]
[1]Louisiana Office of Coastal Protection and Restoration, [2]CH2M HILL, Inc.

Coping With Global Sea-Rise – Actions Other Coastal Areas In The US Are Taking
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Beneficial Use of Dredged Material- Policy and Practice in Louisiana and Texas
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Aquatic Resource Research Emphasis within a Regulatory Context
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Defining Restoration Targets for Flooding and Salinity in Louisiana's Intermediate and Brackish Marshes

J. Andy Nyman[1], Megan K. La Peyre[2], and Sarai C. Piazza[3], Christian Winslow[4]
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An Evaluation of Restoration Targets for Flooding and Salinity in Louisiana's Intermediate and Brackish Marshes

Edward J. Raynor[1], **Tabitha Owen**[1], Aaron R. Pierce[1], Cecilia Leumas[2] and Frank C. Rohwer[2]
[1] Nicholls State University, [2]Louisiana State University Agricultural Center
STUDENT POSTER

Developing Wetland-Based Carbon Markets as a Potential Funding Mechanism for Coastal Protection and Restoration

Brian C. Perez[1], Charles Killebrew[2], Alice Abney[1], Jim Bays[1], Doug Huxley[1], Jim Jordahl[1], Steve Mader[1], Steve Mathies[2], Jennifer Mouton[2], Matthew A. Wilson[1], Jerome Zeringue[2]
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Will the *Avicennia-Spartina* Association be a Component of a Louisiana Sustainable Coast?

Christine N. Pickens[1], Karen L. McKee[2], and Mark W. Hester[1].
[1] University of Louisiana, Lafayette, [2] National Wetlands Research Center, US Geological Survey
STUDENT POSTER - 2nd Place (tie) in SOC Student Poster Contest

Coastal Restoration and Protection Implementation Plan for Plaquemines Parish

Joe Suhayda[1] , Mike Flores[2], Bruce Badon[3], and W. Gagliano[4]
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The West Bay Sediment Diversion on the Lower Mississippi River

Cherie Price
U.S. Army Corps of Engineers

The CWPPRA West Bay Sediment Diversion project, constructed in 2003, is the largest sediment diversion in Louisiana and has afforded an extraordinary opportunity to advance the planning and design of diversions for the purpose of coastal restoration in Louisiana. The project was designed to restore and maintain approximately 9,831 acres of fresh to intermediate marsh by diverting fresh water and sediment from the Mississippi River over the 20-year project life through 2023.

As part of the project, the first phase of a work plan was completed in an effort to better determine the amount of riverine shoaling that is specifically attributable to the West Bay Diversion. The work plan included collecting extensive sediment and hydrodynamic data on the lower Mississippi River (MR), a geomorphic analysis from Belle Chasse to East Jetty, a 1D model to evaluate long term sedimentation trends, 2/3D models to analyze specific multidimensional riverine behaviors and an analysis of the bay side receiving area. The work plan is an unprecedented, comprehensive approach, which includes an examination of the historical anthropogenic modifications and natural changes to the lower Mississippi River.

Preliminary results indicate that the West Bay Diversion is inducing between 20-40% of the material that is depositing in the Pilottown Anchorage Area and the Mississippi River Navigation Channel, above and below the diversion conveyance channel. Future work will better define these percentages and determine the statistical confidence in the results. Disappointing but highly revealing is that the project influence area within the receiving area has experienced no subaerial land gain and a net loss of subaqueous land. In an effort to promote land growth, a mile-wide sediment retention island was constructed in the West Bay receiving area perpendicular to the flow entering the area to create vegetated marsh that can slow velocities and trap fine grained sediments. The island provides an exciting opportunity to monitor the effects of placing sediments on the receiving end of large scale diversions.

Implications
Restoring and protecting Louisiana's coast requires large scale solutions such as river diversions. However, the West Bay Sediment Diversion project has shown that planning effective river diversions that adequately consider potential negative impacts and benefits is an extremely complex undertaking. The Mississippi River system is very noisy with multiple anthropogenic and natural changes that make it difficult to evaluate specific effects from various individual modifications/changes and is also difficult to predict. On the receiving end, West Bay and other passes on the lower MS river are showing that building land in open water systems is not effective as a near term (10-50 years) solution without containment or retention features.

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The Coastal Project Planning Process – A Difficult Path to Authorization for Dual Purpose Projects

Norwyn Johnson
Louisiana Office of Coastal Protection and Restoration

Louisiana's fight to protect and restore our rapidly disappearing coast is directly linked to the Federal government's water resources program and policies. To best leverage state funding and resources we must pursue project authorization from the U. S. Congress. Today, the authorization process involves the preparation of a feasibility report in concert with the U. S. Army Corps of Engineers. Once authorized a project cannot be constructed without additional legislative approval to appropriate funding. Implementation of large coastal projects remains dependent upon this lengthy, multi-stepped process.

The existing water resources project authorization and appropriation process does not support the immediate or long term needs of coastal Louisiana. We cannot wait 30-40 years for new projects. The Water Resources Development Act (WRDA) of 2007 was heralded as a vehicle to make the process more efficient and to bring reform of the Corps. There is little evidence things have changed to the extent anticipated in the legislation. Some changes to the study process actually lengthen study phases and increase study costs.

Will there be any new authorizations for Louisiana? Why does a feasibility report take so long to complete? What are the challenges and issues confronting a typical feasibility report? This presentation will address these questions and highlight the problems inherent in developing a dual purpose project through illustrations from the Southwest Coastal Louisiana Feasibility Study which is integrating protection and restoration measures into a comprehensive plan for Cameron, Calcasieu, and Vermilion parishes.

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Louisiana Office of Coastal Protection and Restoration

Quantification of Potential Carbon Sequestration Rates in Louisiana Wetlands

Sarah K. Mack[1], John W. Day[2,3], and Robert R. Lane[2,3], Tiffany M. Potter[4]
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As greenhouse gas (GHG) regulatory policies and trading systems emerge, there is a need for definitive science to determine the net carbon impacts of natural wetlands. To guide future policy regimes and wetland carbon research, this paper identifies the carbon storage pools of natural wetlands and discusses the primary carbon sink mechanisms that require quantification to measure carbon sequestration by Louisiana wetlands, the timeframe over which it takes place, and the amount of carbon emitted during wetland loss. Based upon peer-reviewed literature, an analysis was conducted to quantify the rates of accretion and carbon sequestration where it is being enhanced by wetland assimilation or river diversion projects. The analysis calculated carbon sequestration as applicable towards carbon credits for three scenarios: (1) a regional wetland assimilation system planned to receive municipal effluent from the city of New Orleans; (2) the wetlands influenced by the existing Caernarvon Mississippi River diversion; and (3) the wetlands influenced by a theoretical large-scale diversion near Buras, Louisiana using the current rate of relative sea level rise and an increased rate of relative sea level rise that corresponds with climate change predictions. The analysis determined that the additional carbon sequestration of wetland assimilation systems averaged over 50 years, including reintroduced cypress and prevented wetland loss, would be approximately 54 CO2e ha/yr (22 CO2e ac/yr). The analysis further determined that the additional carbon sequestration due to river diversions averaged over 50 years, including prevented wetland loss but excluding introduced cypress, would be approximately 28 CO2e ha/yr (11 CO2e ac/yr). Wetland restoration measures designed to offset sea level rise associated with climate change will require increased vertical accretion resulting in increased carbon sequestration rates. This paper concludes with a detailed summary of the further research required to provide a scientific basis to quantify carbon sequestration and certify offsets from wetland projects.

For a variety of financial, environmental, and political reasons, substantial interest exists for carbon credits derived from terrestrial landscapes among governments, environmental organizations, private companies, and carbon funds, driven by the potential that carbon credits may obtain a premium price in the future. Monetization of these assets has important implications in coastal Louisiana. Wetland restoration will help the region adjust to climate change by enhancing carbon sequestration, preventing carbon release during wetland loss, offsetting sea level rise, and increasing the resiliency of the wetland ecosystem to drought by introducing continuous inputs of freshwater. In addition, restored wetlands dissipate surge and wave energies thereby protecting levees from breeching during the tropical storm events that are predicted to increase due to climate change. The inclusion of wetland restoration management approaches in the emerging carbon market and GHG policy regimes will facilitate rapid and effective climate change mitigation and adaptation.

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Restoring Bayou Lafourche - Benefits for Coastal Louisiana

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Located along the Mississippi River, Bayou Lafourche was the foundation of commercial and residential development of the surrounding area. Historically, when the river's distributaries flooded, they delivered sediment that helped build the bayou's marshes. However, as river navigation needs changed and greater flood control was required, the river system's course was altered with dams and levees. Since 1904, Bayou Lafourche has been disconnected from the river by a flood-control dam. Consequently, tidal intrusion in the bayou increased, the supply of freshwater diminished, and wetlands deteriorated. The repercussions of the dam continue to this day for over 300,000 area residents, businesses and industry that rely on the bayou's natural resources.

CH2M HILL partnered with the OCPR to design a conveyance system that will divert freshwater from the Mississippi River into Bayou Lafourche at a rate of 650 to 1300 mgd. The first phase of the project will improve channel capacity within the uppermost 6 miles of the bayou by removing a significant wedge of flow-blocking sediment. To verify the bayou's original position or "footprint," CH2M HILL researched the historic path of the bayou. After analyzing bayou cross sections and stage recordings from 1890 to present, the team determined the historic mean low water and mean high water locations adjacent to Bayou Lafourche. This enabled the Louisiana SLO to assess state boundaries relative to the project's construction and future maintenance requirements.

