STATE OF THE COAST

SESSION ABSTRACT COMPILATION

STATE OF THE COAST CONFERENCE

MARCH 18 – 20, 2014

ERNEST N. MORIAL CONVENTION CENTER

NEW ORLEANS, LA

CONFERENCE SUMMARY

11 Session Blocks, 8 Meeting Rooms

- 88 Sessions
- 57 Conventional Sessions
- 8 Panel Discussions
    - Building Resiliency Workshop I
    - Building Resiliency Workshop II
    - Climate Change
    - Blue Carbon
    - Permitting in Uncertainty
    - Master Plan Dark Matter
    - Dredging
    - Portrayal of Coastal Louisiana in Film
- Workshops
    - The What, Where, and How of the Coastwide Reference Monitoring System (CRMS) Website
    - The What, Where, and How of the EverVIEW NetCDF Data Visualization Platform
    - The Nature Conservancy (TNC) Decision Support Tool
- Movies
    - *A Louisiana Story, 1948*
    - *My Louisiana love, 2012*
    - *Water Like Stone, 2012*
    - *Beasts of the Southern Wild, 2012*
    - *Can't Stop the Water, 2013*

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Abstracts are ordered alphabetically by original presenting author. Due to the changing nature of the program, this preliminary compilation does not accurately reflect the day of program. Please check the website after the conference for a more comprehensive listing of abstracts and presentations.

Morphological Modeling of Mississippi River Sediment Borrow Sites

Santiago Alfageme[1], Oleg Mourenko[2], and Jonathan Hird[1]
[1] Moffatt & Nichol

A state-of-the-art hydrodynamic, sediment transport, and morphological evolution numerical model was developed using the Delft3D modeling system to investigate sediment transport and morphological evolution of the Mississippi River in the vicinity of three locations proposed as sediment borrow sites for the Mississippi River Long Distance Sediment Pipeline (LDSP) project. The LDSP project will dredge sediment from the Mississippi River and pump it through a pipeline to create an access corridor and marsh across the Barataria Landbridge. This corridor will facilitate the implementation of future restoration projects in the vicinity of the project area.

The three locations modeled are located at Wills Point Anchorage, Alliance Anchorage and Alliance South located between RM 67 and RM 60. The primary purpose of this investigation was to assess the following:

- The evolution of the dredged borrow area over time periods ranging from months to years by estimating the rate and spatial extent at which the dredged borrow area may infill by natural riverine processes.
- The impact of the depth of cut on the rate of infill, and
- The influence of the dredge-pit on the sediment movement and river-bed mechanics farther downstream.

The model was used to successfully hindcast observed infilling rates after sediment was dredged from the Alliance Anchorage borrow site to construct the Bayou Dupont marsh restoration project in 2009/10. A detailed description of the modeling approach, model development, discussion of the model results and sensitivity, and conclusions from the analysis will be presented in the final paper. Generally, modeling results indicate that infilling rates will vary significantly depending on the initial cut depth and river discharge conditions. For example, at the Alliance Anchorage borrow site, the average refill rate in the first year after construction varies between 63% and 67% for a cut depth of -70 ft and -90 ft NAVD88, respectively.

Implications

This effort is one of the first of its kind to evaluate quantitatively the evolution of large dredge borrow areas in the Mississippi River. Historically, marsh creation projects in Barataria Basin have used local borrow sources located in the immediate vicinity of the project sites. However,

this practice is not sustainable. While dredging the river does not restore the natural cycle of sediment deposition from seasonal floodwater flow, it does provide a mechanism to achieve a similar result (i.e. transporting sediment from the Mississippi River to the coastal marsh ecosystem). Therefore this should be a more sustainable approach provided these borrow sites naturally refill over reasonable periods of time and they do not create significant impacts downstream. Models such as the one described above are the only tools available to answer these questions and should be farther developed and calibrated/validated to measured data from ongoing projects.

Implementing Ecosystem-based adaptation of coastal areas through Public-Private Partnerships (PPP)

Monica Altamirano

Deltares

The implementation of green adaptation measures is often hindered by a number of procurement and financing barriers. We explored the possibilities and challenges ahead for these measures to be financed and implemented as PPP. As PPP's are a joint endeavor and not solely depend on a public authority; we opted for the use of collaborative modeling techniques.

Three sessions were organized with representatives from the main decision makers: public client, project sponsors, and financiers. The case of mangrove restoration in Indonesia was chosen to allow for concrete recommendations and quantification of interdependencies. The first workshop focuses on understanding the complexities of natural capital and the differences in behavior in terms of performance and costs of green versus grey option. Besides ensuring wave attenuation, storm protection and shoreline stabilization; mangroves have a nursery function for juvenile fishes, increase water quality, provide additional timber and increase the aesthetic of the area. Nevertheless they take much longer to provide the required main service. In the second workshop the group worked in three assignments aimed at linking the stock of natural capital with the cash balance of the Special Purpose Vehicle implementing the project. Besides defining the required levels of services for the payment of "availability fees" and defining cost drivers; the group explored ways to close the financial viability gap by capturing the positive externalities of mangrove restoration via taxes or via tariffs. Finally all insights were brought together by means of a System Dynamics model and required conditions for bankable projects were explored.

Besides a System Dynamics model that simulates the performance of the mangrove restoration project in financial and natural capital terms, the result is a script for effective collaboration of diverse stakeholders and disciplines to formulate a bankable project applicable to other green adaption measures.

Policy Implications

The proposed methodology has been successful in dealing with one of the main barriers for the private financing of green adaptation, an unfounded perception of excessive risks . As measured by our survey, participants not only gained a better informed view of the risks of the

project but were also more able to define the Internal Rate of Return (IRR) of the eco-engineering design.

The construction time and the cyclical performance of eco-engineering concepts require a different financing model than traditional gray infrastructure. When opting for PPP as project delivery method is of even greater importance to:

a. Define the right performance indicators and allow for more flexibility on level of services for the main service being provided by the project, in this case flood protection.
b. Adapt payment mechanisms so as to make possible a positive project IRR for these projects that take much longer construction periods and have a cyclical fluctuation in performance since they follow the dynamics of natural processes.
c. Develop financial instruments that effectively technology risks.

Shoaling Analysis of the Calcasieu Ship Channel Loop Pass

Mitch Andrus[1], Josef Hoffmann[1], and Samuel Bentley[2]
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The Loop Pass of the Calcasieu Ship Channel, at one time a natural meander bend of the Lower Calcasieu River, is presently a 3.2-mile-long oxbow channel connected to a tidally-dominated reach of the Calcasieu Ship Channel at Cameron, Louisiana. Persistent shoaling within the Loop Pass is a critical concern among local stakeholders and management officials interested in preserving unhindered navigability within this waterway.

Future planning and budgeting of maintenance projects for the Loop Pass is contingent on an understanding of the sources and rates of accretion within the channel. This presentation addresses the dominant hydrodynamic processes in the Lower Calcasieu Ship Channel and Loop Pass, as well as the corresponding sediment transport behavior in these two channel reaches. Implementation of a two-dimensional hydrodynamic and non-cohesive sediment transport model of the study area is presented, and the results of a 10-year simulation are shown. Hydrodynamics of the model were calibrated to stage records at NOAA Station 8768094 within the model domain. Simulated tidal velocities and flow rates in the Calcasieu Ship Channel were compared to published measurements from a 2006 field study. Results of the first year's simulation are compared to that of an offline one-dimensional cohesive sediment transport model, using hydrodynamic output from the two-dimensional model. Simulated bed shear stresses, suspended sediment concentrations, and net annual shoaling rates from both models are presented and compared.

Implications

Shoaling of navigable waterways has enormous economic implications for entities tasked with their maintenance. Results of verified numerical models can inform budgetary estimates of required dredging quantities, and serve as valuable planning tools in determining appropriate dredging frequencies and associated costs.

Keys to Building a Successful Adaptive Management Program

Stuart Appelbaum
ARCADIS

Restoration of the Everglades is one of the largest ecosystem restoration efforts in the world. The Comprehensive Everglades Restoration Plan (CERP), approved by Congress in 2000, provides a framework for the Everglades restoration program. CERP consists of 68 components that will be implemented over the next thirty years. CERP also includes a robust adaptive management program. Congress approved the adaptive management program and authorized $100 million for the first ten years of the monitoring and assessment program. In the years since 2000, an adaptive management strategy was developed, a monitoring and assessment plan was developed and implemented, and an adaptive management implementation guide published. Four independent scientific reviews of CERP have been completed by National Academy of Sciences panels and these panels have been highly complementary of the adaptive management program. In addition, the Everglades adaptive management program has been used as a role model for setting up adaptive management on other large-scale ecosystem restoration efforts.

Using the Everglades program as a model, this presentation will focus on the ingredients for building a successful adaptive management program. Some of these key ingredients include: a statutory or regulatory mandate; funding; an adaptive management framework and linkages; a monitoring program; an assessment program; stakeholder involvement; independent scientific review; and a decision-making process for making implementation adjustments. The presentation will describe the CERP adaptive management program and the key ingredients for success.

Implications

Adaptive management is a critical component of large-scale ecosystem restoration programs due to the large uncertainties involved in these programs. By their very nature, large-scale ecosystem restoration involves large spatial extent and long implementation time scales. Adaptive management provides the ability to adjust, modify, or greatly change restoration plans as new information becomes available. These adjustments are crucial for ensuring long-term restoration success. Adaptive management is also an integral part of the coastal Louisiana restoration effort as outlined in the 2012 Master Plan. The lessons learned from the Everglades program will assist in the design of Louisiana's adaptive management program.

A Legal & Cost Analysis of Rapid Land-Building Technologies in the Netherlands and Louisiana

Megan M. Biven

Rapid-Land building technologies supporting coastal restoration efforts are costly. Wang (2012) found that marsh creation and barrier island projects were of the most expensive of CWPPRA projects constructed between 1991-2009. While these projects are more expensive than other coastal restoration techniques, they yield almost immediate results. To a State facing catastrophic land loss, rapid-land building technologies will continue to feature prominently in future restoration plans. This paper will explore why these restoration techniques are so expensive with the hope that strategies to lower those costs can be identified.

While past papers explore several variables that drive these higher costs, incomplete data creates limitations for any predictive modeling efforts. This paper will instead pursue a more descriptive analysis, and examine the current market framework of the rapid land building industry. It will also create a legal history of maritime laws that apply to dredge vessels that could contribute to higher costs for rapid land building projects. This paper will also look to a country that routinely utilizes rapid land building projects in its fight against coastal land loss and subsidence – the Netherlands. Due to the availability of sediment material in the North Sea and routine beach nourishments, the costs of nourishments in the Netherlands has remained relatively flat. Meanwhile, the costs of marsh creation and barrier island projects are among the most expensive, despite similar availability of sediment material in the Gulf of Mexico. This paper will compare the dredge vessel inventories of the United States and the Netherlands, analyze projects requiring a dredge vessel in both countries, and compare the legal frameworks in which these respective industries operate.

Implications

The State Master Plan (2012) predicts that over $20 billion in future dollars will be needed to fund rapid land building projects. Future coastal restoration policy must not only be technologically feasible and sustainable, but it must be fiscally realistic and responsible. Every year coastal restoration projects in Louisiana must battle competing interests on both the Federal and State level. Exploring ways to reduce these costs will increase the likelihood that these projects will be funded in a shorter amount of time and provide greater value to the general taxpaying public. Reducing these costs is vital in ensuring a sustainable Louisiana coast.

Redefining Salinity Regimes for Wetland Vegetation Along the Louisiana Coast

Whitney P. Broussard III and Jenneke M. Visser
University of Louisiana at Lafayette

Transitions in coastal marsh species composition from seawater dominated saline marshes to river and run-off dominated freshwater marshes is well documented. Along the northern Gulf of Mexico coastal zone, the realized distribution of herbaceous plants along the salinity gradient was first described by Chabreck in 1972, and was based on single grab-samples of surface water taken during coastwide vegetation surveys in the late summer of 1968. Currently, the Coastwide Reference Monitoring System (CRMS) provides hourly salinity measurements and annual vegetation surveys at 392 stations randomly distributed across the Louisiana coastal zone. This provides an opportunity to describe the realized distribution of coastal marsh species in greater detail. Here we present a high-temporal-resolution, 6 year data set of hourly salinity records coupled with cover values of the 40 most dominant species based on annual cover surveys at each of the 392 CRMS stations. Our analysis quantifies the environmental salinity conditions of the most common wetland species in the Louisiana coastal zone according to both annual and growing-season constraints. The results are compared with the 1972 Chabreck survey, which has formed the basis for our current understanding of wetland vegetation salinity regimes. This results demonstrates a slight departure from these previous conceptions of optimal salinity conditions for the most common species, and offers insight into the range and variability of salt concentrations that wetland plants are exposed to.

Implications

Information on the distribution of coastal marsh plants along a typical salinity gradient can support the design of coastal restoration projects and the forecasting of vegetation changes associated with sea-level rise or hydrologic modifications. This information will be valuable to managers and scientists across the Northern Gulf of Mexico in light of expected changes in climate variability and coastal isohaline contours.

Establishing Design Criteria: Living Shorelines

Matt Campbell[1], Josh Carter[1], Tye Fitzgerald[2], and Shannon Haynes[2]
[1] Coast & Harbor Engineering, [2] Coastal Protection and Restoration Authority

Living shorelines have been characterized as a shoreline stabilization technique utilizing a variety of traditional structural and biological materials. Components of living shoreline techniques have included wetland plants, oyster reefs, coir fiber logs, geotextile bags/tubes, vegetated erosion control mats, rocks, soil fill, and many others. Oyster reefs have become a large part of this topic in Louisiana in recent years. The implementation of living shoreline techniques has become more desirable by resource agencies, local governments, non-profit organizations, and the public due to the creation of habitat, improved water quality, and general appeal of "soft solutions" over "hard solutions", which have been seen to cause unintended problems under certain circumstances. There have been numerous attempts to quantify the success of these techniques in various projects around the country. Unfortunately, many of these projects have been shown to not be successful due to over-expectations and limited design knowledge of the techniques.

In order to successfully design and implement these living shoreline techniques, a clear understanding of the design criteria for the project and engineering properties of the project components should be developed. These design criteria will enable engineers to understand performance characteristics and limitations as well as to optimize their designs to be more cost effective and versatile. This presentation discusses the types living shoreline projects relevant to Louisiana and the design criteria that are important for successful implementation. There will also be a discussion of design parameters that are necessary for the proper engineering design of living shoreline technologies. The presentation will highlight living shoreline projects that have been implemented in Louisiana.

Implications

Louisiana's coastline lends itself to living shoreline protection techniques due to the vast ecological resource that it is. The Louisiana Master Plan includes various projects that oysters as a type of living shoreline component. The establishment of appropriate design criteria for implementing living shoreline techniques is critical to the successful implementation of these project and others that are currently being proposed. By the advancement of the relevant design parameters and criteria for the various living shoreline technologies and methodologies, this technique for shoreline protection will become more cost effective and achieve long-term success.

Productivity and resilience in the plant community of the Wax Lake Delta and adjacent mainland marshes

Melissa Vernon Carle, Charles E. Sasser, and D. Elaine Hebert

Rivers provide important subsidies of freshwater, sediment, and nutrients to deltas, which impact deltaic and adjacent mainland plant communities. We used a vegetation index (NDVI) calculated from a time series of 94 Landsat MSS and TM images of the Wax Lake Delta in Atchafalaya Bay, Louisiana, to study long-term, seasonal, and storm-event changes in the vegetation community associated with this actively accreting area of Louisiana's coast. We also collected aboveground biomass data in representative plant communities in the delta and nearby mainland marshes and compared the results to data from coastal wetlands elsewhere in the coastal region. Analysis of peak growing season NDVI from 1975 to 2011 indicate that both total and mean NDVI in the delta have increased over time. Aboveground biomass measurements from the field plots both in the Wax Lake Delta and in neighboring mainland marshes place these systems on the upper end of productivity ranges within the state. Seasonal analysis of NDVI data from 2000 to 2011 demonstrates that total NDVI within the delta increases as a function of year, increasing water temperature, and decreasing river discharge. Average NDVI within the delta is a function of year and water temperature. Comparison of NDVI data from before and after six major storm events that impacted the delta shows that storms passing directly over or to the west of the delta have a significant short-term impact on the plant community, most likely as a result of pulses of salt-water intrusion associated with storm surges. However, in each case, NDVI values recovered to within the 95 percent prediction interval for the long-term trend by the following growing season. Together, these results show that the freshwater marshes within the delta and the adjacent mainland area are among the most productive in the state and are extremely resilient to coastal storm disturbance.

Implications:

As a naturally-developing young river delta that formed at the mouth of a flood control diversion of the lower Atchafalaya River, the Wax Lake Delta provides an important reference system for understanding the potential impact of large-scale diversions proposed in other areas of the Mississippi River delta region. This study demonstrates that the marshes associated with this actively accreting area of the Louisiana coast are among the most productive and resilient wetlands in the state, providing demonstrable evidence that the delivery of substantial freshwater and sediments by the river benefits the productivity of deltaic and adjacent mainland wetlands.

DEMYSTIFYING THE SEDIMENT DIVERSION: Visualizing Precedent, Intervention, and Predicted Results

Bradley Cantrell[1], **Jeff Carney**[2], Matthew Seibert[3]
[1] Director of the School of Landscape Architecture (LSU), [2]Director of the Coastal Sustainability Studio (LSU), [3]Research Associate at the Coastal Sustainability Studio (LSU)

Large-scale sediment diversions from the Mississippi River build the most land in return for the least financial investment – simulating the very means by which the delta was built over thousands of years. However, the re-interpretation of this natural phenomenon by infrastructural engineering requires significant examination of the conflicts emerging across cultural, ecological, and economic sectors. Bringing together a collaborative team of coastal scientists, engineers, and designers, this project employs the tools of dynamic visualization to further the dialogue for coastal protection. The products of this work are short films illustrating the actors, processes, and predicted results of the proposed Mid-Barataria Diversion.

The first short film visualizes the historical processes of the delta-cycle, revealing the development of the delta lobes through river-powered sediment deposition. This delta scale then transitions to the diversion scale. Here the physical intervention of a man-made diversion structure and its operation regime are demonstrated. The predicted operation schedule is informed by the past fifteen years of Mississippi water and sediment data. Concluding with anticipated results on the larger landscape, the final film transitions to the basin scale. Expanded salinity gradients, transitioning ecotones, and land progradation are projected for the Barataria Basin. Supporting research for the films includes papers by Michael Bloom and Harry Roberts; Moffatt and Nichol Engineers; and an excel model developed by Wonsuk Kim. These visualizations demystify the delta building process through animated imagery, communicating how the natural delta-cycle can be transformed into a tool for human use.

Scientific arguments can often overwhelm a lay audience leading to distrust of these necessarily bold protection measures. A clear and visual expression of the risks and benefits- based in empirical evidence- can expand the pressing conversation for coastal protection, mobilize public support, and inspire action.

Implications

With land subsidence, sea level rise, and increased storm frequency threatening Southeast Louisiana, an urgent need exists to confront a disappearing coast whose once robust edge hosts a vibrant population and economy. The greatest challenge in instituting large-scale sediment diversions is political support. This project acts as a precedent-setting model for cross-disciplinary collaboration in exploring the relevant issues concerning diversions, with the final product acting as an education tool in the public sphere. The historic dynamics of the delta-

cycle informs future scenarios and begins to replace the fear of risk with the excitement of future possibilities. Ultimately, visualization of empirical data in coastal protection is demonstrated as an important tool in communicating across disciplines and instigating change within a disappearing landscape threatened by inaction.

Strategies for Building Community Resiliency

Jeff Carney[1], Katrina Durbak[1], Patrick Michaels[1], and Emily Powell[1]
[1] Coastal Sustainability Studio, Louisiana State University

How can we plan in communities facing increasing environmental, social, and economic risks? What tools are enabling communities to adapt, changing how we live, where we live, and the public process with which we make decisions at a neighborhood, municipality, parish, or regional scale? The fundamental question of how we live within a dynamic and high-risk landscape will be addressed through an examination of planning efforts with successful resilience strategies in coastal Louisiana.

The Louisiana Resiliency Assistance Program (LRAP) has promoted a series of strategies for building resilience in local communities that have been developed through the Office of Community Development – Disaster Recovery Unit's (OCD-DRU) Comprehensive Resiliency Pilot Program. These strategies highlight opportunities that spring out of challenging planning situations. Through multi-faceted approaches, different aspects of a community build on each other and work together to strengthen the entire community. The following seven strategies frame specific goals of resilience planning. Each strategy is supported by a series of planning principles that translate the strategy into specific, achievable actions and tools currently being implemented. They address the inherent challenges associated with living in and governing viable communities in a dynamic, rapidly changing landscape. Specific examples taken directly from Louisiana planning projects illustrate each principle. This presentation will introduce a methodology for resilience planning and highlight tested local examples to achieve it.