Diverting freshwater from the Mississippi River into Bayou Lafourche will reduce saltwater intrusion, help protect and sustain marshes by providing the nutrients and freshwater they need to thrive, and ensure the availability of potable water to the bayou's residents and industry. As the project enters the construction phase, the team is looking into new technologies and sustainable energy solutions in designing a pump station that will divert freshwater into the bayou.

Implications
Different elements of this project can be viewed as increasing our knowledge base of how we plan, design and construct Coastal Restoration and Protection Projects. This project demonstrates the importance of Bayou Lafourche as a source of freshwater for coastal restoration and protection projects as well as its benefits to residential, commercial and recreational users of the bayou. Perhaps one of the biggest hurdles cleared through the development of this project involved the land ownership issues adjacent to our historic waterways. The Bayou Lafourche project also demonstrates the need for public involvement by building community support through understanding. In order to successfully tackle the challenges we face, the future of the Bayou Lafourche diversion and other coastal restoration and protection projects necessitates the cooperation among local, state and federal agencies and stakeholders.

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Coping with Global Sea-Rise – Actions Other Coastal Areas In The US Are Taking

Ron Crum
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Recent studies in the Florida Keys indicate average sea levels are now 9" higher than they were a century ago and are expected to rise still more over the next century. Studies at Grand Isle, Louisiana, have confirmed that Louisiana coastal waters are also rising. In addition to sea-rise impacts, Louisiana's coast is also subject to subsidence, compounding this issue for our state.

Whether you believe in global warming or not, is not the issue. The issue is that average sea levels are apparently rising for one reason or other and billions of dollars in infrastructure investment are threatened. Roads, sewers, bridges, parks, and even entire cities are threatened. Many coastal states and cities from Seattle and San Francisco in the West to Miami and New York in the East are taking actions now to identify measures that can be implemented now to protect citizens and property from future potential sea rise.

This presentation will highlight the breadth of actions being taken around the US by other governmental entities, with a secondary focus on actions being taken internationally, to cope with rising seas. Actions appropriate for Louisiana will be identified.

Implications
Infrastructure projects undertaken by state, local and Federal governments are designed to last, in general, 50 years. Most of the US infrastructure in and near the US coastal areas was installed close to 50 years ago and, like most infrastructure across the US, is reaching the end of its useful life. Much of this infrastructure will need to be replaced in the next 10-20 years and when it is replaced, the new designs should take into account projected sea-rise.

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Strategies for Ecosystem Restoration Adaptive Management

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The Comprehensive Everglades Restoration Plan (CERP) provides a framework and guide to restore, protect and preserve the water resources of central and southern Florida, including the Everglades. It includes more than 60 elements, will take more than 30 years to construct and will cost an estimated $7.8 billion.

CERP project implementation is facing severe funding limitations. It is highly likely that funding required for implementing individual CERP projects will either be made available over an extended period of time or may be curtailed. Projects may have to be implemented in an incremental manner over an extended period to fit the available funding streams.

Incremental implementation is also consistent with recommendations of the National Research Council's *First Biennial Review of Progress towards Restoring the Everglades*. The report recommended that, *to help move the Everglades Restoration effort forward while resolving critical scientific unknowns, CERP could in many cases use an "incremental adaptive restoration" approach*. This approach prioritizes restoration elements that are large enough to secure some environmental benefits, but stops short of implementing an entire project at once. Lessons learned will reduce key scientific uncertainties that might otherwise delay project implementation.

Implications
This paper will describe a proposed strategy for incremental adaptive implementation of CERP Projects. The strategy was tested using the Tentatively Selected Plan for one of the larger CERP Projects. Results indicate that this approach can also be successfully be used to develop recommendations for incremental implementation for projects associated with other larger currently on-going ecosystem restoration initiatives such as the Louisiana Coastal Area Ecosystem Restoration.

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Beneficial Use of Dredged Material- Policy and Practice in Louisiana and Texas

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Several hundred million cubic yards of sediment are dredged from the nation's ports, harbors, and waterways each year to maintain these navigation facilities for commerce, recreation, and national defense. The growing scientific and engineering knowledge and public awareness result in using this valuable resource beneficially for many uses including shore protection and environmental enhancement. Louisiana and Texas share a common coastal problem with sediment starved coastal system and have used dredged material beneficially to augment their respective coastal environments including Brazos-Santiago Pass at South Padre Island, Aransas National Wildlife Refuge along the GIWW, wetland restoration along West Bay of Galveston Bay, in Texas and Atchafalaya River Delta, Baptiste Collette and Queen Bess Island in Louisiana. While Texas leads the way in technical implementation of larger scale beneficial use projects, Louisiana has taken the lead in developing a state wide comprehensive coastal protection plan that incorporates beneficial use of dredged material. This presentation brings both ends of the experience spectrum together and discusses lessons learned from each state and provides steps forward for each to learn from the other in policy and practice.

Implications
Policy and practices regarding beneficial use of dredge material assumes importance since it paves way to coastal landscape sustainability. Sediment availability is a constraint and this resource should be judiciously used for the restoration efforts. However, due to conflicts in the existing laws and regulations and lack of adequate laws and regulations, this precious resource has not been put into full use. This paper discusses the inadequacies of existing practices and suggests possible recourse.

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Aquatic Resource Research Emphasis within a Regulatory Context

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The U.S. Army Corps of Engineers regulates jurisdictional wetlands, coastal and otherwise, under Section 10 Rivers and Harbors Act and Section 404 of the Clean Water Act. Section 10 authority extends to tidal and/or navigable waters, while the Clean Water Act extends to all waters of the U.S., including wetlands. Recent Supreme Court Cases, including Rapanos and Carabell vs. US, and subsequent guidance, have ruled that the Corps must establish a nexus between non-relatively permanent waters (non-RPWs) of the US and traditionally navigable waters (TNWs) to exert jurisdiction over those non-RPWs. Corps regulatory field budgets do not allow for research level efforts to establish nexi between these non-RPWs and the TNWs. Many of the TNWs are within or eventually flow through the coastal zone. While impacts from upstream waters to downstream waters and TNWs, including coastal and tidal waters, have been well documented in the literature, watershed-specific data is generally lacking to connect specific upstream waters to receiving TNWs. If a portion of research effort primarily aimed at impacts to coastal waters could be directed toward upstream waters outside of the coastal zone (particularly non-RPWs), typical connections and nexi between upstream non-RPWs and receiving TNWs could be demonstrated via actual data collection within specific watersheds. This information could then be cited within the regulatory context to help establish the basis for jurisdiction (or lack thereof) under the Clean Water Act in cases where a significant nexus determination is required.

Implications
While several state laws address aquatic resources, certain waters in the CZ and all waters outside of the CZ are primarily regulated by Federal Law. Aquatic resources statewide have direct effects on the State of Coastal Waters because most waters in the state eventually flow into navigable or tidal waters, many of which are in the CZ. Any efforts to direct some portion of research outside of the CZ could generate more specific information on impacts from upstream waters to local coastal waters. This empirical information could be used by the regulatory community to more clearly define and defend jurisdictional boundaries, thereby enhancing the ability of coastal land managers and others to plan management strategies, restoration projects, etc., within the realistic context of the regulatory climate at hand.

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Defining Restoration Targets for Flooding and Salinity in Louisiana's Intermediate and Brackish Marshes

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Biologists who plan and manage wetland restoration projects often attempt to modify flooding and salinity because those stresses regulate species composition and productivity of emergent wetland vegetation. It is widely recognized that increased flooding and salinity can stress emergent plants, but there are few measurements to guide planning and operation of water control structures. Marsh flooding can be estimated over large areas with few data where winds have little effect on water levels, but quantifying flooding requires hourly measurements over long time periods where tides are wind dominated such as the northern Gulf of Mexico. Estimating salinity of flood water requires direct daily measurements because coastal marshes are characterized by dynamic salinity gradients.

We analyzed 399,772 hourly observations of water depth and 521,561 hourly observations of water salinity from 14 sites in Louisiana coastal marshes dominated by *Spartina patens* Ait Muhl. In stable marshes with slow wetland loss rates adjacent to the Acadiana Bays, we found that the marsh was flooded 21% of the time and that marsh elevation averaged 1 cm above mean high water, 15 cm above mean water, and 32 cm above mean low water levels. Water salinity averaged 3.7 ppt in the spring (April, May, and June), and 5.4 ppt during the summer (July, August, and September). In marshes adjacent to Calcasieu Lake, where marsh loss was very rapid in the 1960s and 1970s, we found that the marsh was flooded 32% of the time and that marsh elevation averaged at mean high water, 9 cm above mean water, and 19 cm above mean low water levels. Water salinity averaged 10 ppt during the spring and 15 ppt during the summer. We assume that that these conditions caused the rapid marsh loss occurring 40 years ago.

Implications
We assume that the water level and salinity characteristics observed in the Acadian Bays region caused the slow marsh loss typical of this region. This finding would suggest that *S. patens* marshes should flood 21% of the time, water levels should average 1 cm below marsh elevation, and that water salinity should average 3.7 during the spring and 5.4 during the summer. Daily, seasonal, and annual variation in water levels, tidal range, and salinity were evident, and this finding would support the contention that such variation be retained when designing and operating coastal wetland management and restoration projects.

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STUDENT

An Evaluation of Restoration Efforts on Isles Dernieres in Providing Waterbird Nesting Habitat

Edward J. Raynor[1], **Tabitha Owen**[1], Aaron R. Pierce[1], Cecilia Leumas[2] and Frank C. Rohwer[2]
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Louisiana's barrier islands rival all other breeding habitat types in colonial waterbird density. However, this habitat is subject to degradation from wave energy and reduced accretion from the human-altered Mississippi River system. In response to these effects, there has been considerable restoration efforts focused on barrier islands, but little evaluation of their success in regard to habitat functions. Specifically, the Isles Dernieres Barrier Islands Refuge (IDBIR) in Terrebonne Parish, which consists of Wine, Trinity, Whiskey, and Raccoon Islands, is a major waterbird rookery that has experienced substantial restoration through sediment applications, vegetative planting, and sand fencing efforts under the CWPPRA program. Segmented rock breakwaters and a rock containment dike were also constructed to impede shoreline erosion and contain sediment on Raccoon and Wine Islands, respectively. The majority of restored areas on IDBIR are not used by nesting waterbirds, yet suitable nesting habitat appears to be available. Accordingly, managers need to know why waterbirds are not nesting at these restored sites and how restoration efforts can be modified to meet nesting habitat requirements. To determine nesting habitat requirements of colonial waterbirds, we measured a suite of potentially important habitat characteristics for colony formation of two abundant ground-nesting species, Royal Tern (*Thalasseus maxima*) and Sandwich Tern (*Thalasseus sandvicensis*) in 2008 and 2009. Habitat characteristics were also measured at apparently suitable yet inactive sites to determine potential differences between active and inactive habitats through discriminant analysis. Discriminant analysis revealed suitable nesting habitat was available on some inactive sites. Understanding the use of restored barrier islands by waterbirds and their nesting habitat requirements will help improve implementation and planning of future coastal restoration projects.

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Developing Wetland-Based Carbon Markets as a Potential Funding Mechanism for Coastal Protection and Restoration

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Coastal wetlands in the Mississippi River delta naturally undergo geologic subsidence due to compaction and consolidation. Historically, Mississippi River flood cycles were a source of new mineral sediment and nutrients which stimulated the production of organic matter, leading to positive accretion rates to compensate for subsidence. However, changes in management of the Mississippi River have deprived Louisiana's coastal wetlands of needed sediment and nutrients leading to near catastrophic deterioration and loss trends. These trends may be further exacerbated by predicted increases in eustatic sea level rise which may increase the vulnerability of coastal communities. To help reverse or halt coastal wetland loss trends, the State of Louisiana has crafted an aggressive Master Plan to restore and conserve wetland habitat and protect our communities. The cost of restoration and protection of coastal Louisiana is estimated in the billions of dollars and while the State has been proactive in allocating funds as well as securing resources from the Federal government, additional revenue sources are necessary to move forward the tremendous goals identified in an effective and time-critical manner.

Implications
Recognizing that healthy wetlands continually accumulate and bury carbon-rich organic matter into permanent geologic storage, the Louisiana Office of Coastal Protection and Restoration has formed a team to develop and manage an innovative program to leverage emerging voluntary carbon offset programs to support sustainability and compliance goals of private and public organizations. The goals of such a program are to reinvest resulting funds into additional restoration projects which could be significant. While there are currently no wetland-based carbon sequestration offset project protocols, our team has been working with other organizations to leverage similar on-going efforts to investigate the scientific uncertainties that remain for coastal wetland inclusion while pursuing investment opportunities that use existing forestry protocols to generate a "quick to market" path forward.

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***2nd Place (tie) in the SOC Student Poster Contest** STUDENT

Will the *Avicennia-Spartina* Association be a Component of a Louisiana Sustainable Coast?

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An expansion of black mangroves (*Avicennia germinans* (L.) L.) growing in association with smooth cordgrass (*Spartina alterniflora* Loisel.) along the Louisiana coast has recently been documented. The *Avicennia-Spartina* association is affected by factors related to climate change during the intermittent years between severe freeze events that can severely impact *Avicennia* populations in the northern Gulf of Mexico. *Avicennia* and *Spartina* have different carbon fixation pathways (C_3 vs. C_4, respectively), growth forms (woody vs. herbaceous), and nutrient-use efficiencies, therefore, we hypothesized their response to elevated CO_2 and nitrogen supply would be very different and likely influence species interactions. We used a multi-factorial approach to elucidate the effect of elevated CO_2, nitrogen supply, and *Spartina* stem density on *Avicennia* seedling above- and belowground response. Rhizotrons, which permit the monitoring of root growth and morphology by depth over time, containing individual *Avicennia* seedlings were grown at ambient and elevated CO_2 concentrations, high and low nitrogen (NH_4) supply, and planted with various densities of *Spartina* stems. Aboveground growth was monitored over six months; afterwards, biomass was harvested and sorted. Our results indicate that a high nitrogen supply has a strong positive effect on both *Avicennia* and *Spartina* biomass; however, the presence of *Spartina* diminishes the positive effect of nitrogen on *Avicennia*. A low nitrogen supply has a positive effect on *Avicennia* and *Spartina* root morphology. Elevated CO_2 also significantly enhances the growth and morphology of *Avicennia*; however, this effect is most apparent when *Avicennia* are grown without *Spartina*. The *Avicennia-Spartina* association is likely to continue to be a part of a sustainable Louisiana coast, providing wildlife habitat, sediment accretion, and storm surge protection, although it appears that this association will be more strongly influenced by nitrogen supply than the range of elevated CO_2 levels used in this study.

Implications
Climate change poses many uncertainties for the Louisiana coast. Therefore, it is critical that research conducted on climate change utilizes multi-factorial approaches. Our study provides a clear example of a treatment effect that diminishes with the addition of another treatment (elevated CO_2 had a positive effect on *Avicennia* biomass which diminished in the presence of *Spartina*). The implications of our research are that the growth of *Avicennia* seedlings is limited by the presence of *Spartina* when there is an abundant nitrogen supply. Similarly, elevated CO_2 provides very little growth benefit to *Avicennia* when grown in association with *Spartina*.

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Coastal Restoration and Protection Implementation Plan for Plaquemines Parish

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Plaquemines Parish has initiated a plan for implementing coastal restoration projects that provide hurricane flood protection. The plan is based upon the strategic approach outlined in the Louisiana's Comprehensive Master Plan for a Sustainable Coast referred to as "Multiple Lines of Defense". This approach means taking advantage of the flood protection that coastal landscape features, such as wetlands and barrier islands, provide that can add to the flood protection provided by levees. This plan acts as a guide for identifying, developing and implementing coastal restoration projects for the Parish.

The plan recognized that the hurricane flooding threat consisted of two components; storm waves and surge, and that each of these components responded differently to coastal landscape features, such as barrier islands, marshes, internal ridges, and forests. Computer models used by the USACE and FEMA were employed to quantitatively evaluate the benefits of individual and combinations of restoration projects on reducing hurricane waves and surge. The first step was to evaluate current state and federal coastal restoration projects to identify projects providing flood protection benefits. Of particular importance were projects that could be augmented to increase their flood protection benefits. Next, four separate combinations of new coastal landscape features were evaluated which indicated that storm wave and surge flood protection can be achieved by each type of feature, with differing degrees of cost effectiveness and timeliness. The first project to be selected for implementation was a forested ridge project on the west bank of the Parish near Venice, identified as the Reach B-2 project.

Plaquemines Parish is also taking the lead in investigating innovative dredging technologies and mechanisms which could reduce overall project costs associated with dredge and fill activities. Dredging operations comprise the bulk of project expenses for related operations and limit the opportunities to maximize sediment utilization.

Implications
The Parish plan addresses the methodology for implementing the general plans provided in the state and federal planning documents. The plan shows how specific restoration projects that have hurricane protection benefits and that are consistent with the state and federal restoration plans can be developed. This evaluation methodology showed that prior restoration projects provided only limited flood protection benefits. The state and federal master plans require that future restoration projects will have to be quantitatively evaluated for their flood protection impacts including the possibility that certain restoration projects may actually increase the flood threat for certain parts of a Parish while decreasing it for other parts. The plan also addresses the issue of prioritizing coastal restoration projects based upon their cost effectiveness (reduced dredging costs) and timeliness in providing flood protection.

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Hurricane Impacts

Concurrent Session VI: Hurricane Impacts
Moderator: Scott Wilson, US Geological Survey

Observations of the Spatial and Temporal Distribution of Hurricane-induced Land Loss in Coastal Louisiana Over the Past 60 Years
J. A. Barras[1]
[1]U.S. Army Corps of Engineers

*Science and Monitoring of Storm Impacts
Scott Wilson
U.S. Geological Survey

Modeling of Hurricane Impacts on a Coastal Lake Bottom: South Central Louisiana
Angelina M. Freeman[1], Felix Jose[1], Harry H. Roberts[1], and Gregory W. Stone[1]
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Poster Presentations

Wetland Loss During Hurricanes: Failure of Low Salinity Marshes in Breton Sound
Zoe J. Hughes[1], Nick C. Howes[1], Duncan M. FitzGerald[1], Ioannis Y. Georgiou[2], Mark A. Kulp[2], Michael D. Miner[2], Jane M. Smith[3] and John A. Barras[3].
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Utilizing CRMS Vegetation Data to Assess Impact and Recovery from Hurricanes Gustav and Ike
Leigh Anne Sharp[1], Dona Weifenbach[1], and Thomas McGinnis[1]
[1]Office of Coastal Protection and Restoration; Lafayette Field Office

Numerical Modeling of Hydrodynamics and Wetland Loss in Breton Sound, Louisiana
Haihong Zhao[1], Q. Jim Chen[1], John Pardue[1], Clinton Willson[1], and Robert Twilley[2]
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*The original presenter, Dr. Michael Miner, was unable to present the topic described in the conference program. The session moderator, Scott Wilson, instead conducted an interactive question and answer session on "Science and Monitoring of Storm Impacts."