These strategies for resilience are:
1. Planning with the Natural Environment
2. Incorporating Data, Communication, and Visualization
3. Retrofitting Aging Communities
4. Insuring Communities against the Burden of Risk
5. Achieving Economic Stability in a Dynamic Environment
6. Innovating Codes, Ordinances, & Design Guidelines to Reduce Risk
7. The Process of Resiliency Planning

This presentation will address current practices that create more resilient communities and neighborhoods in Louisiana.

Implications
Attendees will learn about innovative strategies that are being used to promote resiliency and how these strategies may be considered in their own communities. By being able to identify

opportunities out of challenging situations and new possibilities for cross-disciplinary integrations, attendees will return to their communities with new ideas for tackling their local and regional issues. The LRAP developed these seven strategies based on extensive research of community resiliency and investigation of national and local precedents, as well as by drawing on the needs and challenges voiced by 30 local Louisiana communities that received planning grants post Hurricanes Gustav and Ike as part of the Community Resiliency Pilot Program. Presenting these strategies and showcasing the innovative work being done on the ground can help us collectively achieve more informed, effective planning-based solutions to reduce future risk.

Living Shoreline Demonstration Project – Analysis of Concept Performance

Josh Carter[1], Arpit Agarwal[2], Dean Goodin[3], and Tye Fitzgerald[4]
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[3]Tetra Tech, Baton Rouge, LA, USA
[4]Louisiana Coastal Protection and Restoration Authority, Baton Rouge, LA, USA

The goal of the project is to establish a living shoreline that will help prevent erosion along the coastal fringe marsh of Bayou La Loutre in St. Bernard Parish, Louisiana by using the living shoreline products to attenuate the wave energy that reaches the shore. The secondary goal is to stimulate oyster growth and thereby increase the biodiversity in the immediate vicinity of the project site. To meet the project goals, living shoreline products are planned to be installed along the shoreline to reduce wave energy and stimulate oyster growth. The project is also intended to provide the Louisiana Coastal Protection and Restoration Authority (CPRA) experience and data on living shoreline products and their performance in order to design more effective living shoreline projects in the future.

To reduce marsh edge erosion, the marsh erosion tolerance to wave energy impacting the shoreline must be established to determine the conditions during which erosion will occur. Modeling and analysis was conducted to determine coastal processes at the site. An analysis of the geotechnical properties of the soil along with wave climate and shoreline morphology was used to develop the marsh erosion tolerance for the site.

The living shoreline products must reduce wave energy transmitted past the designed structure to levels below the marsh erosion tolerance limit to successfully control shoreline erosion. However, known performance characteristics of available living shoreline products are generally limited due to the experimental nature of the products. Therefore, the ability of each product to reduce wave energy transmitted past the designed structure was evaluated along with the hydraulic loading on the structures using 2D-V and 3D computational fluid dynamics modeling tools.

This presentation will discuss results of the marsh erosion tolerance analysis and the wave energy reduction performance of different living shoreline products.

Implications

The Louisiana 2012 Coastal Master Plan includes various projects that could be considered to have some type of living shoreline or oyster reef component. The performance of living shoreline oyster reef techniques in terms of their ability to reduce erosion is generally not well understood, especially for the various innovative products. The development of an understanding of the performance of living shoreline oyster reef techniques is critical to their successful

implementation in the future. This project is a step toward developing an understanding of the performance of the avaialble products.

Advancements in Hurricane Storm Surge Modeling Utilizing the ADCIRC Model

Zachary Cobell, Joannes Westerink, Robert Dalrymple, John Atkinson, Shan Zou, Haihong Zhao, and Hugh Roberts

ARCADIS

Hurricane storm surge modeling has grown thanks to an ever increasing ability to perform data collection during and after the storm. This data collection has led model developers to be able to gain new understanding into the processes that occur when storms threaten coastal areas. Hurricane Katrina, in particular, provides an excellent scenario for testing the interaction of various new model features. The levee erosion and failure in the polders is an excellent test case for the dynamic levee breaching feature in the latest ADCIRC versions. Also, the wave overtopping of the St. Bernard polder's Mississippi River Gulf Outlet (MRGO) levee provides an adequate test case for overtopping calculations completed within the ADCIRC and SWAN routines in coordination with the EuroTop or Van de Meer equations. In addition to examination of these features and validation against measured data, Lagrangian particle tracking has been performed to demonstrate the sources of water entering polders during Hurricane Katrina.

Implications

Using this work as a basis, surge modelers have an increased ability to more accurately represent physical processes that can contribute to flooding within polders during hurricanes. These methods allow the modeler to calculate this directly and dynamically during a simulation. These advancements are the first steps towards more accurately defining risk levels within polders.

Reestablishing Tidal Channel Ecological Functions: Learning from the Large-Scale Restoration Program Along the Arabian Gulf Coastline

Linos Cotsapas, Thomas Minter, Chris Cormack, Jason Hale, and Jacqueline Michel

The estimated 10+ million barrels of oil released at the closing stages of the 1990-1991 Gulf War severely degraded coastal and marine habitats of Saudi Arabia along the Arabian Gulf. More than 20 years later, recovery through natural attenuation is limited with persistent negative ecological impacts to intertidal habitats evident. Reduced abundance and distribution of salt marsh flora and fauna, persistent oiling in channel bank and bottom micro-habitats, and clogged tidal channels which fail to drain during ebb tide are wide-spread. Several restoration practices to address identified stressors were evaluated with refreshing of existing or excavation of new tidal channels selected as the primary method. Excavation of tidal channels removes algal mat, clean, and oil-contaminated sediment that clogs channels; increases the volume of water that may flood and drain channel and marsh habitat during each tidal cycle; and increases potential surface area of channel bank and bottom habitat available for colonization. Short-term (1-3 years) progress of ecological restoration by monitoring sediment re-distribution within tidal channel segments, and patterns of colonization by three benthic taxa in channel bank and bottom micro-habitats was evaluated. Evidence of sediment redistribution, including deposition of organic and inorganic fines along channel bottom, thalweg development, areas of erosion and deposition at channel bends, and point bar accretion, indicated substantial differences in channel habitat response to excavation. These differences may be related to sediment characteristics, stream morphology, surrounding marsh topography, and dynamics of local tidal regime. The spatial extent of colonization by three important bioturbators (*Nasima* crabs, *Grandidierella* amphipods, and *Potamides* mud snails) stabilized within four months of completion of excavation. However, density of individuals within individual channel segments was related to patterns of sediment accretion and substrate development. Considered together, these indicators of ecological recovery became key components that helped improve subsequent large-scale habitat restoration efforts.

An Assessment of the Performance of Raccoon Island Breakwater Projects

Glen Curole
Coastal Protection and Restoration Authority of Louisiana

The TE-48 project examines the effectiveness of shoreline protection features constructed along Raccoon Island's shoreface. This island is positioned approximately 40 km southwest of Cocodrie, Louisiana. In 1997 an earlier CWPPRA project (TE-29) constructed eight detached breakwaters (#0-#7) along the eastern shoreface of Raccoon Island. In 2007 the TE-48 project extended the TE-29 breakwater field to the west by constructing eight additional rock breakwaters (#8-#15) and a rock groin on the eastern edge of the island. Elevation grid models were created using topographic and bathymetric survey data. These models were used to determine volume changes on the different segments of Raccoon Island. The groin expanded the shoreline and gained considerable volume. The large volume increase surrounding this structure initiated salient formation behind TE-29 breakwaters #1 and #2 and closed a channel that developed behind the TE-29 breakwaters #0 and #1. The TE-48 breakwaters all showed volume gains and breakwaters #8 through #12 displayed tombolo or salient formations. However, these sediment induced volume expansions have come to the detriment of the Raccoon Island Spit and breakwaters #3-#6 (TE-29) which have recorded sediment deficits since construction of the TE-48 structures. During Hurricane Gustav, the spit shoreline transgressed appreciably, and the breach separating Raccoon Island and the spit reopened. Since this tropical event, the breach has expanded and the spit volume has continued to decline. Consequently, the retention and continued aggradation of sand resources by the TE-48 structures have lowered the quantity available to nourish the Raccoon Island Spit and the shorelines in the lee of breakwaters #3-#6. Although tropical and extra tropical storms are the primary cause of the large spit volume loss, the sequestering of limited sand resources by the TE-48 structures has impacted volumes on the downdrift spit and in the lee of breakwaters #3-#6.

Implications

The TE-48 project is a great overview of breakwater function in an area with sand scarcity. Although the TE-48 breakwaters were built to similar dimensions as the earlier TE-29 project, the TE-48 breakwaters were placed closer to the shore causing the latter structures to be more efficient at capturing and retaining sand resources. The placement of the groin and the TE-48 breakwaters has raised shoreline contours in their lee. However, downdrift impacts to the spit occurred immediately after construction. In 2008 the spit was breached and its shoreline transgressed substantially during Hurricane Gustav. Since this tropical event, the breach has increased in width, and the length and area of the spit have declined while the TE-48 structures

continue to aggrade their shorelines. In addition, the western TE-29 breakwaters have recorded sediment deficits since TE-48 construction. Therefore, the TE-48 project is an interesting illustration of hurricane impacts and coastal structure function.

Evaluating the Shoreline Protection Functioning of Three Divergent Constructed Oyster Reef Structures in Terrebonne Bay, Louisiana

Glen Curole
Coastal Protection and Restoration Authority of Louisiana

TE-45 is an eight year CWPPRA demonstration project that compares the effectiveness of three dissimilar structures in reducing erosion rates and enhancing oyster production. This presentation will give emphasis to the shoreline protection and elevation change aspects of this study through year five of the project. The project is distributed along three shoreline reaches (Reach A, Reach B, and Reach E) and is located on the northwestern shore of Terrebonne Bay. The shoreline protection features are ReefBlk, A-Jack, and Gabion Mat structures. All three features and paired reference areas were installed at all reaches in 91 m lengths. Shoreline position data were analyzed to estimate shoreline changes in the project and reference areas. Pre- and post-construction shoreline positions were determined by digitizing aerial photographs. Elevation grid models were created using topographic and bathymetric survey data. These models were used to determine volume changes in the project and reference areas and to estimate the settlement of the constructed structures. All the structures have reduced erosion rates along their shorelines and outperformed the reference areas. However, the shorelines behind the Gabion Mat treatment documented the lowest erosion rates during all post-construction intervals and transgressions in the lee of this structure were very minor. Moreover, this structure was significantly superior at reducing erosion rates when compared to the ReefBlk and A-Jack structures. The volume change data show that all shoreline reaches recorded volume losses during both pre- and post-construction intervals while the structure settlement data reveal that the Reach E structures incurred the greatest settlement and have the lowest vertical profile. The results of this project suggest that the Gabion Mat structure is the most effective shoreline protection structure at the TE-45 reaches to date. Therefore, the Gabion Mat treatment seems to show the greatest promise as a shoreline protection structure.

Implications

There are several implications of this study that will benefit future coastal restoration projects. First of all, the experimental design of the TE-45 project was well conceived and comprehensive. The project has three different structure types and paired reference areas at three different reaches and site specific pre-construction data. Therefore, the project was designed to have statistically relevant data and definitive conclusions. Secondly, all the structures significantly reduced erosion rates when compared with pre-construction and reference data. Hence, these structure types should be considered when planning a shoreline protection project. Next, the Gabion Mat treatment functioned at a significantly higher level than the other treatments in reducing the erosion rates. Essentially, no erosion occurred behind the Gabion Mat treatment while post-construction shoreline transgressions behind the ReefBlk and A-Jack treatments were temporally similar. As a result, future Gabion Mat

shoreline protection projects should be planned along shorelines experiencing high erosion rates.

Modeling Louisiana's Coast Plant Communities

Scott Duke-Sylvester

University of Louisiana at Lafayette

We have developed a computational model of plant community dynamics. Our model is designed to eval uate the effects of management actions on the structure and health of Louisiana's coastal wetland plant communities. A number of projects have been initiated or proposed to preserve and restore this ecosyst em while still allowing the area to support Louisiana's economy. These projects involve both modificatio n of the flow of freshwater as well as restoring natural wetlands and barrier islands. Evaluating the long t erm effects of these projects is complex and involves numerous moving pieces operating over an extensive and diverse landscape. The situation is further complicated by projected changes in sea level ri se and climate change associated with global warming. Our model is one of a larger set of linked models that combined the efforts of several research groups. Using hydrological conditions projected by the link ed hydrology models, we are able to evaluate the effects of anthropogenic and climatic changes on Loui siana's wetland plant communities. Unique features of our model include replacing the division of wetla nds into coarse groups defined by salinity conditions with species level responses to environmental conditions and extending the spatial scale of modeling to encompass the entirety of Louisiana's Gulf coa st.

Regressional Analysis Supports Usining Models to Determine NRDA Claims for Small Coastal Oil Spills

Dwight R. Dunk
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The Oil Pollution Act of 1990 (OPA 1990) is a comprehensive law regulating oil spills in U.S. waters. OPA 1990 established strict liability for oil spill damages, replacing the limited liability rule in previous laws. OPA 1990 allows damages for natural resources, the focus of this research. Federal regulations define two natural resource damage assessment methods – Type A computer models, and Type B scientifically rigorous studies. The regulations limit using models to up to $100,000. At that threshold, trustees need to either: limit claims to the threshold, advance a claim using Type B methods, or not pursue a claim; yielding a class of spills defined by the threshold at the lower limit to an undefined upper limit equaling Type B assessment costs, the dollar limit at which it becomes cost efficient to advance a claim. Those three options yield economically inefficient outcomes. My research hypothesis is that an empirically derived simplified natural resource damage assessment model adequately determines natural resource damages from coastal oil spills above the current regulatory limit.

Statistical analyses of closed NOAA natural resource damage cases for coastal oil spills (N=53) were conducted to test my hypothesis. The multiple regression model showed a high correlation (r=0.901) and robust explanatory power (r^2=0.828) of the dependent variable, ln damage claim, by the ln of five explanatory variables: gallons spilled, miles of shoreline oiled, human use compensation, protected natural resources harmed, and region (N=20, F=13.471,d.f. 1=5, d.f. 2= 14, p<0.001). This finding shows that this multiple regression model explains approximately 83% of the settled claim value, from a dataset with a median damage claim of $3,304,166. This regression analysis supports using Type A models to monetize resource damages above the current regulatory threshold.

This research supports raising the Type B threshold to $2.3 million, which correlates to fifty thousand gallons based on a median damage claim of $47/gallon of spilled oil. Raising the threshold would increase the number of natural damage claims using Type A assessments and advance the OPA 1990 goal by: more efficiently internalizing oil spill externalities, reducing spills *ex ante* through increased precautionary investment, and increasing the deterrence value of the law; and concurrently provide additional funds to Trustees to finance coastal restoration projects.

Opportunities for Community Adaptation at the Local Level through Ordinances, Codes, and Design

Katrina Durbak
Louisiana State University Coastal Sustainability Studio

Louisiana coastal communities face tremendous uncertainty from increased flooding, wind damage, environmental degradation, and climate change impacts. Local governments can effectively mitigate these risks and build resilience, through a deliberate use of zoning and subdivision ordinances, building codes, design guidelines, and incentive programs. The planning tools and policy instruments a community uses can provide efficient and cost effective ways for integrating hazard mitigation plans and actions, and preparing for environmental risks and the impacts of climate change.

This presentation will focus on how to apply these policy instruments, traditionally used for guiding development and environmental management, to build resilience by reducing the physical vulnerability of a local coastal community. Utilizing existing planning instruments for new purposes allows a community to draw on locally appropriate policies and avoid entirely changing their local approach to land use management.

In addition to offering ideas for how to adapt local planning tools and policy instruments to build resilience, this presentation will highlight specific examples from coastal communities around the U.S.

Implications

This presentation will provide ideas about how local governments, planners, and policy makers can use their regulatory and incentive-based approaches to land and water management to also address hazard mitigation and climate adaptation needs. Knowledge of these options will be directly useful for local government staff and policymakers, to implement in their communities to build resilience. Furthermore, knowledge of local options is helpful for regional policy-makers to be aware of how regulatory and funding decisions at the state and regional levels play out locally.

Citizen-led Monitoring of Barataria Basin Impacts and Restoration

Scott Eustis[1], Shannon Dosemagen[2]
[1] Gulf Restoration Network, [2] Public Laboratory for Open Technology and Science

The Gulf Future campaign seeks to involve coastal communities in the restoration decisions that affect their daily lives and future livelihoods. Based on community knowledge of past failures and successes in restoration projects, there is a need for citizens most vulnerable to wetland losses to monitor wetlands and wetland restoration projects.

Public Lab, along with contacts at the Gulf Restoration Network, has been inventing a technique for low-cost, collective aerial photographic mapmaking of the impacts of the BP Oil Spill in Northern Barataria Bay since 2010. Public Lab seeks to enable the adoption and adaptation of new and unfamiliar tools to the production of locally relevant environmental data. In 2013 and early 2014, Public Lab is planning a second round of citizen training in aerial photographic techniques in order to monitor of the Barataria wetlands area, a socially and ecologically important region of the Gulf Coast impacted by the BP oil spill, using low-cost, open-source technology.

Implications

Across the Gulf, there is a need for monitoring of wetland projects, as well as industrial impacts. Training communities most affected by industrial impacts in low-cost aerial monitoring techniques can assist in building a record of pollution events, as well as documenting and communicating the vulnerability of protective wetlands.

The spread of such techniques can solve an array of environmental monitoring dilemmas, from reducing the cost of traditional aerial photography, to improving the resolution of map data, to avoiding the interference of summer clouds that hamper higher altitude photography. The spread of such techniques into the hands of citizens most vulnerable to impacts ensures that communities can capture environmental changes as they see them, for the purposes of communication and advocacy.

Innovative Approach to Future Conditions Basin-Side Modeling for Diversion Projects: LCA Medium Diversion at Myrtle Grove with Dedicated Dredging Project

Mark Hammons
FTN Associates, Ltd.

The LCA Medium Diversion at Myrtle Grove with Dedicated Dredging project is a proposed Mississippi River diversion into the Barataria Basin near Myrtle Grove. The project objectives are to provide fresh water, nutrients, and sediments to degraded marshes in the mid-Barataria Basin. Dedicated dredging of sediment from the Mississippi River will complement the diversion feature.

We performed basin-side hydrodynamic, salinity, and water temperature computer modeling of the Barataria Basin to support the selection of a preferred alternative operation plan for the diversion. Existing 2D RMA finite element models of the Barataria Basin were modified and calibrated for use in this study. Four project alternatives and a no-project alternative were modeled, each at target year 1 (TY1) and target year 50 (TY50), representing conditions 1 year and 50 years from the beginning of the project, respectively. Each TY50 scenario was simulated with high, medium, and low sea level rise estimates, resulting in a matrix of 19 different simulations. The duration of each model simulation was three years, representative of high, average, and low Mississippi River water years. The RMA model output will be used as input for fisheries modeling and wetland value assessments to evaluate the project alternatives.

We used ArcGIS to apply rules-based modifications to the model geometry to represent projected future basin conditions, incorporating expected subsidence rates, landscape changes, and diversion land-building at TY50. To accomplish this, a methodology to reproduce the finite element mesh in ArcGIS was developed. Rules based on projected future conditions were then imposed on the mesh, modifying both nodal elevations and element material properties (e.g., roughness) automatically. Consequently, the model geometry for each TY50 scenario was unique and highly detailed. This presentation will describe the techniques used for future conditions geometry modifications as well as practical lessons learned from the modeling study.

Implications

Future conditions modeling has always been one of the challenges of the coastal restoration planning process. One of the innovative aspects of this study was the use of ArcGIS to alter TY50 model geometries based on rules derived from estimated subsidence rates and projected landscape changes. The GIS applications developed for this study enabled TY50 conditions to be simulated without extensive manual edits to the model geometry. This innovation has implications for modeling of future conditions for coastal restoration projects.

The large number of scenarios and long duration of the model simulations posed significant challenges to data management, QA/QC, and results visualization. Lessons learned from these challenges will be discussed.

Inventing Coastlines: The patented technologies of artificial marine habitats and coastal infrastructure.