Observations of the Spatial and Temporal Distribution of Hurricane-induced Land Loss in Coastal Louisiana Over the Past 60 Years

John A. Barras[1]
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A combination of historical aerial photography and Landsat Thematic Mapper (TM) satellite imagery was used to identify hurricane-induced land loss in coastal Louisiana marshes from 1956 through 2005. Hurricane magnitude, track, and landfall information obtained from the National Oceanic and Atmospheric Administration (NOAA) were used to identify candidate storms. Landfall bracketing TM imagery and photography were then examined to identify probable storm-formed or storm-expanded water bodies. Most observed loss was related to the removal or partial removal of marsh vegetation by storm surge or to shoreline erosion caused by enhanced wave action. The TM imagery was successfully used to identify loss caused by Hurricanes Andrew (Aug. 26, 1992), Lili (Oct. 3, 2002), Ivan (Sept. 16, 2004), Katrina (Aug. 29, 2005), and Rita (Sept. 4, 2005) and Tropical Strom Isadore (Sept. 26, 2002). The same techniques were applied to historical aerial photography to identify land loss caused by Hurricanes Audrey (1957), Hilda (1964), and Betsy (1965). The photography lacked the temporal and spatial coverage of the TM imagery but was adequate for identifying historical hurricane-induced land loss.

Detectable hurricane-induced land loss increased with storm magnitude. Hurricane Audrey, a category 4 storm that made landfall at Cameron Louisiana, caused probable land loss 350 km east to the Mississippi River. Category 2 or lesser storms caused detectable localized loss within 100 km east of landfall. Land loss magnitude and spatial distribution was greatest immediately east of storm landfall and then decreased eastward. Storm-induced land-loss decreased immediately to the west of storm landfall implying most identifiable land loss was caused by storm surge rather than wind. Consecutive storm landfalls caused commingled land loss patterns of varying magnitude and spatial distributions consisting of new ponds and expanded ponds, some of which have remained in place for over 60 years.

Implications
These observations suggest that hurricanes have and will continue to contribute to land loss in coastal Louisiana. Hurricane surges sculpt the coastal landscape. The decadal and greater sampling periods used to measure historical land loss lack the temporal resolution to identify hurricane surge-induced loss or to correlate loss with individual storms. Identifying past storm-induced loss may lead to enhanced coastal restoration strategies and improved coastal landscape projections.

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Modeling of Hurricane Impacts on a Coastal Lake Bottom: South Central Louisiana

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We expand the limited understanding of sediment dynamics in Louisiana's coastal lakes through the study of hurricane-induced sediment transport processes in Sister Lake (Terrebonne Parish Louisiana), using coupled hydrodynamic models Mike 21 and Mike 3. Simulation of the complex non-linear interaction between waves and currents was incorporated through dynamic coupling of the hydrodynamic and spectral wave modules. The lake bottom was imaged both pre-and post- Hurricane Rita using high resolution acoustics. Collected bathymetric data in combination with National Geophysical Data Center bathymetry/topography data were triangulated to an unstructured grid. The Hurricane Rita hindcast was forced with blended wind data generated from high resolution H* wind (National Hurricane Center) and NOAA North American Regional Re-Analyzed wind data. The wave conditions at the southern boundary of Sister Lake were extracted from a spectral wave model implemented for the Gulf of Mexico. The Rita hindcast model was also forced with surge levels extracted at the southern boundary of Sister Lake from an ADCIRC model implemented for the Gulf. Results indicate that bed shear stresses across almost the entire model domain prior to Hurricane Rita's landfall were above the critical value causing erosion. Bed shear stresses in the western portion of Sister Lake were below the critical value causing deposition during Rita's landfall. As the storm progressed, the area of deposition increased to almost the entire Sister Lake bottom within 14 hours of landfall, indicating sedimentation over the entire lake bottom post-storm. X-ray radiographs of box cores, collected in critical areas of Sister Lake after Hurricane Rita, support the model results showing clear increments of sedimentation associated with the storm period, corroborated with radionuclide dating. Results of this analysis provide an initial understanding of how the morphology of a coastal Louisiana lake responds to major hurricane events.

Implications
With the prospect of rising sea levels and increasing storm intensities - frequencies for the future, it is especially important for environmental management purposes to be able to assess and understand change in the low-lying coastal plain habitats as a product of storm forcing. Results provide a framework and fundamental understanding of lake bottom characteristics of Louisiana's shallow water environments. Prediction and hindcast studies using numerical models are important tools for coastal management, and in this study clarify hurricane-induced sediment transport and deposition patterns in the geologically complex Sister Lake region. Increased understanding of the morphological storm response processes in coastal bays and lakes must be included as an important component of effective wetland restoration plans.

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Wetland loss during hurricanes: failure of low salinity marshes in Breton Sound

Zoe J. Hughes[1], Nick C. Howes[1], Duncan M. FitzGerald[1], Ioannis Y. Georgiou[2], Mark A. Kulp[2], Michael D. Miner[2], Jane M. Smith[3] and John A. Barras[3].
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During the 2005 hurricane season, the storm surge and wave field associated with Hurricanes Katrina and Rita eroded 527 km^2 of wetlands within the Louisiana coastal plain. Analysis of pre and post storm aerial photographs and vegetation mapping clearly show the preferential erosion of low salinity freshwater and intermediate wetlands, while higher salinity brackish and saline wetlands remained robust and largely unchanged. By combining laboratory and field investigations of shear strength, organics and bulk density across the study area, we highlight geotechnical differences between the soil profiles of high and low salinity regimes. These differences are controlled by vegetation, and result in differential erosion of the marsh platform. In low salinity wetlands, a weak layer (shear strength 500-1450 Pa) was observed ~30 cm below the marsh surface, coinciding with the base of rooting. High salinity wetlands had no such layer (shear strengths > 4500 Pa) and contained deeper rooting. Hindcasting of hydrodynamic conditions using numerical models allows an estimation of near-bed shear stress during Hurricane Katrina. These stresses ranged between 425–3600 Pa, sufficient to cause widespread erosion of the low salinity wetlands. The comparative difference in soil strength is the result of more robust, deeper rooting by saline marsh plants; these conditions may be exacerbated by low inorganic sediment content and high nutrient inputs. We employ a scaling argument to emphasize the importance of the rooting depth term within equations describing marsh surface scouring. The dramatic difference in resiliency of fresh versus more saline marshes suggests that the introduction of freshwater to marshes as part of restoration schemes may weaken existing wetlands rendering it vulnerable to hurricane events.

Implications
Our research identifies a key difference between the geotechnical strength profile of low and high salinity marshes. The results of this study suggest that proposed freshwater diversions should be reassessed not only for their ability to restore low salinity and introduce sediment, but their efficacy in creating robust hurricane resistant marsh, since the potential exists for the development of geotechnically weak soils and thus higher susceptibility to erosion during large magnitude storm events. Introducing sediment, via short-period high-volume freshwater inputs, at a frequency that encouraged saltwater vegetation to colonize the impacted region between diversion events, would potentially produce a more resilient marsh.

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Utilizing CRMS vegetation data to assess impact and recovery from Hurricanes Gustav and Ike

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Vegetation data collected from the Coastwide Reference Monitoring System - *Wetlands* (CRMS) from 2006 to 2009 will be used to assess the areas most impacted by Hurricanes Gustav and Ike. Vegetative cover (percent cover and height) and the quality of that cover will be assessed using the Floristic Quality Index. CRMS sites will be grouped for analysis into 25 subregions that reflect the diversity of existing conditions and management strategies on the Chenier Plain. The vegetation data will be used to create a GIS data layer to be overlaid on a layer of CRMS sites. Areas most and least impacted by the storms and areas that have seen shifts in community type since the storms will be identified. This application of identifying the spatial variation and extent of vegetative community change will have large future implications as sudden changes in vegetative community structure is a key indicator of ecosystem stress. Identifying areas with sudden vegetative community dynamic should be used to focus restoration efforts. Because much of the marsh loss in the coastal zone of Louisiana is the result of vegetation loss, this application will be a beneficial tool for determining where restoration is most needed. Combining the information from vegetative dynamics (changes in percent coverage, floristic quality, and community type) from this application with the elevation change/submergence and hydrologic (water level and salinity) dynamics will not only identify where restoration is needed but also what type of restoration would best suit areas in need of restoration.

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Numerical Modeling of Hydrodynamics and Wetland Loss in Breton Sound, Louisiana

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Wetland losses in the hurricane-prone southeastern states and along the Gulf coast in the U.S. continue at an alarming high rate. In particular, the Louisiana coast with sandy barrier islands, tidal flats, and soft mud bottoms is losing 60 to 70 km^2 of wetlands each year, which accounts for about 80% of the total annual loss of coastal wetlands in the continental United States. The success of protecting coast Louisiana from the devastating impacts of hurricanes and accelerated relative sea level rise requires better capabilities for predicting the response of natural coastal processes to high energy disturbances and engineering solutions in this unique and complex deltaic sedimentary environment. Quantifying and predicting sediment dynamics in the vegetated sedimentary environment during extreme wind events are challenging, but essential for coastal restoration and protection. With the rapid development of computer technology, significant advances in modeling storm surges and surface waves have been made, which allows for coupling a spectral wave prediction model (e.g., SWAN) and a three-dimensional (3D) estuarine circulation model (e.g., ECOM) with an improved sediment transport model (SED) to investigate sediment erosion, transport, and deposition in response to Hurricane Katrina.