Richard L Hindle
Louisiana State University

This presentation discusses the history, design, and patented technologies of artificial marine habitats integrated with coastal infrastructure. The research presented here emphasizes the evolution of artificial marine habitat technology in the international patent archive, and provides an overview of pilot projects and peer-reviewed literature. Integration of artificial habitats with coastal infrastructure is an emerging area of expertise within the field of ecological engineering, and has created exciting opportunities for multidisciplinary long-term research. Pilot projects in Sydney Harbor, Elliot Bay Seattle, the Port of Vancouver, Thames Estuary, and other locations globally have revealed the benefits of artificial habitat creation on intertidal infrastructure and established important precedents for project implementation. Technology plays an important role in the evolution of these hybrid systems, and patent submissions for related technologies have increased rapidly. Technological innovations mirror advances in applied research, spawning an array of innovative solutions to the decline of urbanized marine habitats. This presentation provides an overview of innovation, technological trends, and research in this emerging sector and also makes suggestions for collaborative research and design opportunities in Louisiana. Coastal infrastructure such as seawalls, groynes, breakwaters, bulkheads, jetties, levees, and other forms of armoring have typically been associated with habitat fragmentation and loss of biodiversity, yet Innovative materials and structures such as biologically active concrete, buoyant ecosystems, blue lungs, ecological blocks, and prefabricated seawalls with integrated habitat are rapidly shifting this paradigm. The design and implementation of these hybrid systems creates new collaborative research, business, and design opportunities with the potential to improve solutions to essential coastal infrastructure.

Implications

Coastal urbanization is a global phenomenon brought into stark relief by climate change, sea level rise, and ongoing development pressure. This convergence of factors necessitates the continued renewal and addition of coastal infrastructure such as seawalls, revetments, groynes, breakwaters, and jetties to stabilize and secure urbanized coasts and shores. New ecological engineering technologies make it possible to integrate habitat with coastal infrastructure, adding ecological value to important infrastructure. The implementation, design, research, and business opportunities associated with ecologically engineered infrastructure create many opportunities for collaboration between public and private institutions in the state of Louisiana.

Development of an Interactive Suspended Wave Screen as a Shoreline Protection Alternative to Rock with Applicability in Weak Soils

Josef Hoffman, Beau Tate, Mitch Andrus
Royal Engineers & Consultants, LLC (Royal)

Royal is currently performing design-build services for a shoreline protection demonstration project for the Natural Resources Conservation Service (NRCS). The goal of this project is to test a non-rock alternative to shoreline protection that can be supported by low bearing-capacity soils and attenuate wave energy – thereby reducing, eliminating, or reversing shoreline erosion – over a twenty-year design life.

To meet the objectives of the NRCS for this project, Royal developed a concept for a series of pile-supported panel structures to serve as non-rock breakwaters. The breakwater panels are perforated to allow tidal exchange, while still providing a barrier for dissipating wave energy. To assess how these structures will perform in the marine environment under wave attack, Royal has performed site-specific three-dimensional numerical modeling of the structures with the software code Flow3D to evaluate wave energy transmission through the panels, total wave force on the structure, and estimated scour depths around the piles. Critical system parameters were optimized with the numerical model, including the panel porosity, wall spacing, and the submergence depth of the panels within the water column. Additionally, Royal performed the structural engineering for the panels, connections, and supports to achieve both a structurally sound and easily constructible product. The majority of the structures themselves will be pre-assembled to reduce the amount of time required for field installation.

The wall panels for this system are made of marine-grade ultra-high molecular weight polyethylene (UHMW-PE) and encased within pre-fabricated steel jackets for connection to circular steel pile supports. All steel components are coated with marine-grade polymer coating for corrosion and UV resistance. All member, connection, and foundation elements are designed to resist lateral impact from the 90th percentile design wave over a 20-year design life.

The U.S. patent for this product is pending, under the ownership of Integrated Shoreline Solutions, LLC.

Implications

Traditional rock breakwaters are an effective means of shoreline protection, but have limited applicability in weak soils without expensive foundation preparation. Alternative shoreline protection structures that can perform well in harsh wave climates and poor soil conditions, while promoting cross-shore hydrodynamic and sediment exchange, have substantial implications for holistic environmental protection and restoration.

Long-term Wetland Surface Changes in the Atchafalaya Delta

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The Atchafalaya Delta complex provides insight into the delta processes that can be expected with future sediment diversions. As newly-forming land in the Atchafalaya Delta expands seaward, older natural islands coalesce, become increasingly insulated from physical extremes, and wetland structure/functions approach those of mature headland areas. In the Atchafalaya Delta proper, the surface changes in elevation, soil properties, and vegetation community have been monitored since the early 1980's on three natural islands, which comprise 101 plots arranged on longitudinal and transverse transects that span a cumulative distance of 3,000 m. We evaluated decadal soil elevation and accumulation of mineral and organic matter, including carbon and nitrogen. While the inter-annual soil elevation changes were greater than 2 cm/yr across the delta, the median decadal (1998-2009) rate of soil elevation increase was 1.0 cm/yr (mean = 1.1 ± 0.8). Intermediate elevation wetlands below mean sea level experienced the greatest increase in elevation over the recent ten years, concomitant with an expansion of persistent emergent plant communities, which currently occupy an elevation range of -30 to 35 cm MSL. Elevations higher in the tidal frame support enhanced soil organic matter accumulation, and delta-wide soil organic matter has increased by an order of magnitude since the 1980's (0.6% to 5.6% carbon). Assuming a nominal accretion rate of 1 cm/yr, current burial rates ($g/m^2/yr$) can be predicted for different soil fractions: mineral (4,330), organic (445), carbon (200), and nitrogen (15).

Implications

Delta soil building processes are structured by wetland elevation within the tidal frame and proximity to physical energy. While mineral sedimentation accounts for the bulk of accretion, there has been a substantial transition in elevation compensation through organic matter burial. Persistent clonal plant species have rapidly expanded creating a positive feedback on the retention and subsequent infilling of lower elevation basins within the islands. Results from this study provide a long-term view of deltaic elevation-accretion patterns that can be used to develop a delta sediment budget and improve projections on the pace of delta growth.

Putting the Canary Back in the Coal Mine: Crickets and Ants in the Saltmarshes Post-Macondo Blowout

Linda M. Hooper-Bui, R. Strecker, B. Hesson, G. Soderstrum, M. Accardo, D. Aguillard, E. Thompson, and X. Chen.

Our research has shown that insects and spiders are good bioindicators of environmental pollution from catastrophic oil spills. Even when environmental toxicologists are unable to measure volatiles in samples of the oil pollution, we observed impacts that indicated that volatiles were active on insects and spiders during times when the marsh sediment was exposed to insolation and bacterial degradation. We conducted a 'common garden' experiment also known as an *in situ* bioassay where we placed insects in floating cages 20m from the streamside edge of oiled and unoiled saltwater marshes. More than two years post-spill, insects in cages in oiled marshes exhibited a greater mortality than those in unoiled reference marshes indicating that volatile compounds, possibly from the emulsion, plays a role in insect/spider mortality in oiled marshes. In spill season 1 (2010), ant abundance had decreased by 66% in oiled marshes when compared to reference marshes. By September 2011 or spill season 2, ants in oiled areas had decreased by 97%. In 2012, we were unable to find mature ant colonies in heavily oiled areas and found more than 50 colonies in similar unoiled areas. Only incipient colonies were found in oiled areas in April and May 2012. By July 2012, all but two of those incipient colonies had perish

International Barrier Island and Beach Restoration Experiences

Adam Hosking[1], Kevin Burgess[1] and Mark Glennerster[1]
[1] CH2M HILL, Swindon, UK

The restoration of barrier islands is literally the *front line of coastal protection and restoration* efforts in Louisiana. It is critical that this aspect of the restoration program is successful to provide the foundation for all other elements behind them. In order to *optimize barrier island restoration*, current approaches in Louisiana could benefit from a critical review of international experiences seeking opportunities to improve local practices.

This presentation will provide a brief overview of the *variety of types of beach and barrier island restoration projects* the authors have worked on internationally. These will include projects based purely on beach nourishment, along with those involving a range of structures, also those designed to restore an existing beach/island and those where a new feature was being created.

The basis for restoration project design will be discussed. The importance of a detailed *understanding of coastal processes* will be illustrated, including aspects such as the influence of shifting offshore islands and bars on wave focusing and onshore processes. Also, a *clear articulation of the goals* of each restoration project is vital to the design, including ecosystem benefits, storm resilience and sustainability.

Island and beach design options range from heavily hardened structures in deep water through to nourished beaches with no structures and regular maintenance, with various alternatives between. In the context of the *goals of island restoration on the Louisiana coast*, the rationale and benefits of the generic options will be discussed, in particular, approaches to *improving project resilience*. For example, the incorporation of hard structures to strengthen the island and reduce the likelihood of significant loss during a storm event will be reviewed.

Implications

This presentation will introduce conference delegates to experiences gained from designing coastal projects for a range of purposes worldwide, to highlight design options and applications. The lessons learned from these projects will be directly translated into recommendations for the design of barrier island and beach restoration projects, to offer possible improvements to current design approaches. The recommendations can be immediately incorporated into ongoing and forthcoming projects, to aid deliver of project goals with cost-effective, sustainable, designs.

Delft3D modeling of hurricane-induced surge and waves in coastal Louisiana

Kelin Hu[1], Q. Jim Chen[1], and Hongqing Wang[2]
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The Louisiana coast is extremely susceptible to the impacts of frequent tropical storms and hurricanes because of its unique geometry and position within the Gulf of Mexico. When tropical cyclones approach the coast or make landfall, they often generate very large storm surges and high wind waves. As these events are significant drivers of coastal land change, the ability to accurately predict and model these phenomena is important.

We focus our numerical modeling on Hurricane Isaac, a category 1 storm that made landfall in Louisiana on August 28, 2012, and induced a storm surge greater than 4 m in upper Breton Sound. Simulations of hurricane-induced surge and waves were executed with the Delft3D model. First, an improved asymmetric hurricane wind model integrated with background winds was employed to generate surface wind fields. The waves and surge at the open boundaries were provided by a gulf-scale Delft3D simulation, and two sets of meshes covering southeastern Louisiana were generated for nesting computations. Two fully-coupled Delft3D modules, Delft3D-Flow and Delft3D-Wave, were used to hindcast the water levels and waves, respectively. Vegetation effects were explicitly considered by a sub-module in Delft3D. The spatial distributions of the maximum surge heights, maximum significant wave heights, as well as their temporal variations were examined, and model results agree well with field observations. The effects of hurricane forward speed, wind intensity and vegetation properties such as height and stem density on storm surge were also probed by a series of numerical experiments. The study has been supported in part by the NSF and NOAA.

Implications

The fully-coupled wave-surge model based on Delft3D and validated by field data is capable of simulating both storm surge and wind waves on wetlands, which will help understand the potential impacts of tropical storms and hurricanes on the coast. These simulations are also crucial for planning and designing hurricane protection and coastal restoration projects in Louisiana and the northern Gulf of Mexico.

Probability Distribution of Wave Heights Attenuated by Salt Marsh Vegetation during Tropical Cyclone

Ranjit Jadhav[1] and Q. Jim Chen[2]
[1] FTN Associates, [2] Louisiana State University

Zero-crossing wave heights, obtained from the field measurement of random waves propagating through salt marsh vegetation (*Spartina alterniflora*) during Tropical Storm Lee (2011), were analyzed to examine their probability distribution. Wave data (significant wave heights up to 0.4 m in 0.8 m depth) were collected over a two-day period along a 28 m transect using three pressure transducers sampling at 10 Hz. Wave height distribution in the marsh was observed to deviate from the Rayleigh distribution. The observed probability densities of the larger wave heights were reduced significantly by vegetation, producing wave heights lower than those predicted by the Rayleigh distribution. Using existing vegetation-induced wave attenuation formulations, a special form of two-parameter Weibull distribution is derived for wave heights in the inundated wetland. The scale parameter of the distribution is theoretically shown to be a function of the shape parameter, which agrees with the measurements, effectively reducing the proposed distribution to a one-parameter type. The derived distribution depends on the local parameters only and fits well to the observed distribution of wave heights attenuated by vegetation. Empirical relationships are developed to estimate the shape parameter from the local wave parameters.

Implications

For the effective use of random wave forcing in the design of coastal structures, statistical properties of wave parameters such as wave height are critical. These statistical properties can be readily obtained analytically if the underlying probability laws are discovered. This paper presents, for the first time, the probability distribution of waves attenuated by salt marsh. Significant financial resources have been committed to coastal restoration and protection in the State of Louisiana. Presence of salt marsh vegetation is one of the main features of our coastal landscape. Protection measures built in this environment invariably encounter waves attenuated by salt marsh. It is imperative that we understand the nature of this attenuation and adapt our designs accordingly. This has implications on project effectiveness, design costs and risk assessments.

Building Resilience Community by Community

Pamela Jenkins[1], Tara Lambeth[2], Maggie Olivier[2]

[1]University of New Orleans, [2]UNO/CHART

Preparation for a disaster in coastal Louisiana requires a multi-faceted approach. However, much of the continuity training in preparedness focuses on business operations in an applied and practical format. While business continuity plans place an emphasis on how to bring businesses and organizations back, this training is often done separate from local communities. Throughout our own work with organizations, we operationalize continuity as part of a larger framework about community and resilience.

Over the last three years, we developed an approach to understand community continuity and resilience. The framework allows for the voices of community members and local organizations to define, from their own perspectives, what factors strengthen their resilience. Through interviews and focus groups with small business owners, faith based organizations and nonprofit personnel; we created a model for understanding and teaching about community continuity.

From the data, we found a wide variety of responses to short and long term recovery, preparedness and mitigation. Community continuity, from their perspective, includes disaster recovery, hazard mitigation, and risk management. The literature on disaster recovery underlines the importance of adaptation and flexibility in the face of disaster. From our interviews and focus groups, the themes that emerged reflected not only adaption and flexibility, but the ability of an organization to have a larger vision.

Implications

Coastal Louisiana holds a unique place in the national landscape. The varied cultures, peoples, and places are often characterized as resilient, simply because they remain no matter how battered by events. This study shows that community continuity is complex ranging from infrastructure policies to small group interactions. Moreover, this model of community continuity builds on the local knowledge of practitioners combined with national best practice. This model shows how planning can include continuity and resilience in ways that are approachable. Community continuity means responding and preparing for disaster socially, structurally, economically and environmentally. To be resilient is to be adaptive and sustainable, and requires an extensive planning processes. Our iterative, community driven model for understanding and teaching community continuity allows for specific, local factors within a state and national context.

Adaptive Management of the Central Terrebonne Marshes

Marc Johnson, PE[1], Cliff Li[1], John Jurgensen, PE[2], Ron Boustany[2]

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A broad area of the Central Terrebonne marshes are currently suffering some of the highest loss rates in the state. Previous attempts to stem the losses in the area included a project designed to increase Atchafalaya River flow into the basin; however, computer model results showed that implementation of all of the project features would increase water levels within the basin and further exacerbate marsh loss.

Consequently, the management approach adapted to attempt to limit the salinity influx from the Gulf. The Bayou Dularge Ridge historically restricted the Gulf influence into the marshes; however, a man-made cut through the ridge, originally intended to let small boats pass from the Gulf into Lake Mechant, has increased over the years to a depth of 36 feet and width of 900 ft. The expansion of "Grand Pass" has allowed a substantial alteration of salinity and hydrology in the Central Terrebonne marshes. A proposed structure across Grand Pass that restricts flow into the area will reestablish historic hydrologic and salinity conditions by reducing the artificial intrusion of Gulf marine waters and moderating salinities in the Central Terrebonne marshes.

The project will also increase the Atchafalaya influence in the area by modifying the current structure located in Liners Canal north of Lake Decade to increase freshwater introduction to Lake Decade and providing maintenance dredging at Minors Canal to maintain optimal freshwater conveyance from the GIWW into Lake Decade.

This presentation will show how numerical models were calibrated, verified, and used to size a structure to be placed in the Grand Pass to limit the influx of saline Gulf waters in areas to the north and to verify that the other components will work as intended. Calibration and verification were done during the high flow Morganza Spillway operation during the summer of 2011.

Implications

Some components of a marsh management strategy, although intended to help reduce marsh loss, may work against the goal of marsh restoration. Sometimes managers must adapt and change the approach. Numerical models are valuable tools that can be used to determine if proposed structural alternatives will act as intended in restoring large ecosystems.

Leveraging GIS Tools and Existing Data to Develop a Master Stormwater Plan for Lafourche Parish

Lee Beshoner, PE[1], **Marc Johnson**, PE[1], James Ledet, PE[2]
[1] FTN Associates Ltd., [2] T. Baker Smith LLC

In 2010, Lafourche Parish decided to develop a Master Stormwater Plan for 33 watersheds that were drained by pump stations and one additional large watershed that was drained by gravity into the tidally-influenced northwest Barataria Basin. The project team developed hydrologic models using GIS to classify land use and compute runoff curve numbers and then computed 25-year runoff hydrographs for each watershed. The team used these hydrographs as input to dynamic wave unsteady flow models developed to determine maximum water surface profiles for existing conditions for each of these areas using the HEC-RAS and UNET programs. UNET was used because, unlike HEC-RAS, it supports pump stations as downstream boundary conditions.

After soliciting input from the public and pump operators, the models were then used to identify or confirm drainage system problems and bottlenecks, to determine what improvements provided the most "bang for the buck" for the main channels in the drainage system, and to serve as the basis for a "living" model that will be used to determine the impacts of proposed development in watersheds in the future.

This presentation will show how the GIS-based hydraulic software HEC-GeoRAS and use of Lidar data allowed for much more detailed features to be represented in the models than otherwise would have been available using traditional methods. It will also show how GIS was used to depict results for easy interpretation by the public using color coding and how the model is being used as a tool to limit the impacts of development on flooding within the basins.

Implications

The use of GIS-based tools and existing state-wide Lidar data can be used to develop much more detailed features to be represented in the models than otherwise would have been available using traditional methods, thereby increasing model accuracy.

Marsh Management and Bird Responses in southern Vermilion Parish, LA

Erik I. Johnson[1], Karen Westphal[1], Timmy Vincent[1], Molly Folkerts[2], and James L. Ingold[2]
[1] Audubon Louisiana,[2] Louisiana State University in Shreveport

The Paul J. Rainey Audubon Sanctuary protects 26,000 acres of intermediate and brackish marsh in southeastern Vermilion Parish. Restoration projects include strategic placement of water-control structures, use of a small dredge to rebuild broken marsh operated by one or two people, and prescribed late summer fires in a three-year rotation to improve nutrient circulation and soil quality. Avian responses to these management activities are not well documented so we conducted a two-part study to evaluate the effects of marsh management on 1) the nesting success of Green Herons (*Butorides virescens*) and 2) the relative abundance of secretive marshbirds. We located 242 Green Heron nests between May and July 2013 and revisited a subset of nests every 1-3 weeks, estimating nest success to be 51.1% (n=184), lower than reports from elsewhere in their range. This may be driven by the relative limited nesting habitat, which is primarily along spoil banks and may have increased nest predation risk. We also assessed the relative abundance of secretive marshbirds following prescribed fires using the standard Conway point count protocol from April to May 2012 and 2013. The relative abundance of King Rails (*Rallus elegans*) and Soras (*Porzana carolina*) were 1.8x and 3.0x higher, respectively, in marshes burned during the previous late summer compared to those burned before the previous late summer. Other species, like Seaside Sparrows, Least Bitterns, Common Gallinules, and Marsh Wrens, showed no difference in relative abundance between burned and unburned marshes and instead responded to other habitat-related variables, such as marsh heterogeneity and amount of open water. As we continue monitoring Green Heron nests and conducting fixed-location point counts in upcoming breeding seasons, statistical treatments at survey points will change with rotating fire management, increasing our power to disentangle complex interactions between marsh vegetation composition and fire and responses by birds.

Implications

Land managers and restoration planners often make decisions based on the best available science. For coastal marshes, vegetation responses to stressors and restoration tools have help drive this decision-making process, but rarely are the effects on higher trophic levels quantified, particular to bird communities. We present research on the effects of marsh management and manipulation on a group of particularly understudied birds, collectively known as secretive marshbirds, as well as Green Herons, one of the least studied wading birds in North America. Our results reveal important trade-offs to birds in an extensive intermediate and brackish marsh landscape of southern Vermilion Parish. In particular, secretive marshbird relative

abundance in response to prescribed fires either increased or did not change in the breeding season following a fire. On the other hand, canalization may decrease nest-success for shrub-nesting species along spoil banks, like Green Herons, by focusing and increasing predation risk.

Southwest Feasibility Study: a Reluctant Partnership

Norwyn Johnson
Coastal Protection and Restoration Authority

Louisiana's struggle to protect and restore our rapidly disappearing coast is directly linked to our ability to partner with the Federal government in the implementation of coastal projects. To best leverage state funding and resources we must pursue all available avenues, including traditional water resource project authorization and appropriations from the U. S. Congress. The Southwest Coastal LA Feasibility Study (SW Coastal) is an effort to secure needed protection and restoration for an often neglected area of our coast, the Chenier Plain. As the local sponsor for the study the CPRA has a key role in project planning and design, although this role is probably a lesser one and not as timely as envisioned in Water Resources Development Acts.

The CPRA and the U. S. Army Corps of Engineers (Corps) have partnered on the study since January 2009. After nearly five years of progress and setbacks the study is building momentum for completion, with a Chief of Engineers Report scheduled for September 2014. While a six-year study is not to be emulated, the SW Coastal timeline is years ahead of other feasibility efforts such as Morganza-to-the-Gulf and West Shore, Lake Pontchartrain. Coordination and cooperation between the partners has fluctuated since inception of the study due to inconsistent funding, territorial or process disputes and other issues, but has generally been good. While the State has withdrawn from several other feasibility efforts with the Corps, it has continued to support and promote the SW Coastal effort.

Some lessons learned from the study include: 1) it is preferable to have total study costs funded up front or at least secured with continuous annual funding; 2) balancing the 50/50 cost share between partners is a challenge; 3) the inclusion of NER and NED features in a study is unique and has required examining them individually and then combining them at the end; 4) Corps Vertical Team involvement needs to begin early in the study process; 5) important, decision making meetings should always be the face-to-face type; and 6) report writing must begin early, actually starting from the beginning of the study.

The SW Coastal study benefited from earlier Corps and CPRA efforts, most notably the State's 2012 Coastal Master Plan. Appropriately, the restoration and protection measures included in the report's final array of alternatives are in concert with the Master Plan.

Implications

A cost-shared feasibility study brings together a considerable amount of expertise from each agency. This expertise, coupled with positive interagency cooperation and

coordination can yield significant benefits in the form of efficiencies and schedule milestones. As expected, however, agency preferences and dogma can often conflict with and impact such efficiencies.

The SW Coastal study has the potential to achieve authorization of much needed protection and restoration measures for the region. With the current fiscal climate in Washington, it may be one of the last examples of a CPRA/Corps joint study. Upon authorization, the project's champions in the U. S. House of Representatives and Senate will be called on for yeoman duty in securing appropriations and construction funding.

Measurement of wave-induced current velocity in Salt Marsh of Terrebonne Bay, LA

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A field measurement was carried out in Terrebonne Bay, Louisiana to investigate physical processes that contribute to the wetland loss in south Louisiana. Wetlands have provided many important ecosystem services, but unfortunately these valuable habitats are vanishing with a rapid pace. Human alternations, sediment shortage, storm passages, and wave activities are among the main contributors to the wetland loss in the area. To find out the role of cold-front passage on wetland losses, waves and currents in the saltmarsh wetland as well as incident waves in the adjacent shallow water were measured during a cold-front passage. A bottom-mount pressure transducer was used to measure the incident waves 47 m seaward of the marsh edge, while on the marshland, two Acoustic Doppler Velocimetries (ADVs) along with three staff wave gauges were deployed to measure the waves and velocity along a 3 m shore-normal transect landward.

Totally, 44 hours of data associated with a cold-front passage were analyzed. Wave parameters and flow structure on the marshland with respect to the incident and local wave conditions were investigated. An analysis of the time series data on the marsh showed that the wave height and the mean water depth on the marsh were following the same trend, indicating a depth-limited breaking controlled the wave height at the marsh edge and on the marsh. Based on the measured data, relationships between the incident waves and current and orbital velocities as well as relationships between local waves and longshore and cross-shore currents on the marshland were developed. It is shown that the current velocity on the marsh is related to the local wave energy. Further investigation revealed the 3D nature of the flow inside the wetland, and the presence of undertow flow in the velocity profile was found.

Implications

Measurements of waves and currents are common in the near shore, but are rare in coastal wetlands. An accurate prediction of the current and orbital velocity on the marsh from the incident waves is desirable. The developed relationships in this research between the current velocity, the current direction and the wave orbital velocity with the incident and local waves provide useful tools to estimate the current and orbital velocity inside the wetlands by using the measured and simulated wave data. This unique dataset can be used in studies that require the information about the velocity in the wetland near the marsh edge.

Economically efficient flood protection standards for The Netherlands

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The Netherlands is vulnerable to flooding from the sea and from large rivers, such as the river Rhine. Dikes have been built throughout the ages to control the risk of flooding, often in response to a flood disaster. The current standards for flood protection were part of the work by the (first) Delta Committee following the major flood of 1953, which struck the south-western delta of The Netherlands (Deltacommissie 1960). The standards were partly based on an economic optimization of investment costs and the benefits of damage reduction some 50 years ago (Van Dantzig 1956). Since then, the potential damages have increased manifold. Flood protection standards and are therefore in urgent need of updating. Such an update is one of the objectives of the policy study 'Flood protection for the 21st Century' (In Dutch: *Waterveiligheid 21e eeuw*, abbreviated as 'WV21'). The new flood protection standards will soon be decided by Parliament. The decision will amongst others be based on a cost-benefit analysis and an analysis of casualty risk.

The cost-benefit analysis uses a dynamic optimization model (*OptimaliseRing*) to determine an optimal investment strategy for dike reinforcement (Duits 2011). The model is based on the earlier work of Eijgenraam (Eijgenraam 2005, 2006) The strategy minimizes the discounted investment cost and residual flood damages over a long time horizon. The impacts of economic growth and climate change on flood risk are taken into account. The cost-benefit analysis uses information on flood probabilities, flood consequences and the costs of investments in dike reinforcement. Consequences consist of direct flood damages, but also include an estimate of immaterial damages (based, among other, on the value of statistical life) and indirect damages. From the optimal investment strategy, economically efficient flood protection standards for the coming decades are derived. To make uncertainties explicit, a Monte Carlo analysis was conducted on top of the cost-benefit analysis (Kind 2011; Gauderis et al. 2012).

In 2011, the CBA was finalized (Kind 2011). The main conclusions is that, from an economic point of view, the current safety standards for the coastal areas (1/4000 tot 1/10000 per year) are sufficiently high and that the especially the safety standards for dikes along the major rivers (1/1250 to 1/2000) should be increased. The Monte Carlo analysis showed that this is a robust conclusion. To reach the optimal safety standards, an investment of several billions of euros is needed. The CBA methodology won in 2013 in Texas the prestigious Franz Edelman Award for outstanding achievements in Operations Research.

Restoring Freshwater Wetlands – Keeping Saline Waters at Bay for LaBranche

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Two of the cornerstones of restoration projects in coastal Louisiana are the reintroduction of sediment and freshwater. Recent studies and modeling of the LaBranche wetlands provide insight into the broader coastal issues associated with reducing salinity to create sustainable restoration.

The LaBranche Wetland has experienced significant degradation with the loss of vegetation and conversion of wetlands to open water due to stresses on the system. Over the past fifty years, 6,000 acres of wetlands have been lost. Efforts to restore certain areas have occurred by filling open water areas with lake sediment to create or restore wetland substrate, rock armoring the shoreline against erosion, and plugging/constricting some canals. Additionally, past water management efforts have included the construction of gated water control structures, which have seldom been operated in accordance with their original intent. While many actions have been taken in the area, to date, a single overall integrated management strategy has not been developed or implemented for the system.

In an effort to be able to effectively evaluate the cumulative impacts of the numerous proposed and on-going restoration projects in LaBranche, a numerical model was developed to assess cumulative benefits and impacts. The numerical model is a tool that is able to quantify potential benefits and impacts and provides a better understanding of the interactions between marsh creation, fresh water re-introduction and water control structure components. As such, the model provides the foundation to study various potential management and restoration scenarios. The circulation patterns in the wetlands and the wetland responses to additional freshwater inflow, man-made alterations to flow paths and structural changes to the system were evaluated. Salinities can be reduced within the wetland system by essentially two main methods: 1) Prevent higher salinity waters from entering the system, and 2) Reintroduce additional fresh water into the wetland.

Implications

River diversions for the reintroduction of freshwater to the basins and marsh restoration by infill of open waters are two main techniques to restore the wetlands of coastal Louisiana. A good understanding of both these processes and their interaction is key to sustainable strategies. The LaBranche Wetland provides us unique insights on these two processes and how to achieve their balanced interaction on a macro level.

Improved watershed management throughout the delta is contingent on the effective ability to reintroduce freshwater and sediment into the watershed for wetland and ecosystem restoration as reduced salinities have the potential to enhance vegetative diversity and historic habitat functions. The current modeling in LaBranche Wetland aids in the broader understanding of the balance between structural salinity intrusion reduction measures and freshwater reintroduction.

Assessment of present and future safety level of dikes and levees

Meindert Van
Deltares

Assessing the safety of dikes and levees can be a time-consuming activity. Recently, a semi-automated toolbox called DAM (Dike strength Analysis Module) has been developed in the Netherlands and applied to thousands of miles of Dutch dikes in various regions of the country, each having their own set of safety standards. In addition, it has also been applied successfully in a pilot along the Mississippi River, north of Vicksburg.

For any dike strength analysis, four steps can be identified:
1. Collection of basic data – more and more available from GIS;
2. Data interpretation and preparation for calculation – this requires experience and a consistent approach;
3. Calculations using various types of models, depending e.g. on the failure mode, quality of the data and the engineer involved;
4. Analysis of results and further visualisation and communication.
Usually, most time is not spent on the calculations, but in the preceding step: interpretation of the data. The current practice often prohibits a large-scale, systematic approach involving a significant area.

DAM gives a rationalisation of the second and third steps, by enabling a uniform approach, avoiding individual mistakes and differences in interpretation of equal data, leading to better results. Applications include:
1. Assessment of the current safety level;
2. Assessment of the future safety level from modified boundary conditions, like sea-level rise and increased precipitation;
3. Design mode: semi-automated determination of the required future land use to fulfill future requirements.
Experiences so far showed significant cost reductions and a dramatic increase of the quality of the results on a larger scale.

Depending on the adopted models, results can be presented in more traditional engineers' terms like Factor of Safety, or as a probability of failure.

Implications

With this new toolbox safety analyses, design exercises and impact studies for flood safety can be carried out in a cost-effective, consistent and rational way, fit to the local or regional situation. DAM provides a clear insight in the current and future safety of dikes and levees. The risk reduction by planned and alternative flood protection projects may easily be determined, as well as the adverse effects of climate change.

Cost savings so far also include a reduction in additional soil investigation costs, as DAM could provide a clear insight in what missing information could improve the results.

The Dynamics of Subterranean Flow in the Mississippi River Delta: How Waters Below the Surface Impact our Coastal Landscape

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A comprehensive understanding of the hydrology of the Mississippi River Delta is critical to developing plans to restore Louisiana's coast. To date, nearly all studies have focused exclusively on surface flows. In this talk we will show that there are large, and previously undiscovered, underground pathways by which water from the Mississippi River is transported to the wetlands and estuaries of the Mississippi River Delta. Results suggest that the total flux of groundwater to the coastal zone in the Mississippi River Delta averages 35,000 $ft^3\ s^{-1}$, and can exceed 100,00 $ft^3\ s^{-1}$ at high flow. We suggest that flow preferentially occurs through paleochannels, relict bayous, and other buried deposits of permeable and coarse grained material. These conduits were formed during the previous stages of the delta cycle, which occurred between 10^2 and 10^3 years before present. Flow is driven by the hydrological head difference between the river and the estuary, which is seasonal and can reach 5-8 m during floods. This talk will present data from hydrological budgets that show a large volume of water leaving the Mississippi River and a large, missing source of fresh water to Barataria Bay. We will show that water levels in wells across the delta plain fluctuate with the stage of the Mississippi River. Furthermore, geochemical data indicate advective groundwater flow, and that leachates from the sediments are entering the estuary. Finally, seismic data indicate the prevalence of paleochannels and other buried features that could carry flow. These results indicate an important coupling between surface and deep processes. Subterranean flows are one of dominant sources of freshwater to Louisiana's estuaries, can play a major role in influencing the salinity, biogeochemistry and ecology of Louisiana's coastal zone.

Implications

It is critical that scientist, planners, and decision makers understand how groundwater may impact restoration plans, and the physical and ecological processes that are sensitive to restoration. For example, groundwater flow from the Mississippi River can reduce stream power in the river and contribute to shoaling. Sand boils are a manifestation of groundwater flow, and threaten the stability of levees if left unattended. Our results suggest that groundwater is one of the largest sources of freshwater to the coastal zone, and as such influences the distribution and productivity of plants, fish and shellfish. Groundwater flow has

the potential to both remove nutrients from the river water and add them to coastal bays, thereby affecting patterns of eutrophication across the coast. Ultimately, an enhanced understanding of groundwater dynamics in the coastal zone will help scientists and planners develop better hydrological and ecological models, which is critical to advancing restoration science.

Hydrodynamic and Sediment Transport Modeling using *FLOW-3D* for Siting and Optimization of the LCA Medium Diversion at White Ditch

Randy Lagumbay[1], Hugh Roberts[1], John Richardson[1], Ehab Meselhe[2], Yanxia Ma[2], Hoonshin Jung[2]
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The U.S. Army Corps of Engineer (USACE) New Orleans District (MVN) and the Coastal Protection and Restoration Authority (CPRA) of Louisiana are in the process of designing a diversion channel that will deliver water and sediment to a receiving basin. In this study, a numerical model was used to identify the most promising location for the diversion based on the five intake locations (i.e., from River Mile 57.5 to 68.6) identified in the feasibility study, evaluate the best alignment and sill elevation for the diversion, and investigate how variations in the structure's design could affect its ability to capture sediment. The commercially available computational fluid dynamics (CFD) program known as ***FLOW-3D*** was used to construct the three-dimensional model and simulate flow and sediment transport in a portion of the Mississippi River and the diversion channel. The model was calibrated and validated using field survey data in the Mississippi River. Model studies were carried out in two steps. Steady-flow patterns for determination of design conditions were simulated and then the movement of sediment in the river and through the diversion was calculated. Using these data, the sediment water ratio (SWR) in the outfall channel was computed. In these analyses, the location and design that maximized SWR in the outfall channel was considered to be best. Model results show that the effectiveness of the diversion is affected by the intake location, alignment, sill elevation, and size of the structure. At the conclusion of the study, placement of the structure was recommended and optimum design of the structure was made.

Implications

This study demonstrates the ability of three-dimensional computer flow models to provide useful information for hydraulic structure design. This diversion is intended to reduce net wetland loss in the White Ditch project area between the Mississippi River and Oak River. To achieve this, water and sediment from the Mississippi River will be provided to the White Ditch project area using a controlled diversion structure. Given that the sediment concentration in the Mississippi River varies significantly according to location, it is important to identify the best location for the diversion and optimize the design of the structure so that maximum sediment concentration can be delivered to the project area. As a result, the supply of water and sediment to the impacted area would help prevent net wetland loss.

Where Will Boaters Dock? Information to Increase Post-Storm Resilience of the Commercial Fishing Sector in Vermilion Bay

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In the Vermilion Bay region of Louisiana, no formalized protocol exists for tying down commercial fishing vessels to prevent them from becoming water-borne debris during a storm. After Hurricane Rita in 2005, 18 shrimp boats were grounded on private land on both sides of the Vermilion River. Federal contracts to remove debris took several years to process, with the last commercial fishing boat removed in 2012, seven years after the storm. The lack of publicly-owned waterfront property on the Vermilion River translates to bureaucratic barriers for vessel owners to reclaim possession of their boats. In addition, each shrimp boat is a small business operation and stays out on the water to shrimp until the last moment, resulting in chaotic tie-down procedures before a hurricane hits. Project research seeks to identify the size of the commercial fishing fleet that needs to be accommodated across the Vermilion Bay region, the physical characteristics of the adjacent waterways that might provide safe tie-down locations, and the pre-existing communication protocols with deep draft industries that could apply to the commercial fishing sector. Methods include conducting surveys to quantify the number and size of boats needing inland harbor space, collecting channel width and bathymetric data for the Vermilion River, and working with nearby industrial ports to understand pre-storm preparation activities in order to develop an appropriate communication plan for commercial fishing vessels. Up to this point, the project team has found that approximately 100 commercial fishermen, mostly from the Vietnamese community, are competing for space in the Vermilion River when a storm approaches. The ultimate project goal is to develop a virtual parking lot and widespread communication plan for commercial fishing vessels throughout the Vermilion Bay region to increase community resilience after a disaster. This project is ongoing, and conclusions will be shared at the conference.

Implications

This research has implications for coastal community resiliency policy and planning. When fishing vessels sustain damage during a storm, the effect ripples upstream by impacting small business fishermen, seafood processors, and wholesale distributors. Loose vessels also create destructive barriers on roadways and bridges, disrupting total commerce. This project contributes to community resiliency by organizing a plan for vessels to moor during a storm, ensuring that those vessels sustain little damage and return to business as soon as possible. The process of determining the size of the problem and cooperating with multiple partners to address the need for a solution, while considering cultural barriers, presents a model of engagement that can be implemented as coastal restoration activities require cultural and economic adaptation.

Pelican Reproductive Ecology on Barrier Islands: Considerations for Restoration

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Colonial seabirds are dependent on coastal islands for nesting sites. Many of these islands are the targets for ongoing restoration efforts, the implementation and outcome of which have major implications for seabird populations. Since 2008, we have studied brown pelicans (*Pelecanus occidentalis*) nesting in the Isles Dernieres. This work suggests the presence, but not the species, of woody vegetation is an important determinant of successful pelican nesting. With this basic knowledge, a target for restoration might be development of woody vegetation on barrier islands. However, storm surge from two hurricanes demonstrated that pelican behavior and the differential salt tolerance of woody vegetation can have profound effects on the future utility of the islands as nesting colony sites. On an island where the woody vegetation was dominated by marsh elder (*Iva frutescens*), all elevated nest sites were lost and the island was subject to rapid erosion; these effects did not occur on islands consisting of a mixture of black mangroves (*Avicennia germinans*) and marsh elder. Furthermore, nest site fidelity behaviors resulted in the island with deteriorated nesting habitat becoming an ecological trap for the brown pelicans. Birds continued to return to nest there, but experienced greatly reduced nest success compared to a colony on an island which retained woody vegetation. However, although a mixed community of woody plants, including black mangrove, was important for the viability of one island as a nesting site, such communities were not sufficient to entice pelicans to use an island. Other factors, such as pelican behavior, and predator presence, which can be influenced by restoration decisions, can play a major role in whether pelicans use an island. Our experiences in trying to establish new pelican colonies suggest that the success of restoration strategies is likely to be site specific.

Implications:

The “field of dreams” hypothesis (“if you build it, they will come”) is often applied to the restoration of wildlife habitats. Providing a substrate for vegetation to colonize, or planting vegetation that is known to be used by a species, is probably insufficient to ensure a successful restoration project. Without careful appreciation for the role of both the behavior and habitat requirements of a species, the presence of apparently high quality habitat does not assure its use by a species. Furthermore, for coastal wildlife with considerable island fidelity or limited dispersal abilities, it is important that engineering considerations and vegetation composition be planned to create habitats that will be sustainable, or more realistically, at least viable beyond more than the next few storm events.

Hydrodynamic Energy Regimes in the Wax Lake Delta

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The evolution of the Wax Lake Delta is dependent on the river discharge, sediment load, tidal variations, weather induced water level fluctuations, and other longer term factors such as sea level change, subduction and compaction. In other words, aside from the sediment load and geological factors, most of these factors are related to hydrodynamic processes. Understanding of the hydrodynamic processes and related energy regimes is therefore a prerequisite of the understanding of how the Wax Lake Delta system works in its evolution. In order to address this issue and to quantify the hydrodynamic processes and related energy regimes, we deployed several instruments at the Wax Lake Delta and an adjacent bayou, which provided long-term measurements of water level, velocity, and salinity variations. A preliminary analysis of the large quantify of data allows us to quantify the energy regimes and describe the relative importance of tidal, riverine, and weather-related factors. In this presentation, we summarize the results encompassing most of the year of 2012 and part of 2013. During this time period, dozens of weather systems passed by the study area. Our analysis provides statistical information of hydrodynamic parameters at different stages of the weather system. The tidal and weather-induced flood and ebb as well as the rebound periods after winter storms are analyzed in detail. A spectrum analysis shows that tidal energy is usually less than 25% averaged over the length of a few months. Most of the remaining energy comes from the weather induced hydrodynamic response of the water, on top of the longer time scale annual river discharge variations. The energy distribution is also highly seasonal. The flood and subsequent drainage periods after an atmospheric frontal passage is not always symmetric. This may also hold some keys to the understanding of delta evolution. The hydrodynamic parameters quantifying the inundation-drainage process of the wetland and the suspended sediment concentration at different time stages, and advective transport of the sediment need to be combined together to determine the fate of the sediment in a very dynamic quasi-periodic but also event-dependent environment.

Implications

There are at least two approaches in determining the dynamical processes of the delta evolution: 1) measurements and analyses, and 2) numerical modeling. These two approaches are however not mutually exclusive. Measurements and analyses can provide detailed real conditions in a complex system that no model can replace because no existing models can reach even remotely close to the level of complexity of Wax Lake Delta. Models are only approximations and only part of the physical processes can be included. Observational data can provide valuable information for model validation. Our results can serve both purposes by providing understanding of the

physics and at the same time, verification of numerical models. One of our PhD. students is now working on a high resolution state of the art hydrodynamic model for Wax Lake Delta region which will benefit from the long-term observations, and later in turn, provide a more comprehensive picture of the hydrodynamic processes.