The objective of the study is to develop a computer modeling system that is able to predict storm surges, hurricane waves and corresponding wetland erosion in Breton Sound, Louisiana. Emphasis has been given to the influences of vegetation on the hydrodynamic forcing, including the vegetation-induced momentum and energy dissipation in both wave and surge models, and the sheltering effect of dense vegetation on bottom sediments. We use the integrated models as a tool to quantify the eroded volume of marshlands and cohesive sediments during Hurricane Katrina, and to demonstrate the mutual effects of wetlands, sediments and hydrodynamic forces.

Implications
Although the time scale of the coastal processes driven by high energy events of tropical cyclones is short, it has been recognized that hurricanes are the major driving force of morphological changes in this micro-tide, low wave energy environment. The development of a reliable, integrated model system will enable us to predict the hydrodynamics and sediment dynamics in response to storms, to understand the erosion and deposition processes of wetlands and sediments, and provide guidance for coastal restoration and protection in Louisiana.

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Improving Risk Reduction Projects

Concurrent Session VI: Improving Risk Reduction Projects
Moderator: John Ettinger, Environmental Protection Agency

Morganza to the Gulf State Technical Review Panel: Final Report and Recommendations
Robert Twilley[1] and **Shirley Laska[2]**
[1]Louisiana State University, [2]University of New Orleans

Donaldsonville to the Gulf Science and Engineering Review Panel: Preliminary Findings
Denise J. Reed
Pontchartrain Institute for Environmental Science, University of New Orleans

Sand Hunger at the Eastern Scheldt Storm Surge Barrier
Leo Adriaanse[1] and Eric van Zanten[1]
[1]Ministry of Transport, Public Works and Water Management, Rijkswaterstaat Zeeland

Morganza to the Gulf State Technical Review Panel: Final Report and Recommendations

Robert Twilley[1] and **Shirley Laska[2]**
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The Coastal Protection and Restoration Authority (CPRA) convened a panel of experts to evaluate and report their findings on the current Morganza project. The tasks of the panel were to assess existing information and decisions related to the authorized alignment as described in original and amended documents, and other relevant materials; and to hold public sessions to obtain information and inform the Panel's findings and recommendations to the CPRA and the general public. The findings of the Panel resulting from this evaluation, and recommendations to CPRA on how best to move forward in protecting the project area included three areas: Basic Assessment, Planning for Flood Risk Reduction, and Improved Tools and Analyses for Assessment of Integrated Risk Reduction Outcomes.

Basic Assessment recommendations included continue work on levees, floodgates and environmental structures on the current authorized levee alignment with the goal of providing a minimum system-level of protection to the planning area; continue work on the HNC lock-floodgate structure given its vital role in the protection system and its potential to be used to benefit the ecosystem; integrate proactive wetland restoration approaches into the ongoing design and operation of the Morganza project; and finally to routinely (e.g., every 5 years), revisit the project to reassess risk to communities and the economy, evaluate ecological impacts and benefits, and revise future construction and operation plans and schedules as appropriate.

Planning for Flood Risk Reduction recommendations included initiate a comprehensive, community-based planning process to identify the community and economic dynamics, along with specific infrastructure, that need to be protected for the Terrebonne communities to thrive; increase efforts to inform the business community and the general public of the level of protection and risk reduction provided, thereby encouraging them to pursue additional risk-reduction measures; implement a comprehensive flood management approach for the area that leverages existing programs for non-structural flood risk reduction, provides incentives to businesses and the general public, and provides for the safe location of future business and residential development; develop conservation easements, land-use plans and zoning ordinances to protect existing wetlands in the planning area from loss to development; initiate a public education program to communicate scientifically based assessments of risks to both rural and urban communities, and ensure that information is routinely updated as project construction and other risk reducing activities proceed and economic, community and environmental conditions change.

Finally, Improved Tools and Analyses for Assessment of Integrated Risk Reduction Outcomes included focus on continue efforts to develop a system-wide model to incorporate the effects of rainfall, pumping, lock/floodgate operations, and potential stratification on salinity and water level conditions, and ensure it is integrated with other modeling efforts. Use this system-wide model, as well as conceptual ecological models and monitoring of wetland response, to design and operate environmental structures within the levee system; and convene an independent expert panel to guide this adaptive management process; hold a workshop and/or convene a

panel to consider and synthesize the state of knowledge inform evaluation of project effects on wetlands; apply planning tools that allow integrated, spatially explicit assessments of structural and non-structural measures in risk reduction and that consider a range of possible future economic, social and environment scenarios.

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Donaldsonville to the Gulf Science and Engineering Review Panel: Preliminary Findings

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This project began with a USACE Reconnaissance Study authorized in May 6, 1998 and completed and approved in October 2000. Subsequently a feasibility study was initiated to determine the feasibility of providing flood protection to the populated areas between Bayou Lafourche and the Mississippi River, from Donaldsonville to the Gulf of Mexico. The scope is to *"study various alternatives that will provide flood protection from tidal, hurricane surges, and heavy rainfall events. Determine the adequacy of the existing interior drainage systems and evaluate whether additional pumping capacity is required. Analyze recreational, cultural, and environmental needs."* The feasibility study was initiated on February 6, 2002. Five alternative levee alignments along with non-structural elements and alternatives are being considered in the feasibility study.

In July 2009 after discussion of environmental concerns regarding the narrowed range of project alignments as well as some of the planned engineering design features and project costs, the CPRA called on the Governor's Office of Coastal Activities to organize a team of experts to review and report on the Donaldsonville to the Gulf feasibility study. The DTG Science and Engineering Review Panel focuses on the study's methodological approach and technical products. The deliberations of the Panel are ongoing but their mission is to provide CPRA comments on the methods and approaches being used in the study as, to identify and assess the implications of any important assumptions or uncertainties which might influence the outcome of the study or the success of the project, and to make recommendations regarding adjustments in the planning procedures and analyses which could address likely shortcomings of the study as currently conducted. The Panel is not required to recommend specific alternative alignments or plans, but is encouraged to highlight the potential economic and ecological consequences associated with proposed alignments or plans.

This presentation will provide an overview of the Panel's work at the time of the conference and observations from the Panel Chair on the material reviewed to date.

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Sand Demand at the Eastern Scheldt Storm Surge Barrier

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After the flooding disaster of 1953 it was clear that the flood protection of the south-western delta of the Netherlands had to be improved.. The first Delta Plan consisted of blocking off most of the estuaries in the delta. In the seventies, the first dams being in place, a change in thinking occurred. The Dutch government decided to build a storm-surge barrier. This way valuable tidal nature and shellfish fisheries would be conserved. Professionals predicted, at the time, that nature would experience undisirable side-effects. Channels and tidal flats would reduce in profile. Since then the effects have become visible. The process of erosion of the intertidal areas is proceeding faster than predicted.

May 2008 the results of a first survey on the effects and possible counter measures were reported. Since the constuction of the Oosterschelde storm-surge barrier and the accompanying compartmentalization dams less water has been flowing in and out of the Oosterschelde. In effect, the tidal channels are too big for the smaller amount of water. This causes the water to flow more slowly than before and it has insufficient power to move the sediment from the channels onto the intertidal area. Sand is being moved from the intertidal area into the channels in heavy storms where it remains. The natural balance between sedimentation and erosion is disrupted. This process is known as the ‘sand demand’.

The loss of tidal flats and salt marshes is disadvantageous mainly to nature on the short term On the longer term maintenance of levees will increase and the much appreciated landscape will drown.. Recreational shipping and shellfish fisheries may also be affected negatively.

The survey studied three types of measures in the Oosterschelde. Controlling the cause of the sand demand (by having more water flowing through the channels or applying more sand in the channels) and controlling the effect of the sand demand (preventing the loss of intertidal area by sand nourishments and erosion protection measures).

Pilots with sand nourishments and erosion protection measures are carried out. In 2013 the results of these pilots and of an accompanying study on the natural values that can be maintained with these measures will result in a decision how to cope with the ‘sand demand’.