The Sedimentary Signature of Hurricane Isaac in Coastal Wetlands along the Western Edge of Lake Pontchartrain

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Abstract

Hurricane Isaac, a minimal category 1 storm, caused extensive economic damages to southern Louisiana in 2012 due to its large size, slow forward movement, and intense precipitation. Strong easterly winds across Lake Pontchartrain produced unprecedented flooding along the western edge of the lake, including the community of LaPlace and the forested wetlands between it and the lake. Cores and sediment samples taken in the vicinity of Frenier were subjected to loss-on-ignition, palynological, X-ray fluorescence (XRF), and grain-size analyses in order to identify and describe the sedimentological and geochemical characteristics of the Hurricane Isaac storm deposit.
Visual observation and short-lived radioisotope (^{7}Be) analysis identified a widespread layer of mud as resulting from the passage of Hurricane Isaac. The storm layer generally consists of a gray clastic layer overlain by a draped layer of laminated organic mud. The clastic layer probably represents the traction load delivered by the storm surge, and the overlaying organic mud the suspended load. The posited traction load consists of visually-distinct, large-grained clastic material, while the posited suspended load is characterized by increased concentrations of such marine indicators as bromine (Br), calcium (Ca), and sulphur (S) as well as increased concentration of pollen, and lower levels of such terrestrial metals as titanium (Ti) iron (Fe), vanadium (V), potassium (K), and chromium (Cr).
A similar sedimentary signature was found lower down in a core from ~1 km inland, indicating that similar flooding has occurred in the past. A multi-centennial length event history is being developed from longer cores extracted from the lake edge in order to evaluate the long-term risk of flooding for this location.

Implications

Although the study site has been impacted by a large number of tropical cyclones (Hurricanes Katrina and Rita in 2005, Gustav in 2008, and tropical storm Lee in 2011) during the recent past, the degree of flooding experienced along the western edge of Lake Pontchartrain caused by Hurricane Isaac is unprecedented in the historical record. Some segments of the public have identified the flooding as resulting from the construction of protection levees for the New Orleans area and are now calling for the extension of existing levees to protect Livingston Parish. Characterizing the sedimentological and geochemical signatures of the Isaac storm deposit permits the identification of ancient storm deposits in the sedimentary record, which can then be used to determine the long-term history of such flooding events. This, of course, will improve the ability of planners to evaluate the risk of future events and prioritize construction needs.

Town of Jean Lafitte and Lafourche Parish Comprehensive Resiliency Plans

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Communities across the US are increasingly confronted with the devastating effects of natural and man-made disasters. In coastal places, communities are grappling with how to plan for the future with sea level rise and the increased incidence of catastrophic weather. Specifically in Louisiana, the coastal communities have suffered a disproportionate number of culture-shifting disasters in the past 10 years. To increase resiliency in Louisiana, coastal communities are implementing innovative measures that require thinking outside the status quo community planning approaches.

We will discuss two communities in Louisiana's Mississippi Delta that have recently completed comprehensive community resiliency plans using strategies from the *Best Practices Manual for Development in Louisiana*. Although different in scale, both the town of Jean Lafitte and Lafourche Parish face the same risks inherent to living in the coastal environment — flooding, wetland loss, erosion, and subsidence – all of which have caused significant stress on the communities' economic and environmental assets as well as residents' overall quality of life. To prepare plans that address challenges and reduces risk, the communities not only took an in-depth look at their social and economic framework, but also paid special attention to geological structure, soil composition, hydrology and anticipated land loss. Analyses conducted for the two plans, along with diverse public engagement, guided the strategic community development to reduce current and future risks that threaten the communities' existence and limit future growth and vibrancy.

Implications

The two case studies highlight opportunities and challenges associated with living and working in the coastal environment. Using best practices from a variety of scientific and non-scientific disciplines that facilitate and encourage the comprehensive planning process, appropriate and scalable solutions to reduce present and future risks to the respective communities were developed. As resiliency planning is relatively new to our communities, the proposed abstract provides an overview of the resources and tools used to develop risk reduction development and redevelopment strategies that could be applicable elsewhere. Furthermore, the two case studies address how coastal communities are planning for changes along Louisiana's coast line due to current and future protection and restoration efforts.

Modelling primary production in a turbid estuary

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The growth of phytoplankton in many estuarine environments is usually regulated by the availability of nutrients and the underwater light regime. Phytoplankton is of great ecological value, providing the base of the food chain. In highly turbid stuaries primary production is likely to be limited by low underwater light intensity. Increased turbidity due to man-made morphological changes may lead to reduced primary production by phytoplankton, and consequently to reduced food availability for higher trophic levels (zoobenthos, shell fish, fish and ultimately birds and marine mammals). An example of a highly turbid estuary is the Eems-Dollard Estuary (Wadden Sea, The Netherlands). Turbidity in this estuary has been increasing since 1950 or earlier, which possibly has decreased primary production. In order to understand system behavior and to provide knowledge for system management, extensive measurement campaigns were undertaken, combined with state-of-the-art numerical modelling. The impact of human activities on primary production is quantified using effect-chain modelling, in which a hydrodynamic model is coupled to a sediment transport model and a water quality and primary production model. The sediment transport module consists of a recently developed sand-mud model, which can quantify the dredging-induced long-term changes in turbidity. The water quality and primary production model explicitly simulates water quality and sediment quality as based on comprehensive sediment diagenesis. Effect-chain modelling is used to quantify historic changes in sediment dynamics and primary production, and to assess the effectiveness of measures mitigating turbidity increase.

Implications

Many estuaries are becoming increasingly turbid by human activities due to land reclamations, port construction, and deepening of navigation channels. Increasing our knowledge on the environmental impact of such developments, and developing tools to better quantify them, is essential for a more sustainable management of estuarine environments.

Tracer Technology: a Tool for Understanding Sediment Transport Processes and Determining the Pathways, Rate and Fate of Transport in Coastal Environments.

Jonathan K. Marsh[1] and Amy H. Parry[1]
[1] ETS Worldwide Ltd.

Movement and re-distribution of sediment, whether natural or man-made, can lead to significant changes and impacts to the coastal system and sensitive habitats due to changes in hydrodynamics and sediment dynamics including coastal erosion, turbidity plumes and burial of sensitive ecological communities. Working with sediments is an important element for many of the projects in the dynamic environment along the Louisiana coastal landscape. A thorough understanding of coastal processes is also an essential element of being able to accurately predict the impacts of future challenges faced along the coastline to reduce uncertainty and increase the possibility of finding sustainable solutions. Measuring and predicting sediment transport, often through numerical modeling, can be costly and in many cases the output is not able to predict the likely environmental impacts accurately as it is common for modeling to over-simplify the complexity of coastal systems with poor assumptions, omissions in model formulations, crude representations of boundary conditions and poor model calibration and validation data.

Over the past 20 years, ETS Worldwide Ltd. (ETS) has developed a unique tracer technology, which involves environmentally benign non-toxic fluorescent tracer particles. These particles are manufactured to mimic the size, density and where applicable the surface charge of a wide variety of target species including sand and silt sized sediments. ETS has successfully implemented these particles in over 85 sediment transport studies globally, including in Louisiana, and have demonstrated the effectiveness of the particles in determining and quantifying sediment transport pathways, rate and fate of transport in a variety of marine environments. The user friendly, versatile and cost effective technology has been reported as being able to answer questions that cannot be determined by other field measurements and modeling, and is an essential tool understanding small-scale sediment transport processes such as erosion, resuspension, advection, dispersal, settling and deposition.

Implications

The aim would be to introduce the tracer technology and describe previous applications and discuss potential future applications in Louisiana and how the tracer technology could improve the understanding of the complex coastline. Previous projects in Louisiana include working for the U.S. Army Corps of Engineers, New Orleans District, to assess the efficiency of dustpan dredging and the rate at which disposed material is returned to the Atchafalaya Bar Channel and assessing the efficiency of the Old River Control Structure during 'flushing events'. Future applications could include; validating models to assess the fate of silt from cuts in levee sediment diversions, assessing the efficiency and fate of material during agitation dredging, assessing the source and infill rates for borrow pits, determining sand movement and fate related to coastal erosion, nearshore placement and formation of Barrier Island to prevent erosion and beneficial use of sediments for habitat creation and coastal defence.

Assessment of Oyster Reef Development on Fabricated Gabion Mats, A-Jacks and Reef Blocks at CWPPRA Project TE-45, Terrebonne Bay, Four-Years Post Construction

Earl Melancon

Nicholls State University

CWPPRA Project TE-45 is located at three sites on the north shore of Terrebonne Bay, Louisiana, and consists of three fabricated shoreline protection structures, each in triplicate 300ft linear lengths: 2ft-tall ReefBlks (foreshore), 2ft-tall A-Jacks (shoreline), and 20ftx5ft Gabion Mats (onshore). This is an 8-year project and this presentation documents how oyster populations have developed 4-years post-construction. Gabion Mats contour the shoreline with sloping tidal elevations that produce an oyster population gradient across the length of the 20ft mats. Oyster density peaks at mid mat between 3-4m distance from the top and then begins to either slightly decline or become asymptotic. Approximately 32% consolidated oyster reef is present on the lower (seaward) half of the Gabion Mats. A-Jacks exhibited about 30% consolidated reef with no apparent significant differences in oyster populations based on where located on the structure; windward vs. leeward or top vs. side. ReefBlks, however, after four years are showing significant problems. At the two-year post construction assessment, ReefBlks were showing the greatest oyster reef development, but by years three and four had deteriorated and declined significantly. ReefBlks are progressively losing a significant amount of oyster shell, which is the foundation material within its structure. This loss of shell has produced large void (gap) spaces with resulting reduced live oysters and reef development. Where shell still exists in sufficient quantities, the ReefBlks have developed about 25% consolidated reef. It is hypothesized that trapped stone crabs within the structures are responsible for the loss by destroying shell as they feed on attached fauna, including small oysters; the possible synergy of environmental factors that created this situation will be discussed. According to the ReefBlk developer who owns the patent, over 3,000 have been deployed across the northern Gulf of Mexico with no similar type failures.

Implications

Louisiana's interior bay shorelines are experiencing high rates of erosion and marsh loss. There is significant dual benefit in lessening bay shoreline erosion with the use of fabricated structures that also have the ability to establish oyster populations. Oyster populations can continuously respond to changing environmental conditions such salinity, subsidence and sea level rise with continuous reef growth as the initially placed fabricated structures deteriorate over time. Oyster reefs can potentially become a living shoreline protector.

Retrofitting Communities through Planning and Design to be More Resilient

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In Louisiana, increased vulnerability to natural hazards demands innovative planning and design solutions to adapt our existing communities to be more resilient. Great opportunities exist to strengthen our communities, although these measures can require significant upfront investment, stress fiscal constraints, inhibit short-term economic development, appear redundant, and generate conflict amongst stakeholders. To address the complex nature of these challenges, emerging planning, design, and construction techniques, such as water resource management, home elevations, and innovative zoning, are being used around the world and in Louisiana to allow communities to adapt and address vulnerability, while maintaining the essential functions and culture of the place.

Today we are working not to seal communities off from risk but to better prepare them to bounce back faster, smarter and stronger after an event. But the application of "resilience" to planning can do much more than prepare our built environment for a difficult and unpredictable future; it can, in fact, catalyze positive change across many sectors and scales of a community. Changes that make communities more resilient to storms also benefit communities in terms of economic development and social stability.

This session will present the following topics related to community design and planning adaptation strategies that promote a community's strength in day-to-day operations, as well as post-disaster situations:

1. Techniques for re-designing existing sites;

2. Modification of land use regulations and financial incentives to encourage sustainable development in and around coastal and flood prone areas;

3. Case study examples of coastal communities that have successfully adapted progressive building and land use strategies to address risk while projecting economic growth; and
4. Results of a design charrette in Terrebonne Parish looking at a community resilience center in Dulac, a grocery store in Chauvin, and a fire station in Montegut.

Implications

Attendees will learn about innovative strategies that are being used to promote resiliency and how these strategies may be considered in their own communities. Specifically, attendees will learn how to assess the existing assets of a site or building; consider its flood hazards; consider the material and construction methods used onsite in the design of buildings and natural systems infrastructure; consider a building's use in relationship to two program scenarios, day-to-day community self-reliance program and post-disaster program; and finally how this type of analysis can result in appropriate design solutions for communities in high-risk areas. Within this framework the following issues will be broadly addressed: green infrastructure; alternative land uses; hardening public infrastructure; flood protection infrastructure; and windproofing and waterproofing of buildings.

Large-scale Coastal Restoration of Salt Marshes and Tidal Flat Ecosystems along the Arabia Gulf: Applying Principals of Adaptive Management

Jacqueline Michel, Linos Cotsapas, Jason Hale, Chris Cormack, Thomas Minter, Lincoln Smith

More than 20 years after the 1991 Gulf War oil spill released an estimated 10 million barrels of oil into the Arabian Gulf, almost 1,200 hectares of salt marsh and tidal flat habitats (of more than 2,000 ha surveyed) remained in a severely degraded state. Factors contributing to slow ecological recovery included clogged tidal channels, persistent ponding across the marsh plain, overgrowth of laminated algal mat, and other physical barriers to fauna and flora recruitment. Spatially variable but persistent oiling of marsh and channel substrate also played a role. Surveys were conducted in 2009 to prioritize sites for restoration and twenty large-scale restoration projects were conducted along the Arabian Gulf shoreline of Saudi Arabia. Overall restoration objectives were to increase the rate of ecological recovery rather than removal of contaminants. Project goals included: 1) increase suitable habitat for grazers and bioturbators; 2) reduce total petroleum hydrocarbon levels; and 3) improve physical processes that will reduce associated stressors. Therefore, the principle remediation activities include excavation of new or existing tidal channels, tilling of marsh surface to break up physical barriers, and transplantation of mangroves (*Avicennia marina*). In all, 163,000 m of tidal channels were excavated or refreshed to improve hydrology; 3,000,000 m^2 of marsh and flats were tilled to break up barriers as well as to release or further degrade trapped oil; 110,000+ m^3 of contaminated soils were removed; 105,000 mangroves were planted, with a total of 18,000,000 m^2 of salt marshes and flats remediated. Adaptive management was key to success; small studies were conducted to develop pilot projects, from which revised techniques were scaled up via demonstration projects. The scope of work for the large-scale restoration contracts reflected the accumulated knowledge. Each restoration project included a monitoring program, and a Multi-Metric Index was used to integrate up to 40 metrics to document and predict overall ecosystem recovery over time.

Implications

This presentation shows the importance of on-the-ground application of the principals of adaptive management when developing innovation restoration projects. Also, the use of the Multi-Metric Index has proven to be a valuable tool to both document past restoration progress and predict the trajectory of future habitat recovery.

Tree production and growth in tidal swamps and the operation of the Davis Pond Diversion during the Deepwater Horizon Incident

Beth A. Middleton

USGS

Abstract: Elevated salinity influences tidal freshwater swamps across the Gulf of Mexico, and upstream hydrologic alteration, sea level rise, and tidal inundation may increase the salinities of coastal swamps. While higher flow operation of the Davis Pond Diversion during the Deepwater Horizon incident was intended only to push oil away from the shorelines of Louisiana, long-term field studies conducted downstream of this diversion in Jean Lafitte National Historical Park and Preserve (JLNHP&P) also gave insight into how salinity stress in coastal forests might be reduced. Freshwater flows from the Davis Pond Diversion increased by 6 times the normal amount from May through October 2010. In this study, the annual rate of biomass production was measured using litter traps and root ingrowth cores. Stem growth of trees was measured with dendrobands. Tree production and growth increased by as much as 2.7 times for at least two years following this hydrologic event in JLNHP&P. In contrast, in Big Thicket National Preserve in Texas, trees in coastal freshwater forests died in high salinity environments during the drought of 2012. Tree growth is lower in higher salinity levels in tidal swamps along the Gulf Coast from Texas to Florida. Freshwater releases to reduce salinity levels may be a key conservation approach in the restoration and management of hydrologically-impacted swamps along the Gulf Coast. This project was funded by a National Science Foundation RAPID award and the U.S. Geological Survey Ecosystems program.

Water quality of Lake Pontchartrain during Bonnet Carré Spillway diversion and non-diversion years

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Controlled diversions of Mississippi River water into adjacent basins for wetland restoration may also alter estuarine surface-water quality. For example, the introduction of river water into Lake Pontchartrain during openings of the Bonnet Carré Spillway is known to substantially change the chemistry and ecology of the lake from a nutrient-poor brackish system to a nutrient-rich freshwater system (Mize and Demcheck, 2009). These effects were extensively monitored by the US Geological Survey in cooperation with the US Army Corps of Engineers during April-October 2008 and again during May-October 2011. Constituents monitored during both events included major inorganic ions, nutrients, chlorophylls, phytoplankton, and triazine herbicides. The initial water-quality response during both events was similar and characterized by dramatic shifts in inorganic constituents such as chloride and inorganic nitrate, but the subsequent response was primarily biological as the lake system adjusted to the influx of freshwater and nutrients. In 2008 and 2011 the phytoplankton community illustrated an extended response in the lake to the influx of river water. However, during 2011 the response of the algal community, particularly the blue-green algae, was much less pronounced than in 2008. One possible reason is the hydrologic differences between the two diversions. The 2008 diversion delivered a maximum of about 160,000 cubic feet per second (cfs) from April 11-May 8. The 2011 diversion delivered a maximum of 316,000 cfs later in the season (May 9- June 20) effectively moving the expected algal response eastward into Mississippi Sound.

Implications

Water-quality data in Lake Pontchartrain have most frequently been collected and assessed in response to spillway openings. Until recently, the lack of background water-quality data from the lake has hindered the assessment of the impacts of freshwater diversions. In response to these concerns, in 2013 water-quality was sampled during a non-diversion year. This presentation compares and contrasts water-quality conditions in Lake Pontchartrain during the 2008 and 2011 diversion years with the non-diversion year 2013, emphasizing the response of biological (primarily phytoplankton) communities. Response of the basin to diversions depends on the timing and magnitude of the diversions. Comparison with non-diversion years suggests that the lake may still show substantial shifts in physico-chemical and biological conditions, based instead on local inputs.

Accessing and Interpreting Coastal Restoration

Amanda Moore
National Wildlife Federation

Each year, thousands of people visit the Bayou Bienvenue Wetland Triangle viewing platform in New Orleans' Lower 9th Ward, making it one of the most visited sites on Louisiana's coast. In the fall of 2013, national conservation organizations and a local community organization unveiled museum-quality, interpretive, and interactive signage at the platform. This signage helps visitors understand what they are seeing when they look out over a cypress ghost swamp in the backyard of a community devastated by Hurricane Katrina. Visitors learn why the Bayou Bienvenue Wetland Triangle is important to the community, what has happened to the area in the last century, including impacts of the MRGO shipping channel, and how the Triangle serves as a portal to the larger issues facing Louisiana's coast.
This is an innovative project for coastal Louisiana restoration. While at the viewing platform, visitors have numerous opportunities to interact with the signs and the natural area around them. Visitors can scan a QR code with their smartphones and watch videos about Bayou Bienvenue and other coastal restoration projects. They can use their phones to sign an action alert or text "BAYOU" to donate to the CSED's coastal outreach program, call to listen to locals and coastal experts further discuss the coastal crisis facing Louisiana, and sign up for volunteer opportunities with local organizations.

This presentation will overview the sign project partnership, design and build process, obstacles, lessons learned, and impacts of the project to date.

Implications:

This project will help bolster coastal restoration efforts in southeast Louisiana, as well as grow national and local understanding and support for Mississippi River Delta restoration. By enhancing access to coastal areas, especially those in close proximity to large population centers, and creating clear and effective engagement opportunities for support and involvement in coastal restoration efforts, interactive signage projects like the one in the Lower 9th Ward can build robust public support for coastal restoration efforts in the Mississippi River Delta. This innovative and inclusive project can serve as a demonstration for signage projects across the coast that can highlight priority projects in need of restoration.

Eco-Geomorphologic Evolution of the Brazos River Delta in the last 10,000 years: A Case Study of the Texas Upper Coast

Juan Moya, Elizabeth Spalding, Naomy Perez

Atkins North America, Austin, TX

The coastal evolution of the Brazos River (BR) in the last 10,000 years has had a regional influence in different geomorphologic aspects of the coast, including substantial changes in river and estuary morphology and location (planform). The river deltaic paths of the BR migrated west as far as 18 miles as seal level reached the current location we know today. Several ecosystems had to adapt to the migration of the deltas along the fluvial and the estuarine systems. The specific transition from river to estuarine morphological changes can be dated and reconstructed including the habitats that got adapted to the new morphologic regimes beyond the coastal zone.

Geologic records of the Brazos River area (Blum and Aslam 2006; Anderson 2007; Blum 2013) show that about 8,000 years BP the sea level approached the coast almost as we know it today and the rivers were forced to drop a large amount of sediments as result in order to adapt to the new base level. Deep gorges and channels were completely filled during this period including the paths of the BR and other rivers, where the previous fluvial morphologies that lasted almost hundreds of thousands of years were completely covered by this new sediment accumulation/deposition that included river migration, leveling of alluvial plains, dynamic avulsion, and delta channel extension. A new set of estuarine morphological features and ecosystems resulted as this coastal sedimentary accumulation progressed creating unique ecosystems such as the Columbia Bottom Lands, barrier island marshes, seagrasses, deltaic swamps, etc. The location of the new coastal habitat that covered the previous BR eco-systems can be observed today. In recent years, the impacts of human development and industrial infrastructure have impacted these “new” natural habitats created in the last few thousand years.

This presentation shows how the evolution of the coastal eco-systems can be dated since geology, geomorphology and ecosystems are interconnected on the areas next to the BR delta and estuaries. Specific techniques to restore these coastal ecosystems will have to consider the evolution of these fluvial/estuarine/coastal geomorphologic features in order to be successful in the short- and long-term.

This presentation shows the specific fluvial geomorphologic evolution that is unique to the BR Texas upper coast. The eco-geomorphologic concepts presented show how the geologic and geomorphologic controls need to be understood in order to maintain a balance between the ecological services and the natural conditions of rivers, estuaries and barrier islands.

Beyond just sea level rise: incorporating climate into coastal wetland vulnerability assessments

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Along the Gulf of Mexico coast, climate greatly influences coastal wetland ecosystem structure and function. The coast spans two relatively dramatic and ecologically-relevant climate gradients: (1) a winter temperature gradient; and (2) a precipitation gradient. Ecologists have long noted that macroclimatic drivers regulate coastal wetland ecosystem types in the region (e.g., mangroves, salt marshes, tidal salt flats). However, quantitative climate-coastal wetland relationships have not been investigated at the regional scale. We used historical climate data (1970-2000), coastal wetland coverage data, and alternative future climate scenarios to develop distribution and abundance models for the region. We identified winter climate-based thresholds that separate mangrove forests from salt marshes. We also identified precipitation-based thresholds that separate vegetated wetlands from non-vegetated wetlands. Our results highlight the importance of incorporating climatic drivers (i.e., temperature and precipitation) into coastal wetland vulnerability assessments along the Gulf of Mexico. In Louisiana, incorporating winter climate is especially important since relatively small changes in the intensity and frequency of extreme winter events could result in landscape-level mangrove replacement of salt marsh.

Implications

The long-term benefits of coastal restoration and protection will be greatly influenced by future changing conditions. Resource managers are often asked the following two questions: (1) How will climate change affect coastal wetlands and their ability to support fish and wildlife habitat and other important ecosystem goods and services?; and (2) How can we improve efforts to sustain the natural and cultural resources provided by coastal wetlands for current and future generations? Incorporating climatic drivers (i.e., temperature and freshwater availability) into coastal wetland vulnerability assessments will help coastal wetland scientists and resource managers better address these questions and plan their restoration and protection efforts accordingly.

Planning and the Pursuit of Resilience in Post-Katrina Louisiana: An Examination of Parish-level Attitudes and Actions

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Following the devastation of Hurricanes Katrina and Rita in 2005, Louisiana communities, left vulnerable, looked to leaders to aid in the rebuilding effort. State officials responded by formulating a 50-year regional plan entitled Louisiana Speaks, thereby creating an opportunity to introduce comprehensive planning to those Louisiana communities which have been traditionally slow to adopt planning principles.

Concentrating on the parish (county) level, this study explores whether this effort has led to greater acceptance and broader adoption of comprehensive planning. Using survey responses of parish planning leaders, combined with recent demographic data, the research examined whether there has been an increase in planning measures during the seven years following the 2005 hurricanes and subsequent emergence of Louisiana Speaks. Examination of these questions sheds light on the extent to which experiences associated with the 2005 hurricanes and the subsequent outreach efforts to encourage planning for long-term community resilience may have changed the culture of land-use planning in Louisiana.

The results show an increase in overall planning measures throughout Louisiana, specifically an increase in rural parishes adopting comprehensive planning. Prior to 2005, comprehensive planning was adopted almost exclusively by residents of urban centers. The findings also point to a growing trend of parishes framing comprehensive planning as a means to achieve greater resilience. This suggests a shift in public support for planning in Louisiana from traditional urban growth planning to new measures that may help communities reduce vulnerabilities to future, large-scale disturbances. The findings yield insight into the conditions under which planning is more likely to be embraced by community stakeholders, and how traumatic events like Hurricanes Katrina and Rita can introduce a window of opportunity for new planning efforts.

Implications

This study explores the belief that uncertainty following traumatic events can open windows of opportunity for change, especially in communities that have been traditionally opposed to similar influences. Historically, Louisiana has been slow to adopt comprehensive planning; however, the hurricane season of 2005 gave planning professionals an opportunity to open dialogue with communities about the importance of planning, especially for increased

resilience to future disturbances. Louisiana residents appear more accepting of resilience planning than traditional land-use planning, and professional planners should consider community and stakeholder attitudes when asking for support for future planning efforts.

The Atchafalaya River Basin: State of the Science and Opportunities for Conservation and Restoration

Bryan P. Piazza
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Like many large river systems the Atchafalaya River Basin (ARB) provides ecosystem services (biodiversity, flood control, carbon storage, navigation, oil and gas resources, forest, fish and wildlife resources) that have been used extensively by humans as well as ecosystem services for which there are few developed markets (e.g., carbon sequestration, nutrient reduction). As a consequence of its value, a number of anthropogenic modifications have created largescale changes in the ARB for flood protection, navigation, and resource extraction. These modifications have altered systemwide and local hydrology and created a system that is potentially unsustainable, due to a number of issues, including habitat conversion and largescale water quality problems.

Even with modification, the ARB is locally, regionally, and globally important. It contains almost 405,000 ha of uninterrupted forest, wetlands, bayous, lakes and coastal delta, is a biodiversity hotspot of global significance and contains the largest remaining stand of coastal baldcypress left in the US. Its building delta is unique to the Louisiana coast and serves as a model for coastal restoration. These facts have spurred a movement for conservation and restoration of the ARB and an opportunity to provide comprehensive science-based solutions and progressive watershed management strategies.

This talk summarizes the current state of science in the ARB and describes work TNC is doing to advance land protection, science-based decision making, and hydrologic restoration by providing tools for engaging stakeholders and incentivizing conservation.

Implications

The ARB has begun to take a centerpiece role in the larger coastal management and water resource use issues in Louisiana, and is now discussed in terms of its role in coastal restoration, hurricane protection, coastal hypoxia, potential future nutrient/carbon marketing, and agricultural water supply. Future decisions for conservation and restoration in the ARB will need to be made inside of this larger management framework, which will require expanding science, management structures and increasing stakeholder constituencies. Our goal is to provide support for ongoing and future efforts to restore and manage the ARB inside of this increasing management framework by providing objective assessments, innovative conservation, and scientific research, with a particular focus on decision-making and stakeholder relations.

The Louisiana Freshwater Assessment Project: Science-based Decision Support for Water Resources in Louisiana.

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Louisiana is a water state. With over 125,000 miles of rivers, bayous, and streams and abundant annual rainfall, water has been and will continue to be important to our economy, culture, and fish and wildlife resources. The future sustainability of Louisiana's natural resources, its drinking water, and economic development, will be underlain by assurance of a high quality and sustainable freshwater supply. While Louisiana's water wealth has been taken for granted, evidence is beginning to suggest that continued abundance of fresh water in Louisiana may not be a foregone conclusion, and decisions made regarding freshwater resources (e.g., residential and industrial development, water transfers and sales) will affect citizens, economic development, fish and wildlife, and coastal resources.

These factors illustrate the need for sustainable water planning in Louisiana – a task that is just beginning. While the end result of water planning is unclear, it is imperative to have quality scientific information and science-based decision support regarding, among other things, status and trends of surface and groundwater resources, river and stream flow, current and future water use, sources and locations of freshwater threats, and linkage of freshwater and coastal systems.

We describe the Louisiana Freshwater Assessment (LFA), an evaluation of watershed health, including landscape integrity (i.e., land use and cover, floodplain connectivity, channelization), water quality, and biological health (i.e., trends in species diversity indicators,) of Louisiana's watersheds. We also describe: statewide surface-flow modeling and linkage with existing groundwater models to simulate hydrologic interactions between surface waters and deep aquifers. Lastly, we preview a suite of streamflow metrics and decision-support apps that represent measures of hydrologic resilience, alteration, stream health, and the impact of groundwater pumping on surface water flows.

Implications

The LFA is intended to 1) draw attention to the status of Louisiana's freshwater resources; 2) facilitate large-scale, science-based water planning in Louisiana; and 3) provide a powerful and user-friendly tool for any stakeholder (e.g., policy- and decision-makers, resource managers, local watershed conservation groups, and the general public) to develop freshwater science and conservation strategies, prioritize freshwater conservation, and evaluate the effects of current and future water use and watershed development proposals. By fully integrating this system with the Gulf of Mexico Resilience Decision Support Tool, another freely-available online

mapping system developed by TNC, we aim to promote water management decisions that are consistent with coastal resources and coastal restoration efforts in Louisiana.

Louisiana's Water Innovation Cluster: Is It Ready for Global Competition?

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Horizon Initiative Water Committee
Greater New Orleans Foundation/Idea Village *Water Challenge*

The rapid growth of Louisiana's coastal restoration science and technology assets is paralleled by the growth of business resources to fulfill myriad project needs. In the public sector, the responsibility and processes for implementing projects are clear, but in the private sector, roles are distributed, speculative and unclear. Many institutions and organizations in Louisiana seek to further develop the state's research, education, engineering and related restoration assets into a globally competitive set of industries with exportable expertise and products that help the state capitalize on its water challenges. Globally, similar efforts are identified (and often branded) as water clusters. This presentation explores the phenomenon of the development of water clusters by public-private partnerships and initiatives nationally and internationally in a comparative analysis of where Louisiana stands.

We posit that many opportunities exist for Louisiana to define powerful components of the water sector, and to develop a unique and influential water cluster that embraces many technologies not previously connected in any other state or country. But this undertaking requires leadership plus a statewide culture of innovation, and the responsibility for developing Louisiana's water cluster is in a nascent stage. In the short term, the cluster is growing in a *de facto* manner. Whether this will produce a truly globally competitive water cluster is a question that remains unanswered.

Implications

The development of a far-reaching, innovative, accessible and inclusive water cluster initiative has potential to strengthen coastal restoration efforts by: streamlining communications; expanding opportunities for innovation; building a strong network locally and nationally in support of projects and funding; reducing redundancy and improving efficiency; and by celebrating and branding Louisiana as a globally important water research and technology leader. It has potential to be a connecting resource across nearly unlimited sectors, with primary impacts in infrastructure, education, business and community development, industry, disaster management and resilience, health, the environment, culture, and tourism. If successfully implemented, Louisiana's water cluster could prove to be as unique and influential as its music, food and *joie de vivre.*

Evaluation of Louisiana Barrier Shoreline Restoration Strategies and its Applicability in Damage Assessment

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CPRA and CEC conducted a region-wide study to evaluate performance and qualitatively identify benefits of Louisiana's barrier shoreline restoration projects to system sustainability. Results of evaluation spurred recommendations for applications including:

Utilizing shoreline change rate data, establish background erosion rates for input into post-storm damage assessments and computation/quantification of storm related erosion

Utilizing near-term erosion rates and land loss rates, determine of advanced fill and additional marsh acreage components of future restoration project design templates;

Validate method developed within study for utilizing LiDAR data to compute land areas of barrier shorelines and compute marsh elevation changes between surveys by comparing these data to settlement plate monitoring data; and compare results to predicted design curves to assess project performance (marsh elevation changes over time);

Incorporating criteria for barrier shoreline breaching developed through cross-shore modeling of individual project designs and near-term erosion rates, predict potential for breaching of individual barrier shoreline segments;

Improving Barrier Island Value Assessment of Wetland Value Assessment (WVA) Model by incorporating additional benefits of barrier shoreline restoration projects unaccounted for in WVA model, as well as including synergistic impacts of related projects and societal, cultural, and institutional benefits not currently considered in WVA model; and

Improving Barrier Island Comprehensive Monitoring work plan including increasing survey domain to fully enable tracking of sediment transport pathways throughout period of analysis; correcting survey data sets to common vertical datums / reference geoids, collecting vegetation assemblage, succession, and cover area data to calibrate and improve future WVA analyses; conducting bathymetric surveys and hydraulic measurements of inlet channels and deltas to develop system-wide sediment budget; and improving marsh elevation change monitoring to enable comparison of these data to design predictions to improve understanding of marsh platform evolution over time.

Implications

The State's Master Plan focuses a strategic effort on restoring barrier shorelines and creating and sustaining marsh and wetland habitats. Applications of this study will improve the science

and understanding of barrier shoreline and marsh creation projects, improve project monitoring to enhance future planning and design efforts, and enhance the longevity and sustainability of the system through and save significant financial resources derived from improved project performance.

Sediment Distribution in the Wax Lake Delta-Marshlands: Implications to River Diversions

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Coastal researchers and managers now generally agree that river diversions are the best methods of preserving and reclaiming Louisiana coastal plain land. However, it has become clear in recent years that the Mississippi River cannot provide the quantity of sediment needed to offset growing coastal plain accommodation space. A reduction of available Mississippi River sediment, an increasing rate of sea level rise (~ 1 mm/yr over the last 7 kyrs and ~ 3 mm/yr today), and continued subsidence are the primary causal factors of this critical situation. These conditions dictate that riverine sediment resources must be used wisely in order to make a significant impact on stabilizing existing wetlands and building new land.

The Wax Lake Delta (WLD) is referred to as a model for expected response to river diversions. Currently, > 50% of suspended sediment available to the Lower Mississippi River is delivered to the coast through the Wax Lake Outlet (WLO) and Lower Atchafalaya River Outlet (LARO). Field measurements (ADCP) of water discharge to Atchafalaya Bay during the peak of the 2013 flood were 4555 m^3/s at the mouth of the WLO and 3673 m^3/s at the LARO. A surprising 18% of this combined discharge (1495 m^3/s) arrives in the bay through marsh channels (7.5 % from Big Hog Bayou). Even with strong flood discharge from marsh channels (currents > 120 cm/s), flow is reversed during the high water prefrontal phase of most cold front passages (flow reversal velocities >70 cm/s). Measurements (Be^7 and feldspar plots) of overbank sediment accumulation from the marsh along Big Hog Bayou indicate significant accretion (up to 6.8cm) over the 2-year monitoring period. Additionally, Cs^{-137} profiles of vibracores indicate an average of > 1 cm accretion/yr over the last 50+ years with higher bulk densities and vegetation biomass than other freshwater marshes outside the influence of the Wax Lake and Atchafalaya deltas. The synergistic relationship between river floods and cold front passages provides a natural mechanism for distributing suspended sediment to marshlands adjacent to river diversions. However, river diversions in the up-river parts of interdistributary basins should benefit the most from these cold-front related processes.

Implications

The land-building and associated marsh stabilization potential of river diversions is largely dependent on location. Results of this study suggest that cold front passages have the potential to force suspended sediment into surrounding marshlands by water level setup and flow reversal in marsh (tidal) channels during the prefrontal period. Natural processes of sediment distribution should be considered when selecting river diversion sites.

Adaptive Management of Large-Scale Ecosystem Restoration

The Big Picture: An Analysis of Institutional Structures

Estelle S. Robichaux
Environmental Defense Fund

There are numerous, on-going, large-scale ecosystem restoration efforts around the United States, most of which attempt some form of adaptive management – California Bay-Delta, Chesapeake Bay, Columbia River, Everglades, Great Lakes, Platte River. With the initiation of these efforts, generally funded through federal-state partnerships, comes the creation of a governing institution, whether unique or collaborative.

Based on a review of the primary literature, this research will start by providing an overview of the physical characteristics and environmental issues of select large-scale ecosystems, followed by an assessment of the associated institutional structures. The analysis of institutional structures will focus on the functions of adaptive management within these institutions. More specifically, I will seek to answer questions such as:

What form does adaptive management take within this program? Are stakeholders actively and purposefully engaged in a consensus-building and decision-making process? For instance, in the Platte River Recovery Implementation Program, stakeholders not only participate in the decision-making process but also are also able to vote along with federal and state agency stakeholders. In most other instances, such as in the Chesapeake Bay, only government or other official entities have a spot on the governing boards.

To what level is adaptive management passive or active within this program? That is, does the adaptive management strategy within this restoration effort embrace the "learning by doing" mantra by actively probing the ecosystem to learn more about it and its system responses, or is "adaptation" simply a response to undesirable conditions? For programs such as the Platte River and Everglades, where there are hypotheses that have been prescribed in management plants, what is the status of these assessments?

Implications

As Louisiana moves forward with implementing its plans for coastal restoration, this critical analysis of established large-scale ecosystem restoration efforts will provide valuable lessons about state-federal partnerships, collaborative institutional structures, stakeholder involvement in decision-making, and options for adaptive ecosystem management.

Passing Vessel Effects on Shorelines and Wetlands

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Large vessels traveling within navigation channels often cause hydraulic forces, imparting significant erosion on nearby shorelines. These forces are generated because the vessel has a large cross-sectional area relative to the channel, allowing limited area for displaced water to travel from the front of the vessel to the rear. Three powerful phenomena occur during this displacement: transverse stern waves, return-current, and divergent waves.
The understanding of these phenomena in a perfectly constricted channel has been well studied and documented. However, in many coastal engineering projects the guidance for perfectly constricted channels is not directly applicable. For instance, it is difficult to assess passing vessel effects when a deep draft navigation channel is abutted to an open shallow (compared to the channel) bay, a common occurrence in coastal Louisiana.

For more complex scenarios, numerical models generated with software such as the Adaptive Hydraulics Modeling System (ADH) (Tate 2008) are increasingly being applied to better understand the effects of passing vessels. ADH, a circulation model developed by the U.S. Army Corps of Engineers, has the ability to incorporate vessel movements by applying a pressure field equal to the draft of the vessel. Characteristics can be specified including size, speed, and track of one or multiple vessels.

ADH modeling was performed to assess shoreline protection impacts on several projects along the Houston Ship Channel and within Galveston Bay, Texas. Field measurements were performed near areas of concern to directly observe the passing vessel effects and to calibrate and verify the ADH modeling. Measurements were obtained by strategically placing acoustic doppler velocimeters (ADVs), which measure pressure and 3-dimensional current velocity, and collecting data as ships pass. Results from the ADH analysis were used to assist in hydraulic stability and cross-section design of structures for shoreline protection for upland areas and marsh restoration projects.

Implications

Louisiana's working coastline has many instances of navigation channels serving large passing vessels that impact nearby shorelines and wetland areas daily. Lessons learned from ADH modeling in the Houston-Galveston area are directly applicable to sites across coastal Louisiana including Sabine Pass Ship Channel, the Calcasieu Ship Channel, the U.S. Gulf Intracoastal Waterway, and the Barataria Waterway. Better understanding of these passing vessel effects in areas not conforming to the geometry of a perfectly constricted channel will lead to more

stable and effective shoreline protection measures, potentially reducing the rapid amount of erosion in these areas.

Development and Adaptation of the CASM to Evaluate Food Web Dynamics and Species Responses in Barataria Basin

Kate Watkins, **Shaye Sable**, and Erol Karadogan
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A version of the comprehensive aquatic systems model (CASM) was developed to simulate species biomass responses in Barataria Basin to the operational alternatives for the proposed sediment diversion at Myrtle Grove. The CASM food web is comprised of phytoplankton and periphyton groups, zooplankton and zoobenthos, and important consumer species including brown and white shrimp, blue crabs, oysters, bay anchovy, gulf menhaden, largemouth bass, red drum and spotted seatrout. Daily population growth of each producer and consumer group is determined by bioenergetics-based equations, and daily inputs for light, temperature, depth, nutrients, suspended sediments and organic matter differentially modify photosynthesis and consumption of the populations. Daily biomass of species can also be modified by salinity, turbidity, and structural habitat.