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Ecosystem Modeling

Concurrent Session VII: Ecosystem Modeling
Moderator: Greg Stone, Louisiana State University

Hydrodynamic and Water Quality Modeling for the Convey Atchafalaya River Water to Northern Terrebonne Marshes Study
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A Method for Estimating the Benefits of Freshwater Introduction into Coastal Wetland Ecosystems in Louisiana: Nutrient and Sediment Analyses
Ron Boustany
USGS National Wetlands Research Center

Using Coastwide Reference Monitoring System (CRMS) Data to Refine Existing Habitat Switching Algorithms
Gregg A. Snedden[1], Gregory D. Steyer[1], and Jenneke Visser[2]
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Poster Presentations

Implementation of a 3-Dimensional Hydrodynamic Model for Sabine Bank, Louisiana
Mohammad Nabi Allahdadi [1,2], Felix Jose[2], Georgy.W.Stone[1,2] and Eurico D'Sa[1,2]
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Empirical Model that Relates Mitigation of Salt Water Intrusion with Societal Impacts of Increase Flow Rate Discharge on Bayou Lafourche
Henry Foust
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A Fully Coupled Hydrodynamic, Salinity and Sediment Model of Mobile Bay
Tate McAlpin[1], Gaurav Savant[2], Jennifer Tate[1], and Charlie Berger[1]
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Hydrodynamic and Water Quality Modeling for the *Convey Atchafalaya River Water to Northern Terrebonne Marshes* Study

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The *Convey Atchafalaya River Water to Northern Terrebonne Marshes* study is a Louisiana Coastal Area (LCA) project to investigate the potential of increasing existing Atchafalaya River fresh water influence to reduce the rate of loss in degrading central (Lake Boudreaux) and eastern (Grand Bayou) Northern Terrebonne marshes via the Gulf Intracoastal Waterway (GIWW). Potential project features include diverting additional Atchafalaya River water into the GIWW, improving conveyance by repairing banks and enlarging constrictions in the GIWW, improving water distribution within the marsh, and implementing outfall management measures. The project area extends from the Lower Atchafalaya River on the west to the Barataria Basin on the east. A two-dimensional finite element hydrodynamic and water quality model of the project area was developed and calibrated to provide a basis for evaluating the proposed project alternatives. The model was developed using RMA2 (hydrodynamic modeling) and RMA11 (water quality modeling) software from Resource Modelling Associates of Sydney, Australia. The model incorporated finite element representations of portions of the project area originally developed for previous coastal restoration and hurricane protection projects. These finite element meshes were edited and expanded for this modeling project. Despite the large size and complexity of the model, the simulations were executed on high-end personal computers running 64-bit operating systems, with very manageable runtimes. This presentation will describe the development and calibration of the model.

Implications
Coastal restoration and hurricane protection projects often require modeling of large areas with sufficient resolution to evaluate the impact of proposed project features. In the past, such modeling has required access to computer resources available only to those supported by major research funding, thereby limiting the accessibility to and increasing the cost of modeling. Thanks to advances in computer technology and matrix solution techniques, even large and complex finite element models can have reasonable runtimes on inexpensive personal computers. Future coastal restoration projects could benefit from the type of modeling developed for this project, which demonstrates the feasibility, affordability, and accessibility of two-dimensional hydrodynamic and water quality modeling for coastal restoration projects.

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A method for estimating the benefits of freshwater introduction into coastal wetland ecosystems in Louisiana: nutrient and sediment analyses. Natural Resources Conservation Service. Lafayette, LA

Ron Boustany
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A desktop numeric model (NSED) was developed to estimate the potential benefits of nutrients and sediments introduced into coastal marshes in Louisiana from freshwater diversions and to improve the predictability of coastal restoration alternatives. Nutrient benefits are based on the cumulative volume of water introduced by an average annual flow rate (cubic feet per second, cfs), the average total nitrogen and phosphorus concentration of the source water (mg l^{-1}), the nutrient requirements of the plants based upon the annual plant production rate per unit area (g m^{-2} y^{-1}), and proportion of nutrients retained in the system. Sediment benefits are based upon the cumulative volume of water introduced by the average annual flow, total suspended solid concentration (mg l^{-1}), bulk density of the receiving marsh area (g cm^{-3}), average depth of the receiver area (ft), and the retention of material introduced into the system. The sum of nutrient and sediment benefits represents a gross change that is then applied to adjust the annual land change rate. Model validation was performed on the three longest operating diversions in Louisiana– Caernarvon, Naomi Siphon, and West Pointe a la Hache Siphon. For the period of observation, the model output differed from observed land changes by -1.8%, 1.8, and 4.9% for each of the diversions, respectively. Model applications indicate that volume, concentration and retention of materials tend to be the most important controlling factors in determining the efficiency of marsh building. The model has proven to be a very useful tool for rapid assessment of benefits ranging from large scale diversions to small flow restoration projects.

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Using Coastwide Reference Monitoring System (CRMS) Data to Refine Existing Habitat Switching Algorithms

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Climate change and ecosystem restoration measures can result in altered hydroperiods and salinity regimes in coastal regions. Using models to predict shifts in floral community composition in response to these changes is an increasingly important task for coastal resource managers. Accurate determination of community response along environmental gradients is critical to enhancing performance of these models. To date, many predictive models are based on relatively little field data. Louisiana's Coastwide Reference Monitoring System (CRMS) provides data related to vegetation community composition, soil characteristics, and hydrology at over 300 coastal marsh locations in Louisiana, and CRMS provides an opportunity to empirically refine algorithms that feed community models. Two-Way Indicator Species Analysis (TWINSPAN) was used to determine commonly occurring vegetation assemblages at 173 CRMS sites. Canonical correspondence analysis (CCA) identified salinity and tidal amplitude as the hydrologic variables that most strongly correlated with community composition. Polytomous logistic regressions were used to parameterize community response curves and estimate the realized environmental niche of each community type. These findings can be readily integrated into existing vegetation community change models to increase reliability of future projections.

Implications
Most restoration efforts in coastal Louisiana alter the hydrology in the vicinity of the project area (e.g., altered salinity, changes in flooding duration, altered tidal exchange). Effective evaluation of restoration alternatives is important to maximize ecological benefits from a finite pool of restoration resources. Predicting changes in ecosystem structure that result from hydrologic perturbations is an important part of this evaluation, and the reliability of these predictions is limited by the accuracy of algorithms that drive ecosystem response models. Data collected under CRMS are currently providing robust datasets to 1) determine which aspects of hydrology are most important in governing vegetation communities and 2) provide statistically robust coefficients for algorithms used in ecosystem models.

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Implementation of a 3-Dimensional Hydrodynamic Model for Sabine Bank, Louisiana

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This paper relates the implementation of MIKE3, a 3-Dimensional flexible mesh (FM) flow model, for Sabine Bank, off the Louisiana-Texas coast, a potential sand source for beach restoration in southwest Louisiana. Earlier studies conducted along the northern Gulf of Mexico, focusing on the seasonal current distribution based on measured data, were reviewed. In addition, further analysis of TABS current measurements were conducted to relate such studies with the flow dynamics of Sabine Bank. Based on our analyses, contributions of various components (tidal and non-tidal) in the generation and transformation of flow fields at this location were determined. This is crucial in hydrodynamic numerical modeling because it directly affects identification of appropriate boundary conditions. Regarding the geometry of the model domain, there are three open boundaries and the boundary condition data including water level and current vectors are extracted from a global model for the Gulf of Mexico, which also encompasses the western Atlantic. The Global model considers wind, heat flux and solar radiation as inputs; hence the loop current and it's shed-off eddies are well simulated and their influence on the study area is also considered. The high resolution model for Sabine Bank is forced with NARR wind data extracted from NCEP/NOAA archives. Model results are calibrated and verified using archived current data from a network of TABS stations scattered along the Texas coast. The model outputs can be further used in sediment transport studies for the region, especially in identifying suitable dredging sites from the Sabine Bank, to replenish the eroding beaches nearby. The modeling study demonstrates the effectiveness of coupling the regional circulation model with a local model to simulate the current pattern of the northern Gulf of Mexico.

Implications
The coast along southwest Louisiana has undergone extensive erosion due to a myriad of factors, including the landfall of tropical cyclones. Given the transgressive nature of this coast, offshore sand bodies are of considerable importance as viable resources to replenish the rapid landward movement/erosion of these beaches. The hydrodynamics associated with offshore sand shoals/banks along the southwest Louisiana coast are not well understood, and in particular, potential impacts associated dredging for beach replenishment. Thus the primary focus of this research is to identify and elucidate the complex interactions of wind induced currents and tidal signals with the geomorphology of the bank. The outcome from the study can be considered as a benchmark on considering future design dredging scenarios on Sabine Bank for replenishing the nearby beaches. Also, this model will be ideal for simulating the seasonal flow dynamics associated with the complex coastal geomorphologic settings of the Louisiana coast.

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Empirical model that relates mitigation of salt water intrusion with societal impacts of increase flow rate discharge on Bayou Lafourche

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The purpose of this research is to provide an Empirical model that relates mitigation of salt water intrusion with societal impacts of increase flow rate discharge on Bayou Lafourche, which will be done in 4 stages. **Stage one** – development of stage vs. discharge curves at critical locations along the bayou; **stage two** – determination of impacts associated with each stage at each location; **stage three** – development of empirical model that relates the recession of the salt water wedge with increased flow rate (the empirical model will be validated against a more exact model); and **stage four** – presentation of the results of this study to a group of stakeholders and utilizing a decision process known as analytical hierarchy process to provide an optimum discharge that balances salt water intrusion with the impacts of increased flow rate on the bayou. Benefits of this work include a methodology that allows for a quantifiable decision process tool that trades-off ecological concerns with societal impacts and provides input, in a rational manner, for all concern stakeholders. It is envisioned that the same process that occurred for this research can be utilized on other water bodies when trading off ecological concerns with societal impacts.

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A Fully Coupled Hydrodynamic, Salinity and Sediment Model of Mobile Bay

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The ADaptive Hydraulics (ADH) code can be used as a fully coupled 2D hydrodynamic, salinity, and sediment model. ADH is a finite element adaptive code that can be used to model the hydrodynamics of a system independently or in conjunction with salinity and sediment. ADH simulations can be performed as barotropic or baroclinic. When the baroclinic terms are included, the density effects are coupled into the hydrodynamic calculations and thereby the sediment calculations as well. ADH can also be used to calculate the sediment concentrations, deposition/erosion, and bed change. For each time step, the bed change is determined and used to alter the bed elevation. This couples the sediment effects back into the hydrodynamic calculations. A numerical model of Mobile Bay will be used to demonstrate these capabilities within ADH. Animations will be shown that demonstrate the hydrodynamic, salinity, and sediment behavior within the bay.

Implications
ADH is an adaptive finite element code that can be used to model hydrodynamic, salinity, and sediment as a fully coupled system. ADH is a versatile, robust model that can be used to model anything from riverine systems to dam/levee breach systems to estuarine systems, like Mobile Bay. This presentation will exemplify ADH's capabilities for estuarine type problems and will provide attendees with an understanding of how this model can be applied to future projects. This will provide attendees with better understanding of the ADH model in general and address expectations of prospective users while also providing a description of the current modeling effort of Mobile Bay.

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Research and Development

Poster Presentations

The CREST Program: Connecting Coastal Research with Management and Restoration
Doug Daigle
CREST Program

Applied Research & Development
James W. Pahl
Louisiana Office of Coastal Protection and Restoration

Status Report from the LACES Division
Richard C. Raynie
Louisiana Office of Coastal Protection and Restoration

Systems Assessment
A. Carol Parsons Richards, Sydney Dobson, Richard Raynie
Louisiana Office of Coastal Protection and Restoration, LACES Division

Coastal Sustainability Studio
Robert Twilley, Jeffrey Carney, Lynne Carter, Jori Erdman, Elizabeth Mossop, Alaina Owens, Clinton Willson
Louisiana State University

The CREST Program: Connecting Coastal Research with Management and Restoration

Doug Daigle
CREST Program

The challenges in coastal restoration are dynamic, as managers and policymakers work within political and structural processes that don't always match the scale of problems such as land loss and sea-level rise. The mission of the CREST Program (Coastal Restoration and Enhancement Through Science and Technology) is to improve our ability to restore critically important coastal habitat by facilitating the development, dissemination, and use of innovative and practical technologies and techniques. CREST is a collaborative effort of 11 Louisiana universities* and the University of Southern Mississippi.

Implications: The CREST program's research agenda capitalizes on the high concentration of coastal restoration professionals in our region, and supports work by graduate students as well. The range of projects funded by CREST covers crucial areas of restoration research – freshwater and sediment budgets for coastal basins, the species of vegetation best adapted to restoration of a variety of habitats, the response of habitats to actions like freshwater diversions, and the socio-economic aspects of restoration, among others. Selected projects that address these topics show how a body of science is being built that can aid and complement efforts by the state, federal agencies, and local governments. CREST is unique in its outreach to local, state, and federal coastal management and policy bodies as part of the effort to bring restoration science to the public.

*Louisiana State University (LSU), LSU Agricultural Center, Louisiana Universities Marine Consortium, Loyola University, McNeese State University, Nichols State University, Southeastern Louisiana University, Southern University at New Orleans, Tulane University, University of Louisiana at Lafayette, University of New Orleans

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Applied Research & Development

James W. Pahl
Louisiana Office of Coastal Protection and Restoration

The Office of Coastal Protection and Restoration's Applied Research & Development Section conducts applied research into technical uncertainties, develops data and tools needed by managers and coordinates with external programs to ensure that State-funded activities reinforce a collective strategy to forward the overall coastal protection and restoration program. The Louisiana Legislature established the Office of Coastal Protection and Restoration (OCPR) to ensure a coordinated approach between hurricane protection and coastal restoration activities in the Louisiana coastal zone. Within OCPR, the Louisiana Applied Engineering & Science (LACES) Division was established to support the technical needs of program and project delivery teams. That support involves both directly conducting applied research into technical uncertainties surrounding programmatic activities and goals and developing data and tools needed by OCPR program and project managers, as well as managing contracted activities. Support also includes coordinating with external research & development programs to ensure that State-funded activities are not redundant with external efforts and in fact reinforce a collective strategy to move the overall coastal protection and restoration program forward. These are responsibilities of the LACES Applied Research & Development Section, and are detailed in this poster.

Implications:
Numerous technical uncertainties complicate the planning and implementation of hurricane protection and coastal restoration projects for which OCPR is responsible. Conducting applied research to address those uncertainties and developing tools to assist project managers therefore plays an important role in helping more the protection and restoration program forward. OCPR Applied Research & Development also is working to serve as a coordination point where the activities and results from multiple research & development programs is made available to program and project managers in south Louisiana, so that scarce public R&D dollars are most responsibly applied to the issues at hand.

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Status Report from the Louisiana Applied Coastal Engineering & Science (LACES) Division

Richard C. Raynie
Louisiana Office of Coastal Protection and Restoration

Louisiana is developing a robust, integrated program to identify and resolve scientific and technical uncertainties, and actively communicate the latest scientific and technical information throughout the planning and implementation of coastal protection and restoration projects. The Louisiana Applied Coastal Engineering & Science (LACES) Division was created within OCPR to 1) promote scientific, technical, and engineering advancements for the sustainability of coastal Louisiana, drawing on regional, national, and international expertise, as necessary; 2) support the adaptive implementation of the Master Plan; 3) coordinate with, and supplement as necessary, on-going research & data collection initiatives that inform coastal protection and restoration decisions; 4) facilitate the integration of credible technical information into the decision making process; and 5) integrate the knowledge and interactions from a variety of disciplines including engineering, toxicology, natural, physical, and social sciences, and economics.

This session will discuss some of the key activities of the LACES Division for FY2010, including the Applied Research & Development Section "needs assessment"; the Adaptive Management initiatives of the Systems Assessment Section; the development of a Sediment Management Plan for Louisiana; and the web-enabled information management system, managed by the Data Management & Training Section, which provides access to critical information.

Implications
The success of Louisiana's Master Plan depends on well-informed decisions, streamlined and efficient processes, building institutional knowledge, and effective communication of available information. LACES plays a critical role in advancing these efforts and communicating the activities of this Division to coastal partners and stakeholders is important for understanding how science & technology are integrated into the Master Plan implementation process.

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Louisiana Applied Coastal Engineering and Science (LACES) Systems Assessment Section: Background and Overview

A. Carol Parsons Richards, Sydney Dobson, Richard Raynie
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The Louisiana Office of Coastal Protection and Restoration (OCPR) has recently established a Systems Assessment Section within the Louisiana Applied Coastal Engineering and Science (LACES) Division. The mission of the LACES Division is to support the scientific, engineering, research, and technological needs of OCPR. To help achieve the LACES mission, the Systems Assessment Section will provide assistance specifically to the OCPR Planning Division by supplying scientific input and facilitating feedback on lessons learned from previous projects. In addition, this section will provide knowledge and interactions from various internal OCPR sections, external disciplines and academia for incorporation into the planning process, facilitate adaptive management among monitoring, planning, engineering, and construction, and synthesize and assess the collective performance of the OCPR. This poster will focus on ongoing and future planned activities that strive to meet the section's goals, including 2012 Master Plan Predictive Tools, Louisiana Applied Modeling Program (LAMP), LCA Monitoring and Adaptive Management Plans, and Innovative Technologies.

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Coastal Sustainability Studio

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The Coastal Sustainability Studio (CSS) is a relatively new endeavor that seeks to use a multi-disciplinary and systems-oriented approach to develop pragmatic, trans-disciplinary techniques for reducing environmental vulnerability and enhancing community resiliency along coastal Louisiana. The CSS approaches issues differently than traditional planning efforts in deltaic coasts, placing greater emphasis on achieving both environmental and economic sustainability. The CSS deliberately links challenges of storm disturbances, land-use transformations, and climate change to develop adaptations in coupled natural and human systems. The goal of the CSS is to design sustainable systems that reduce vulnerability associated with diverse scenarios of coastal hazards, habitat degradation, and global environmental change. The CSS achieves this by promoting collaboration of local and out-of-state experts to find innovative and sustainable solutions to critical problems associated with coastal protection and restoration.

The minimum requirements for a project to be accepted into the CSS include (1) at least three disciplinary perspectives involved (coastal science, engineering, and planning/design), which enables the CSS to holistically tackle problems that are more complex than any one discipline can solve, and (2) the project must be driven by the needs of the community (ranging from neighborhood, city, and regional scales) that will be impacted. The CSS is not only an approach to achieving a sustainable coast; it is also a physical location on the Louisiana State University campus where principles of coastal sustainability and systems thinking are applied and practiced by an intermingling of students, faculty and staff. The CSS is currently developing novel scenarios for the New Orleans area, specifically to restore environmental, community, and economic sustainability to the Lower Ninth Ward and Bayou Bienvenue / Central Wetlands.

Implications
The efforts of the Coastal Sustainability Studio (CSS) will greatly enhance restoration and protection planning in coastal Louisiana in two primary ways. First, the CSS approaches sustainability and resiliency of natural and human systems differently than traditional planning efforts, namely by employing a holistic set of multidisciplinary and multi-scaled approaches. It serves as an overarching effort, incorporating parts of various coastal plans and pairing traditional methodologies with cutting edge restoration, protection, and design strategies and scenarios.

The second implication for future coastal planning in Louisiana is that the CSS strives to train the next generation of coupled coastal-engineering-planning experts by pairing high achieving graduate students with expert talents in these (and other) fields of study to address real issues related to coastal sustainability. This nontraditional training/apprentice framework and unique student experience will yield groups of professionals trained to address highly complex and multidisciplinary coastal matters.

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Oil Spill

Poster Presentations

Small Oil Spill Vegetative Impact Study: A Survey of the Magnitude and Distribution of Oil Spills within the Louisiana Coastal Zone and Coastal Area
Aaron S. Bass
SJB Group, LLC.