For Barataria Basin, a single CASM was run using all daily environmental inputs averaged from field data for the entire system from 1999-2010, and the predicted seasonal biomasses for species were calibrated to biomasses estimated from LDWF and NOAA sampling programs. The estuary-wide calibrated CASM was then set up for 18 polygons overlaid on the RMA hydrodynamic model grid so that the 18 polygons had varying daily environmental inputs estimated from the nearest field stations or else generated by the RMA grid cells. Species biomasses were simulated for single years at the 18 polygons. The species biomass distributions were then described by the differences in the environmental inputs and the food web interactions at the polygons. The modeled distributions of key species were evaluated by scientists and managers at NOAA, LDWF, and USFWS to determine if the species parameters, distributions and interactions were realistic. The CASM can be run using the outputs generated from hydrodynamic and water quality models of the basin in order to evaluate the relative changes in species biomass and distribution due to coastal restoration and protection projects.

Implications

A fish community modeling approach such as the CASM is good for evaluating species biomass responses to coastal restoration and protection efforts in Louisiana estuaries if food web interactions and bottom-up processes due to changing physical and chemical conditions are thought to be important in the system. The CASM approach is particularly useful for evaluating the bottom-up processes within the food web that might occur on relatively short time scales or vary within the year, such as seasonal or pulsed operations from freshwater diversions, because it incorporates a large suite of daily environmental conditions as model inputs to

modify the food web processes, it has flexible spatial arrangement so that it can be easily linked with existing hydrodynamic and water quality models, and it simulates daily growth and food web interaction processes via bioenergetics for the component producer and consumer groups.

Feasibility Studies for Large-Scale Mississippi River Sediment Diversions

Jenni Schindler[1], J. Alex McCorquodale[2], Mallory Rodrigue[1]
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Many different statistics citing the rate of land loss in Coastal Louisiana have been presented over the years. What is known is that the rate of loss is higher than what is currently being built with marsh creation and other land-building projects. One solution is to design and build large-scale sediment diversions that provide a direct feed of a large sediment amounts to the starving marshes. Fenstermaker was tasked by the Coastal Protection and Restoration Authority (CPRA) to numerically model and analyze two proposed large-scale sediment diversions along the Mississippi River in order to identify the optimal size, location, and operational regime. The two proposed sediment diversions were included in the 2012 Coastal Master Plan. One of the diversions is located near Lower Breton Sound and the other is located near Lower Barataria.

This study involves using the Pontchartrain/Barataria Basin Eco-Hydrologic Compartment Model from the 2012 Coastal Master Plan. The model was developed at the University of New Orleans (UNO) and is currently being modified by Fenstermaker. The modifications include refinement of the model's compartments and links, re-calibration, and re-validation. The model will be executed for 50 years to provide a comprehensive view of the state of the coast in the future.

The model will simulate water quality and hydrologic responses to the Pontchartrain/Barataria Basin diversions . The output will be handed off to a Wetland Morphology team from the United States Geological Survey (USGS) who will then use a numerical model to predict the sediment-building potential of each proposed alternative. These models will help the CPRA to determine the most beneficial sizes, locations along the Mississippi River, and operational regimes of the two proposed diversions.

Implications

This study examines large-scale sediment diversions and their impacts on water quality and land-building. A numerical model will be used to quantify sediment loads in the Pontchartrain/Barataria Basin for 50 years into the future. The goal of the study is to use science to help the CPRA to design two large-scale sediment diversions along the Lower Mississippi River that will provide a multitude of benefits to the system and help restore the Coast. As the model is a selection tool, this study will provide insight regarding which size and location of the diversions will provide optimum sediment/land building in the receiving basin. Studies such as these are pivotal in making timely restoration decisions with confidence, as the model can simulate long-term effects in a dynamic system.

Development of the CPRA Oyster Lease Acquisition and Compensation Program (OLACP) – From Litigation to Legislation

Jason Shackelford

SWCA Environmental Consultants

The Louisiana oyster fishery is a lease-based industry in which the state has historically leased oyster habitat via 15-year contracts, for a nominal fee. In addition, the state has maintained public oyster grounds from which seed and marketable oysters could be obtained by leaseholders and the public. This system coexisted and competed with the oil and gas industry for a number of years. The introduction of the state's coastal restoration and protection program in the early 1990's complicated this relationship and introduced an additional competing use of state owned water bottoms. Once issued, an oyster lease cannot be cancelled or revoked. Therefore, the state needed to establish a program by which the leases could be acquired. In order to accomplish this, a single, consistent valuation method had to be established. Prior to the adoption of the current Oyster Lease Acquisition and Compensation Program (OLACP), there were many competing valuation methodologies associated with oyster lease harvest rights. Some of these included: damage payments from oil and gas activities; lease auction sale data; recorded sales; judicial awards; and an earlier voluntary acquisition program. These different value indicators will be explored and compared in relation to the current Fair Market Value Appraisal Methodology employed under the OLACP. Their role and relative importance in the development of the OLACP will be explored.

Surge Barrier Impact on Salinity in Vermilion Bay

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Vermilion Bay is located south of Abbeville and west of Morgan City along the Louisiana coast. Approximately 2,000 square miles drain into this ecologically and economically important water body. The area is also prone to surge inundation as shown by Hurricanes Rita (2005) and Ike (2008). As part of a larger study, Fenstermaker and CPRA analyzed the impacts of surge barriers placed in northern Vermilion Bay along the Gulf Intracoastal Waterway (GIWW).

Fenstermaker examined salinity and water level impacts to Vermilion Bay, while storm surge reduction was studied separately. The purpose of Fenstermaker's study was to investigate the impacts caused by redirecting freshwater discharge on the Vermilion River, Boston Canal, Oaks Canal, Delcambre-Avery, and Weeks Bay during normal tide cycles of 2010. These closure structures redirected freshwater along the GIWW and over time led to a salinity increase in Vermilion Bay. The effect on water levels during normal tides was minimal.

Salinity fluctuations can adversely affect individual organisms and the ecosystem as a whole. While surge barriers provide much needed protection during storm events, the barriers can negatively impact the surrounding ecosystem if not properly utilized and maintained. Placement and function of surge barriers and other protective measures are vitally important to an ecosystem as they can impede and redirect existing drainage and salinity regimes.

Implications

This study examined the impacts of storm surge barriers on salinity and water levels in Vermilion Bay. Surge barriers are located throughout coastal Louisiana protecting life and habitat. The benefits of surge barriers can be offset with improper placement and function due to disruption of the natural environment. The impacts on salinity and water levels should be evaluated during planning and implementation of surge barriers.

Using the late Holocene stratigraphic record to guide Mississippi Delta restoration: 1. Overview

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Reestablishment of the natural processes that created the Mississippi Delta is widely recognized as one of the key steps to coastal restoration. To guide river diversion planning, it is essential to understand natural fluviodeltaic sediment-dispersal processes. Although the Wax Lake Delta (WLD) has offered invaluable knowledge in this context, it captures only one end-member scenario of delta evolution over decadal time scales, while delta cycles in the Mississippi Delta occur typically over centennial to millennial time scales. Here we use recently collected sedimentologic and geochronologic data from the Lafourche subdelta to investigate vertical accretion and downstream progradation rates, sediment-trapping efficiency, and organic carbon sequestration rates associated with fluviodeltaic sedimentation over delta-cycle time scales.

Along Bayou Lafourche, sediment texture changes from mud-dominated overbank deposits that accumulated in swamp environments upstream, to sand-dominated river-mouth bar deposits that accumulated in open water environments downstream. This texture change implies a longitudinal decrease of the system's capacity to retain the relatively fine proportion of its sediment load. A sediment-trapping efficiency of ~50% is estimated for a large crevasse splay in the upstream portion. In contrast, sediment trapping efficiency in the downstream open water environment is likely similar to that of the WLD, i.e., <30%.

The geochronology data demonstrate that fluviodeltaic sedimentation is distinctly episodic. Vertical accretion rates as high as 1 to 4 cm/yr at a centennial time scale are recorded in the upstream portion of Bayou Lafourche, consistent with the high sediment trapping efficiencies. Finally, we quantify rates of organic carbon sequestration by means of clastic overbank sedimentation and peat accumulation. Surprisingly, despite their lower organic carbon content these rates appear to be higher in clastic strata, which is the direct result of the extremely high sedimentation rates.

Implications

Because Bayou Lafourche likely carried approximately half the Mississippi River discharge during most of its lifespan, it offers a useful analog for the modern Mississippi River which has

seen a ~50% reduction of its sediment load due to inland damming. Our data show that the sediment-trapping efficiency changes significantly from vegetated inland wetlands to open water environments farther seaward. Thus, prioritizing locations with a relatively high sediment trapping efficiency, such as inland vegetated swamps, should be considered in river-diversion planning in the Mississippi Delta.

Furthermore, coastal restoration by means of river diversions can potentially store a significant amount of organic carbon that would otherwise be exported to the ocean and mostly released back to the atmosphere by oxidization. River diversion projects can therefore generate sizable carbon credits that may be traded to offset the cost of coastal restoration.

The Expanded Small Scale Physical Model of the Lower Mississippi River

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The Expanded Small Scale Physical Model (ESSPM) of the Lower Mississippi River is funded by the Louisiana Coastal Protection and Restoration Authority (CPRA) as a replacement for a smaller physical model built in 2003. Due to the scale distortion (H=1':12000', V=1':500'; Distortion Factor=24) and limited domain (Myrtle Grove to GoM), the original model was only able to provide qualitative data pertaining to the feasibility of large scale (> 100,000 cfs) sediment diversions in the lowermost river. While valuable, it was recognized that a more scientifically defendable model would be more useful in improving our understanding of the river hydraulics and sediment transport. Improvements in the ESSPM include an improved scale (H=1':6000', V=1':400'; Distortion Factor=15) and significant expansion of the domain (Donaldsonville to the GOM). In addition, careful study and optimization of the hydraulic and sediment scaling allow for significant improvements in the ability of the model to mimic the river sediment's re-suspension and transport characteristics.

The ESSPM model bed will be constructed of 216 high density foam panels that are to be precisely routed using a Computer Numerically Controlled (CNC) router. The routing operations should begin in late 2013 and be complete in early 2014. A new facility is currently being designed to house the much larger model. In addition to laboratory, office, and meeting room space, the facility will include a state of the art exhibit center that will include outreach and educational displays for visitors and guests. Once complete, the routed panels will be shipped to the facility and assembled on a custom made model bed.

Implications

The Primary goal of the ESSPM is to provide planning level information on the location and size parameters for Master Plan Sediment Diversions. Additionally, the model will provide qualitative insight on how regions of the Lower Mississippi River behave when several sediment diversion are operated simultaneously. The model facility will serve as a center for physical modeling and computer modeling, as well as a state of the art museum that showcases the work of CPRA. Once constructed and calibrated, the ESSPM will be maintained and operated by engineers and technicians from Louisiana State University.

Practical Examples of Integrated Ecosystem Modeling – When Water, Sediment, Vegetation, Climate and Man meet

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Natural ecosystems are driven by complex interactions between the different natural constituents, these being e.g. water, sediments, vegetation, flora, fauna, chemical particles, wind, waves, storm, anthropogenic activities, etc. Therefore, understanding and predicting the behavior or the impact of even a single constituent demands for an integrated approach that implements different expertise and integrated predictive tools. Our focus is on sediment modeling, and it's interaction with water and water quality, wave forcing, vegetation, storms and hurricanes, and anthropogenic structures. Here we introduce few case studies located in different Countries and environments, where we highlight the importance and the benefits of an integrated approach, and the advantage of an integrated (numerical) tool. The case studies we present are carried out with different coupled modules of the numerical software Delft3D (Open Source) and include some of the latest development that we aim at sharing with the modeling community.

Implications

Integrated analysis approach and modeling is an essential tool to correctly capture the behavior of the ecosystem. Considering the different constituents of an ecosystem separately leads to the wrong interpretations and predictions. Lastly, integration does not mean complication. Often an integrated analysis allows for simpler modeling with focus on the most important constituents only.

Effects of Hydroperiod Variation on Vegetation Belowground Productivity: Implications for River Diversions

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Sea level is expected to rise between 55 and 140 cm in the next century and will greatly increase wetland hydroperiods throughout coastal Louisiana. It is reasonable to expect hydroperiods throughout extensive regions of the Mississippi River delta plain to also be strongly influenced by the multitude of large river diversions being planned under Louisiana's 2012 Coastal Master Plan. We conducted a field experiment to examine how variability in inundation duration affects the end-of-season belowground biomass of three wetland plant species. PVC planters, called marsh organs, were installed at three sites in the delta plain. Each marsh organ consisted of six rows of six 15-cm diameter pipes, with the top of each row being situated at a different elevation in the tidal frame. Marsh organs were deployed during the spring. Each pipe was filled with surrounding wetland sediment, and then planted with stems of the dominant vegetation in the surrounding marsh: *Spartina patens* (middle Breton Sound), *Spartina alterniflora* (lower Breton Sound), or *Sagittaria lancifolia* (Wax Lake headland marshes). Inundation durations were recorded for each row of all marsh organs, and belowground biomass was assessed for each pipe at the end of the growing season. *Spartina patens* showed the strongest biomass response to hydroperiod variability, with a significant reduction occurring in all rows that were flooded greater than 50% of the time. *Sagittaria lancifolia* was most tolerant to increased hydroperiod, with biomass reductions only evident in rows where flooding exceeded 86%. The response of *Spartina alterniflora* was intermediate relative to the other two species, and showed belowground biomass reductions when flooded greater than 69% of the time. These results demonstrate that we can expect different plant species, and hence different regions of the coast, to respond differently to altered flooding regimes that result from sea-level rise and restoration activities.

Implications

Belowground production by coastal wetland vegetation is a critical contributor to landscape sustainability in regions that receive little or no fluvial sediment subsidies. Results of this study illustrate the importance of considering the inundation tolerance of co-dominant species when implementing river diversions into regions across the delta plain. Though diversions may provide much needed mineral sediments for land-building, these subsidies may come at the expense of belowground productivity and subsequent organic accretion in areas co-dominated by flood-intolerant species such as *Spartina patens.* Successful diversions into these regions may require the use of brief, punctuated discharge events that coincide with suspended load

maxima in the Mississippi River to maximize sediment delivery while simultaneously limiting wetland hydroperiod to within the physiological tolerance range of co-dominant species of marsh plant communities in the receiving basin.

Controls on Resistance of Sediment-Amended Salt Marshes to Climate Change-Induced Disturbances

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Salt marshes are continually exposed to climate change-induced disturbances, which can lead to submergence and loss of ecosystem function in less resilient systems. Hurricane scour, drought-induced marsh collapse and sea-level rise are examples of large-scale disturbances related to climate that ultimately impact vulnerable salt marshes by altering the hydrology of the system. Many of these disturbances result in prolonged flooding and salt marsh submergence. Therefore, one method of rehabilitating submerged salt marshes is to increase the elevation of the marsh surface to reduce flooding, increase soil aeration and stimulate plant production. We conducted a long-term study of a sediment-restored salt marsh to understand what environmental conditions result in functional equivalency to a natural marsh and whether the restored system is sustainable over time. The study site was a previously degraded salt marsh that was impacted by drought-induced Sudden Vegetation Dieback and received sediment-slurry additions in 2002 from the adjacent water body, Bayou LaFourche. Restored sites at intermediate elevations had greater productivity and greater resilience compared to natural marshes within five years of sediment addition. Additionally, eleven years later, long-term monitoring of the sediment addition sites revealed a differential response between restored and natural marshes to subsequent dieback, with restored marshes at higher elevation having greater resistance than natural salt marshes at low elevations.

Implications

Long-term study of these restored systems has provided us with a greater understanding of how elevation influences ecological function and resistance to disturbance in restored salt marshes. We identified optimal elevations where ecological functions, such as primary production, decomposition, resilience and resistance, are equivalent, or in some cases superior, to natural marshes. We also identified thresholds of elevation where ecological function is diminished. This information not only expands our basic understanding of hydrogeomorphic feedbacks in salt marshes, but also provides managers with elevation targets to optimize restoration success. This research also demonstrates both the immediate (<5 years) and long-term (>10 years) sustainability of sediment-enhanced salt marshes, which will inform future restoration planning activities.

Sharing Perspectives on Social Science: Best Practices for Gulf Coast Restoration

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In Louisiana and elsewhere, questions remain on how social science information can best be used in coastal restoration decision-making processes. However, it is less well known why this is the case, and what can be done to address this gap. The Nature Conservancy and Oxfam convened more than 50 experts from state and federal agencies, universities, and NGOs, to answer these questions in a day-long workshop held in July 2013. Based upon the findings of the workshop, entitiled "Sharing Perspectives on Social Science: Best Practices for Gulf Coast Restoration," the Conservancy and Oxfam developed a white paper which identifies more than a dozen best practices restoration decision-makers and others should consider adopting to correct this imbalance.

The white paper is premised on two principles:

- Restoration projects must address the needs of both human and natural communities, approaches that single out either will not succeed.

- Social science must have a greater presence as coastal restoration decisions are made. For purposes of the meeting and this report, social science was defined as: the research and resulting quantitative or qualitative data that describe social, economic, and cultural uses of natural resources and the social, economic, and cultural conditions of the people and communities that depend upon or benefit from these natural resources, including particularly vulnerable populations and communities.

The paper elaborates on what experts at the convening identified as the most important practices for improving the use and collection of social science data in ecosystem restoration decision-making, including ways to overcome existing hurdles and apply these practices in upcoming Gulf Coast restoration processes. The practices fall into three broad categories: bringing key voices to the table, broading decision-making processes around restoration project selection and planning, and adding long term value by encouraging social scientists to apply rigorous and holistic research methods in their work.

Implications

In many coastal restoration decision-making processes, it is clear that the significant knowledge of social scientists and coastal residents is not being applied adequately, as public agencies work diligently planning how the coast's restoration should unfold. While advances are being made in collaboration between engineering and physical science practitioners and decisionmakers, strides could still be made in-terms of building systemic approaches to address the human dimensions of restoration. Correcting this imbalance is important for many reasons: Greater inclusion will not only head off lawsuits and other costly project delays, it would also supply information vital to the success of restoration projects.

The best practices identified in the white paper are important tools for coastal decision-makers and other stakeholders to consider in order to design and implement coastal restoration projects that not only restore the environment, but also help Gulf residents benefit to the maximum extent possible from these projects.

Historical Dynamics of the Pipeline Canal and Land Loss Controversy

Jason Theriot

Energy development and the Louisiana Gulf Coast have a shared history. Throughout the twentieth century, the energy industry transformed the Louisiana coast—an area dominated by 3 million acres of wetlands—into a corridor for transporting and processing oil and gas for the nation. Billions of barrels of oil and trillions of cubic feet of natural gas from the Gulf of Mexico have moved across Louisiana's coastal wetlands through an intricate pipeline network. Today, roughly one quarter of America's oil and gas resources flow through this system. Building and maintaining this energy infrastructure has been crucial to the economic prosperity of the region and the nation, but has also resulted in an unintended ecological consequence: coastal wetland loss.

Approximately 191 major pipeline systems originate from the offshore waters and enter Louisiana's vast coastal zone, an area roughly 220 miles across and as much as 75 miles inland from the Gulf, most of it marshlands. The installation of these pipelines in the coastal area required the dredging of an estimated ten thousand miles of canals to support these operations. This intricate canal system has resulted in some of the most visible changes to the landscape. In fact, there are few places in coastal Louisiana where these canals do not exist. Over the last several decades, the environmental impacts associated with oil field canals have become one of the more controversial issues in the region, as evidence linking these canals to land loss emerged.

This presentation will provide a historical overview of the technological, political, and economic reasons that explain how pipeline canal dredging in the wetlands became a standard industry practice, and why this economically efficient but environmentally destructive method was allowed to continue with only minor improvements throughout the post-World War II decades. A close look at the development of one of the largest pipelines ever built in the coastal Louisiana in the mid-1950s will offer an informative case study for analyzing how these systems were built in the era prior to environmental reforms and how the marsh landscape around the 300-mile-long pipeline canal has changed over the last half century. The information will also provide valuable context for understanding the epic legal disputes against the oil and gas industry for extensive damages to wetlands over the decades caused by digging pipeline canals.

Modeling basement subsidence beneath and beyond the Mississippi Delta

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The contribution of deep crustal processes to land-surface subsidence in coastal Louisiana has been a subject of vigorous debate over the past decade. To a significant extent, this debate has been fueled by the use of a variety of techniques to measure subsidence rates, each with their unique strengths and weaknesses. So far, few attempts have been made to fully integrate geodetic and geologic observational evidence within a modeling framework.

This presentation first reviews measurements of basement subsidence in coastal Louisiana (the basement is defined here as the top of the Pleistocene surface) over a wide range of timescales, including geodetic (GPS) time series, Holocene relative sea-level records, and vertical crustal motions derived from a deformed late Pleistocene long profile of the Lower Mississippi River. We use this evidence to evaluate geophysical model experiments that consider the isostatic effects of ice, water, and sediment loading and unloading. For this purpose, we have constructed the most sophisticated sediment (un)loading history for this region to date. In addition to the Holocene delta, this includes (among others) the shelf and submarine fan loads as well as erosional phenomena such as the paleovalley of the Lower Mississippi River. Our model also fully incorporates the waxing and waning of ice sheets, including their effects on ocean-water loading.