Deepwater Horizon Oil Spill: Impacts to Coastal Louisiana's Wildlife and Habitat
Mike Carloss
Louisiana Department of Wildlife and Fisheries
No Abstract Available

Preliminary Observations on Use of Excitation-Emission Fluorescence Matrix Spectroscopy (EEMs) to Detect Oil Signature in Seawater Samples from Oil Spill
Eurico D'Sa, Edward Overton
Louisiana State University

Potential of Restoration and Phytoremediation with *Phragmites australis* for Oil-impacted Marshes
Qianxin Lin
Louisiana State University

Gulf War Oil Spill: Coastal Remediation and Restoration in the Kingdom of Saudi Arabia
Sharook P. Madon
CH2M HILL, Inc.

Is *In-situ* Burning an Appropriate Option for Oil Spill Remediation in Wetlands?
Irv Mendelssohn
Louisiana State University

Integrated Emergency Response Services
Stephen Petron
CH2M HILL, Inc.

The Response of St. Lawrence Seaway Marshes to Oil Spill
Jane Rowan
Bioengineering Group

Small Oil Spill Vegetative Impact Study: A Survey of the Magnitude and Distribution of Oil Spills within the Louisiana Coastal Zone and Coastal Area

Aaron S. Bass
SJB Group, LLC.

The magnitude and distribution of reported petroleum spills in the Louisiana Coastal Zone and Coastal Area were determined from data obtained from the Louisiana Department of Environmental Quality. Data included location (parish and field), quantity, and source (ex. pipeline rupture, valve malfunction). Field investigations were conducted to assess the vegetative damages caused by petroleum spills in fresh, brackish, and salt marshes. These spills represented a variety of habitats, spill quantities, and ages.

There were 1,723 reported spills between 1990 and March 1999. Fifty-four percent of the spills occurred in Plaquemines, Lafourche, and Terrebonne Parishes. Twenty-seven percent of the total reported volume occurred in Plaquemines Parish. St. Bernard and Lafourche Parishes had 21% and 14% respectively.

There were 985 reported spills designated by field. Twenty-one fields had ten or more spills and were designated as "hot-spots". Lake Washington Field had the highest frequency of spills with 74 reported.

Flowline ruptures and miscellaneous equipment failures were responsible for 31% and 28% of the spills respectively. Small volume spills of five barrels or less were the most frequent. These small spills constituted 66% of all reported spills.

Nineteen spill sites were investigated in Cameron, Terrebonne, and Lafourche Parishes. They consisted of nine fresh marsh, two brackish marsh, seven salt marsh, and one upland site. Six of the fresh marsh sites had recovered and two were not detectable. Only one of the fresh marsh sites had not recovered. One brackish marsh spill site had partially recovered and one was not detectable.

Only one salt marsh site appeared to have full vegetative recovery. Two salt marsh sites had no recovery and two sites had visible damages, but were considered partially recovered. In general, residual impacts to vegetation was greater at the salt marsh spill sites that at the fresh marsh sites.

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Preliminary Observations on Use of Excitation-Emission Fluorescence Matrix Spectroscopy (EEMs) to Detect Oil Signature in Seawater Samples from Oil Spill

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The oil spill impact in oceanic and coastal waters due to the Deepwater Horizon oil rig accident in the northern Gulf of Mexico requires a detailed understanding of its distribution and fate in order to assess its environmental effects. Some processes that the spilled oil undergoes include dispersion and dissolution in seawater. Knowledge on the composition and concentration of the soluble components of oil is needed to understand its impact on the marine ecosystem as aromatic hydrocarbons generally exhibit high solubility and toxicity in the aquatic environment. While sensitive detection methods such as gas-chromatography-mass spectroscopy (GC-MS) require the extraction and concentration of samples prior to analysis, fluorescence spectroscopy provides a more direct and rapid method of detecting the presence and relative concentration of oils (e.g., polycyclic aromatic hydrocarbons or PAHs) in seawater. Here we describe initial results on the use of excitation-emission matrix fluorescence spectroscopy (EEMs) to detect oil signature in seawater samples obtained near the oil spill site and close to the Mississippi River delta.

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Potential of Restoration and Phytoremediation with *Phragmites australis* for Oil-Impacted Marshes

Qianxin Lin and Irving A. Mendelssohn
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Oil spills can cause extensive impacts to coastal wetland plants. *Phragmites australis* (common reed, roseau cane) is a widespread dominant marsh plant species, and is being impacted by the *Deepwater Horizon* oil spill. Little information is available concerning this species' tolerance to oil. This information is essential if we are to consider *P. australis* for restoration and remediation of oil contaminated marshes. This research was designed to fill this information gap. The tolerance limit of *P. australis* to south Louisiana crude oil applied to the sediment was estimated to be between 80 and 320 mg g^{-1} based on a suite of plant variables. Thus, this species has potential for restoration of oil-contaminated wetlands. Phytoremediation with *P. australis* reduced the residual oil concentrations in the sediment, demonstrating the potential for accelerating oil spill degradation and cleanup in wetland environments.

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Gulf War Oil Spill: Coastal Remediation and Restoration in the Kingdom of Saudi Arabia

Sharook P. Madon[1], Stephen E. Petron[1], Todd M. Montello[2], Jason Hale[2], Chris Cormack[2], Tom Freeman[2], Jeremy Gabriel[2], Owen Langman[2], Linos Cotsapas[2], Jacqueline Michel[2], and Michael Risk[2]
[1]CH2M HILL, Inc. and [2]Research Planning, Inc.

Description:
The oil spills related to the 1991 Gulf War remain the largest in history to date. Over 11,000,000 barrels of oil impacted approximately 800 km of Saudi Arabia's shoreline between the Kuwait Border and Abu Ali Island. In 2009, the Kingdom of Saudi Arabia (KSA), with funding provided through the United Nations Compensation Commission (UNCC), undertook one of the most ambitious coastal remediation and restoration project in the world. The UNCC has identified KSA's Presidency of Meteorology and Environment (PME) as the National Focal Point (NFP) tasked with directing the remediation and restoration efforts. The challenge is to restore ecological function with the intertidal and specific marine habitats that were impacted by the 1991 Gulf War oil spill, without additional collateral damages to the environment, and to provide net environmental benefits as a direct result of remediation and restoration activities.

The CH2M HILL/RPI team (Team) has the important task of supporting the NFP's management of the coastal and marine restoration it will embark upon during the 3-year period beginning in 2009. As the NFP's Program Management Support Contractor (PMSC), the Team is responsible for the overall planning and implementation of this complex project. Specific key tasks include the review/evaluation of the remediation and restoration designs, technical meetings with stakeholders, field validation surveys, development of remediation and restoration objectives, prioritization of coastal remediation and restoration projects, design of pilot, demonstration and large-scale remediation/restoration projects, overall implementation of these projects, and development and implementation of monitoring protocols and an assessment framework to evaluate remediation and restoration success.

Studies to date have indicated limited oil removal by natural processes on moderately exposed and sheltered tidal flats and salt marshes. Furthermore, ecological recovery has been slow, particularly within sheltered habitats due to continuing chemical toxicity of oil residues and physical barriers to recovery.

Sharook P. Madon
CH2M HILL, Inc.

Integrated Emergency Response Services

Alice Abney, Brian Perez and **Stephen Petron**
CH2M HILL, Inc.

The poster will provide key capabilities in providing integrated emergency response services. With comprehensive expertise in emergency response, environmental cleanup, program and project management, and rapid deployment, CH2M HILL is poised to offer a wide variety of services to respond aggressively to oil spills and other disasters – natural or manmade. Our experience on massive recovery efforts includes the Valdez oil spill in Alaska, Hurricanes Katrina and Rita along the Gulf Coast, the Kingdom of Saudi Arabia's coastal restoration related to oil releases after Gulf War I, and the Indian Ocean tsunami.

With more than 80 years of service to clients across the Gulf Coast, we have extensive local community networks and strong working relationships with elected officials in the affected areas. CH2M HILL's dedicated professionals in Louisiana, Mississippi, Alabama, Texas, and Florida are backed by 23,500 professionals worldwide, offering comprehensive services, a depth of expertise and resource, the ability to mobilize rapidly, and respond quickly.

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The Impact of Oil on Marsh Communities in the St. Lawrence River: NEPCO 14 Oil Spill of June 1976

Jane Rowan, Kathy Bradford, Beth Fenstermacher and Dan DeLongchamp
Bioengineering Group

A study was conducted on fish and waterfowl populations in Goose Bay and the St Lawrence River marshes that had been exposed to a spill consisting of No. 6 Industrial fuel oil. The spill occurred at approximately 1:30 a.m. on June 23, 1976 after the tank barge Nepco 140 carrying 107,000 barrels of oil encountered a shoal in the American Narrows section of the St Lawrence River. The higher than normal water level and the large river flows at the time (9800 m^3/sec) carried the oil quickly through the Thousand Island region, and particularly into Goose Bay. Clean up consisted of removal of heavily and moderately oil vegetation. This study looked at impacts to fish and waterfowl populations the year of the spill, and in 1977 and 1978.
This poster will present the results of this study as outlined in a paper by a professor from the State University of New York, College of Environmental Science and Forestry at Syracuse University. The citation of the paper follows:

Alexander, Maurice M., P. Longabucco, and D. Phillips. 1981. Proceedings, 1981 Oil Spill Conference (Prevention, Behavior, Control, Cleanup) March 2-5 1981. Atlanta, Georgia. Pages 333-340. American Petroleum Institute Publication No. 4334.

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Author Index