Model calculations show that most (but not all) of these effects must be considered to explain the spatial and temporal variability of vertical crustal motions as indicated by observations. Among others, our findings demonstrate that the effective elastic thickness of the lithosphere in coastal Louisiana is likely to be time-dependent, with a value of ~100 km on timescales of human interest. This is considerably more than previous studies have assumed. While the present study is primarily a sensitivity analysis aimed at understanding the relative importance of driving mechanisms, we anticipate that a continued effort will enable us to tune the model so as to fully match key observations.

Implications

Effective management and restoration of Louisiana's coastal zone requires detailed evidence on the causes and rates of subsidence, including its variability in time and space. While mapping of

present-day land-surface subsidence rates is not yet feasible (largely due to its high spatial variability), our understanding of the controls of subsidence of the Pleistocene and deeper basement is currently advancing rapidly. The importance of such knowledge is that it will enable, among others, spatially explicit predictions of future rates of subsidence of any infrastructure (e.g., coastal-defense systems) anchored in Pleistocene strata.

Nutrient biogeochemistry during the early stages of development in the Mississippi River deltaic floodplain

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Nutrient biogeochemistry associated with the early stages of soil development in deltaic floodplains has not been well defined. Such a model should follow classic patterns of soil nutrient pools described for alluvial ecosystems that are dominated by mineral matter high in phosphorus and low in carbon and nitrogen. We will demonstrate how patterns of soil chemistry and dissolved inorganic nutrient fluxes along the emerging Wax Lake delta (WLD) chronosequence are consistent with conceptual models of long-term nutrient availability described for other newly emergent ecosystems. As soils in the WLD aged, the subsequent increase in organic matter stimulated net N_2, oxygen, nitrate, and nitrite fluxes producing greater fluxes in more mature soils. Soil nutrient development along an emerging delta chronosequence largely coincides with classic patterns of soil development described for alluvial floodplains, and substrate age together with ambient nitrogen availability can be used to explain nutrient biogeochemistry during early delta evolution. Mechanistic numerical computer models were developed to simulate nitrogen biogeochemistry in the deltaic floodplain of the Mississippi River incorporating results from the experimental soil cores previously described to evaluate fate of nitrate at the landscape level. A vertical exchange model was calibrated to observations of nutrient fluxes made in soil core incubations. The vertical exchange model was used to develop a horizontal exchange model, incorporating residence time of water moving downstream along the surface of the wetland landscape. The horizontal exchange model was validated against field observations of nitrogen concentrations as part of a systematic monthly sampling grid on a couple of deltaic lobes during 2013 flood-stage season. Measures of water flow and residence time demonstrate a three flow-path model is best to simulate nutrient patterns. Residence time was an important control of nitrate removal rates, and temperature was found to have a small positive effect on this efficiency, although this varied depending on the form of nitrogen. Nitrate removal rates increased to 90% by increasing water detention time to 3 months on the delta lobe.

Implications

Most surface water nitrate reductions result from a combination of denitrification, DNRA, and vegetation uptake, with roughly two thirds of the reduction due to denitrification. The

complement of both vertical and horizontal exchange models demonstrates the utility of both core incubation studies and detailed field observations of multiple flow paths of water across the delta floodplain to address issues of nitrate removal efficiencies of restored wetlands along the Mississippi River Delta. Comparing results between the two models underscores the importance of considering spatial scales in wetland biogeochemical analysis. The present analysis does indicate that removal efficiencies greater than 50% can be achieved at moderate loading rates and residence times, and that maximum nitrogen removal occurs at peak flood times, when proposed river diversions would operate.

Changes in distribution of common plant species in coastal Louisiana: 1997-2013

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We used data from the coastwide vegetation surveys (1997, 2001, 2007, and 2013) to document changes in distribution and cover for several common marsh species (*Amaranthus australis, Avicennia germinans, Cladium mariscus, Distichlis spicata, Iva frutescens, Juncus roemerianus, Morrella cerifera, Panicum hemitomon, Paspalum vaginatum, Phragmites australis, Sagittaria lancifolia, Schoenoplectus americanus, Schoenoplectus californicus, Spartina alterniflora, Spartina patens,* and *Typha* spp.). Several species showed remarkable increases in distribution in 2013, while others are declining. The potential factors driving these changes will be discussed.

Implications

Although changes in marsh type are an important way to monitor coastal vegetation trends, the changes in distribution and cover of common species provides more insight into the coastal processes that drive these changes. For example, the distribution of *Amaranthus australis* and *Iva frutescens* are highly indicative of areas affected by hurricanes. The changes in the distribution of *Schoenoplectus americanus* can reflect changes in herbivory pressure. The changes in *Typha* spp and *Cladium mariscus* may reflect changes in nutrient loading.

Backyard gardens and after-school crabbing: The importance of subsistence in community and culture in Coastal Louisiana

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Ironically, as cable television shows like "Swamp People" and "Duck Dynasty" spotlight Louisiana's longtime subsistence culture and folkways, multiple environmental and economic shifts in Coastal Louisiana threaten the actual viability of individual and community subsistence behaviors, favoring instead commercial and sport fishers and hunters. Two years of ethnographic work in Terrebonne and Lafourche Parishes documents the key role that subsistence activities continue to play in the lives of residents, including fishing, shrimping, hunting and, particularly, gardening. More than 2,000 log entries reveal that the food harvested or gathered in small-level activities (roadside fishing, backyard gardens, vacation-time hunting) not only supplies calories, but perhaps more importantly, functions as a community glue through networks of sharing and reciprocity. Key shifts that threaten these community activities include 1) physical land loss, 2) loss of land access/increases in costs (through private lease holders and fees), 3) shifts from intermittent or cyclical to year-round wage work, and 4) decrease in key elder role in training children. These shifts are inextricably linked to massive environmental and economic shifts, and locals understand this. We argue that the loss of subsistence activity is not merely the loss of a minor recreational activity, but rather the loss of a fundamental family and community undertaking, that has deep cultural implications. Because subsistence activities are key to both community cohesiveness and cultural identity and because no one we interviewed believed that current subsistence activities would be possible in two or three generations, we argue that Coastal management policy needs to widen its view to include activities like as fishing from docks, hunting on levees, and gardening in empty lots, as well as helping perpetuate these activities. Likewise, definitions need to become more flexible so that categories like "sport" and "commercial" do not define policy limits.

Implications

Coastal preservation work could include advocacy efforts for small-level subsistence activities and communities could focus work on developing ways to ensure the log-term viability of these activities (including training young people, ensuring the availability of access to hunting and fishing areas). In addition, the definitions in our policies, such as "subsistence," "sport" and

“commercial” need to be carefully evaluated to see if they are flexible enough to capture the wide range of and motivations for existing activities.

Predicting the Impacts of River Diversion and Sea-level Rise on Eastern Oyster Growth and Production

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Currently there is much debate and controversy regarding the use of freshwater diversions for coastal restoration in the Mississippi River Delta and the effects of diversions on restoring wetlands over the long-run while maintaining eastern oyster (*Crassostrea virginica*) production in the short and long-term in coastal Louisiana. Large freshwater diversions that are sediment laden could dramatically change estuarine salinity, temperature, suspended sediment concentration, chlorophyll *a* concentration, water circulation and water level, thus affecting oyster spawning, recruitment, growth, and survival.

We developed a high-resolution coupled hydrodynamic-water quality-oyster population model to investigate diversion impacts on oyster growth and production. We selected the Breton Sound Estuary (BSE) in the eastern Mississippi Deltaic Plain as the spatial domain for the modeling study. The coupled model was calibrated and validated against field observed physical and biological factors. We applied the model to predict the impacts of the Caernarvon Diversion with various discharge rates (low, medium, and high) on oyster production in BSE under different scenarios of relative sea-level rise (RSLR) compared to the baseline condition (Mississippi River flow without diversion under current RSLR). Preliminary results indicate that large river diversions under rising sea level conditions affect the size and location of the optimal zones for oyster growth and production due to their impacts on spatial and temporal patterns of the physical parameters (especially salinity) that control oyster growth and mortality.

Implications

Mississippi River diversions under future RSLR conditions could result in changes in the size and location of the optimal zones for oyster growth and production. Therefore, it is suggested that a balance between wetland building and fishery production benefits be considered for the implementation of future river diversion projects in BSE.

Changing the Paradigm: Stormwater Management for the Greater New Orleans Area

J.L. Watts, PE, CFM, D.WRE

Traditional

The City of New Orleans' drainage system reflects the city's unique history. Of the three places in the United States at elevations below sea level, the Greater New Orleans (GNO) area is the only one with significant population and industry. The GNO area continuously struggles to manage its drainage systems, despite ongoing development, soil subsidence, and sea level rise. The City of New Orleans' drainage system serves nearly 95 square miles with approximately 1,500 miles of pipe. The City of New Orleans commissioned CDM Smith to develop hydrologic and hydraulic computer modeling evaluation using the U.S. Environmental Protection Agency Storm Water Management Model to determine the traditional drainage infrastructure improvements required to convey the 10-year, 24-hour storm with no more than 6 inches of flooding in the street. It was envisioned that this evaluation would serve as a baseline to define what was needed with evaluation of what should be to either exceed it in level of service or reduction in cost.

Green Infrastructure

Many stormwater best management practices (BMPs) were considered for the GNO area to determine the ones most relevant for use. The criteria include both desired characteristics for the BMPs and limiting conditions inherent to the GNO area. The primary issue hindering typical BMPs is the soils with their high ground water table and low hydraulic conductivity. Most soils in and around New Orleans are classified as Hydrologic Group D and considered "functionally impervious," due to a combination of high clay content and high compaction. The Pontchartrain Park and Gentilly Woods neighborhoods, collectively known as Pontilly, were approved by GOHSEP and FEMA for a Hazard Mitigation Grant Program (HMGP) project. The Pontilly neighborhoods were designed for significantly different conditions than currently exist and the level of development that has occurred in the area has overstressed the storage and conveyance capacity of the existing drainage infrastructure. Restoration initiatives, post Hurricane Katrina, have resulted in the removal of a significant portion of the impervious area through structure acquisition and demolition. The vacant property resulting from the removal of these structures has created an opportunity for stormwater retrofit using stormwater BMPs that provide a favorable benefit cost ratio (BCR). The design of a stormwater management system for the Pontilly area will seek to manage each drop of rainwater where it falls. Though not practical everywhere, this approach nevertheless calls for a distributed, but connected,

series of small stormwater BMPs linked together in a stormwater "mitigation train." It is the vision of the CDM Smith team to employ various BMP approaches as appropriate in different sections of the Pontilly neighborhood watershed.

Future Vision

Building upon the opportunities envisioned in the Pontilly Stormwater HMGP project, green infrastructure possibilities for the GNO area were explored. For the Greater New Orleans Urban Water Plan (GNO UWP) project, models of the east banks of Jefferson Parish and Orleans Parish, as well as St. Bernard Parish were created to evaluate the options of both traditional drainage system improvements as well as green infrastructure. The GNO UWP illustrates a vision of change, altering the GNO area's relationship with water from one of conflict to one of appreciation.

Comparative influence of chronic sea level rise *vs*. acute hurricane disturbance on coastal bottomland hardwood swamp productivity – lessons for living on the edge?

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Across their distribution along coastal plain river drainages and bottomlands, ecosystem processes and properties in periodically flooded bottomland hardwood forests are exquisitely sensitive to variation in soil water content and hydroperiod. Coastal bottomland hardwood swamps have experienced tropical storm disturbance for thousands of years. As climate change progresses, forested wetlands (swamps) along the Gulf Coast are likely to experience increased seaward influence, including increased flooding and increased frequency of strong tropical storms. How will these simultaneous changes in key state factors influence forest/swamp productivity?

A 13 year record of aboveground and belowground ephemeral carbon pools along a hydrologic gradient in a mature coastal bottomland hardwood forest in the coastal Mississippi Delta indicates that foliage and fine root production are limited by both low and high soil water content and production peaks in the zone of periodic short-term flooding. Soil respiration carbon flux follows the same pattern. Interannual variation in precipitation, and its impacts on soil water content and hydroperiod, are reflected in changes in the relative magnitude of ephemeral carbon pools and fluxes along this hydrologic gradient, and as differences in overall magnitude among years. Interannual variation is most pronounced as flooding "stress" increases along this hydrologic gradient. Disturbance caused by a strong hurricane shifted patterns of foliar production across this gradient, reducing the variation attributed to position along the hydrologic subsidy-stress continuum. The once most productive zone of forest carbon assimilation experienced the greatest depression in foliar productivity immediately following the strong storm, while the most flooded zone experienced the least change. Remarkably, within 5 years foliar productivity attained pre-hurricane levels across the hydrologic gradient, however subsequent storm events have eroded this apparent recovery.

Implications

I employ these data to distinguish coastal bottomland hardwood swamp responses to hydrologic variation *vs*. storm disturbance, and I assess the synthetic impacts of both climate change influences on these key carbon pools and ecosystem properties. I then translate these outcomes into a climate change response planning framework, describing a spectrum of

questions facing coastal landscape natural resource managers and offering insights from this one forest that is living on the edge.

EPA Urban Waters Program: Reconnecting Urban Communities to Their Waterways

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In June 2011, the Environmental Protection Agency (EPA) launched the Urban Waters Federal Partnership (UWFP) at seven pilot locations across the country including New Orleans, Louisiana. The UWFP was envisioned as an innovative federal collaboration comprised of initially 11 agencies (now 13 agencies) led by EPA, the Department of Interior, and the U.S. Department of Agriculture and coordinated by the White House Domestic Policy Council. The UWFP aligns with the Partnership for Sustainable Communities and also supports the Administration's America's Great Outdoors Initiative.

Through the UWFP, the EPA is "seeking to help communities — especially underserved communities — as they work to access, improve and benefit from their urban waters and the surrounding land." A fundamental component is leveraging existing programs to support projects and build partnerships with a variety of federal, state, and local partners that foster increased connection, understanding, and stewardship of local waterways. The agency's Urban Waters Vision states that the combined efforts of the many partners and stakeholders will "restore urban water quality, revitalize our communities and reconnect communities to their urban waterways." This collaboration will align federal government programs and investments in these communities, expand partnerships, build local capacity, and find innovative ways to communicate the environmental and economic potential of safe and clean urban waters.

The New Orleans/Lake Pontchartrain Urban Waters Pilot Partnership is comprised of nearly 60 organizations in the New Orleans Metropolitan Area and the Lake Pontchartrain watershed. The Partnership identified five areas to initially focus collaborative efforts including the West End area (West End Pier and New Canal Lighthouse), Pontchartrain Beach area, the Lafitte Corridor and Greenway, the Shea Penland Coastal Education and Research Facility, and the East End area. The five focus areas cover a range of locally-driven initiatives including environmental education, economic revitalization, facilities reconstruction, and enhanced access to urban waterways.

Implications

The Urban Waters Strategy is four-pronged and includes connecting communities to their urban waterbodies and engaging the communities in restoration with the ultimate outcomes of improved water quality and revitalized communities. This approach is cyclical and has longevity from generation to generation, and community engagement is critical to ensure current and future generations understand the significance of restoring and protecting urban waterways and the coastal wetland ecology of Southeast Louisiana. The New Orleans Partnership has been collaborating on these issues across various organizations under the facilitation of an Urban Waters Ambassador, and the partnership continues to grow. This model is proving effective across the country resulting in EPA launching an additional 11 Urban Waters Locations in other cities due to the growing popularity. Communities are recognizing the importance of breaking down silos and having the various organizations collaborate to achieve more robust outcomes from orchestrated efforts in the same watershed.

A Quantitative Comparison of Modeling Approaches for Simulating Land Building Processes from River and Sediment Diversions

Erol Karadogan[1,2], Gyan Basyal[1] and Angela New[1], **Clinton S. Willson[1]**

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Two- and three-dimensional numerical modeling of the complex hydrodynamics and geomorphology in a sediment diversion receiving area is computationally intensive. This imposes significant challenges since the effectiveness of sediment diversions is based on long-term (decades) land building processes. Approaches to reduce the computational requirements for simulating the long-term land-building processes in deltas include: semi-analytic methods that utilize simplified hydraulics, sediment transport processes and delta geometries but can simulate decades of land building in minutes; the use of a morphologic acceleration factor that is used to assist in dealing with the difference in time-scale between hydrodynamic and morphological developments; and the use of an adaptive finite element meshing approach that adjusts the computational domain to match the dominant flow and geomorphology.

In this presentation, we present the results from simulations of long-term (e.g., greater than 10 years), land building using three models: (1) a simplified "spreadsheet" model; (2) Delft 3D with and without the morphologic factor function; and (3) the USACE adaptive hydraulics (AdH) model with and without the mesh adaption. AdH has the ability to dynamically refine the mesh in areas where more resolution is needed due to changes in the flow and/or geomorphologic conditions and then unrefine previously refined areas when the added resolution is no longer needed. Each of the three models was used to simulate typical sediment diversion flow and sediment loading conditions into two representative coastal receiving basins: a simplified, open water basin; and a more realistic, topographically complex basin. Qualitative comparisons are made between the overall land building area and morphological features captured by the different approaches and field- and lab-based studies. Next, the simulation times and computations resources required for the approaches are quantified and compared. Finally, we make recommendations on the appropriateness of the approaches for short- and long-term simulations of land building.

Implications

The complexity of sediment diversion hydrodynamics and sediment transport and the long-term nature of the land building processes create a need to balance computational resources,

geomorphologic accuracy and computational burden. Thus, it is important that we understand the implications of these tradeoffs and how they impact our ability to make decisions about the long-term effectiveness of lower river sediment diversions.

The Impact of Vertical Distortion on the Hydrodynamics and Sediment Transport in the Expanded Small-scale Physical Model.

Clinton S. Willson[1], Getnet Agegnehu[1], Gyan Basyal[1], Aaron Bennett[1], Benjamin Hartman[1], Angela New[1], and Jonathan Puls

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The new Expanded Small Scale Physical Model (ESSPM) of the Lower Mississippi River has been designed to improve our ability to physically model the flow and sediment (sand) transport in the Lower Mississippi River. However, the model scaling (Horizontal 1:12,000, Vertical 1:500, Distortion Factor of 15) will still limit the ability to replicate some of the complex hydrodynamic and sediment transport processes. Thus, it is critical to understand and quantify the impacts of the scaling and distortion on the accuracy and precision of the physical model data and results.

Distorted scale physical modeling requires the relaxation of some of the similarity criteria used to scale the geometry, hydraulics and sediment transport from the field (i.e., the river) to the lab. Some advantages of distorted scale modeling include: larger horizontal domains, greater water depths, larger Reynolds numbers, and reduced time scales. Disadvantages include: skewed geometry, lack of friction similarity, and altered 2- and 3-D flow patterns and pressure distributions. Therefore, it is critical to clearly lay out the model design, be clear about what similarity criteria have been relaxed and understand what results cannot be scaled up, thus making it clear what the expectations are for the model and the applicability and usefulness of the experimental data.

This presentation will first focus on a description of the similarity laws that were used in the ESSPM design and what limitations are expected due to the use of a distorted scale. Second, the distortion value used will be compared to other physical modeling studies. Third, one-, two- and three-dimensional numerical models will be used to quantitatively study the impact of the various levels of scaling and distortion on the hydrodynamics by comparing water levels, velocities, and turbulent structures.

Implications

While the primary objective of the ESSPM is to provide planning level data and information regarding the Lower Mississippi River and proposed sediment diversions, there is still a need to quantitatively understand the impact of the scaling and distortion on the hydrodynamics and sediment transport. A rigorous analysis of the scaling and detailed hydrodynamic modeling will be critical if the model results are to be utilized in the best way possible.

USACE Status of Evaluating and Permitting Lower Mississippi River Diversions

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Louisiana has lost about 1,900 square miles of its coastal wetlands since 1932, including approximately 17 square miles of coastal wetlands every year since 1985. Combating land loss in coastal Louisiana (which is due to multiple factors, including dredging canals for oil and gas exploration and pipelines, salt water intrusion, storm damage, river management, sea level rise, subsidence, and invasive species), requires a systematic approach employing multiple restoration tools, such as river diversions, headland and barrier island restorations, and marsh creations.

The State of Louisiana has indicated its intent to pursue implementation of several water and/or sediment diversions on the Lower Mississippi River for ecosystem restoration. There are numerous legal, policy, technical, scientific, environmental, socioeconomic, and stakeholder issues related to Mississippi River diversions. In addition, the construction of a diversion has the potential to require a Department of Army (DA) permit and result in the State altering/modifying an existing Federal project, which under 33 USC Section 408, requires the approval of the Chief of Engineers of the US Army Corps of Engineers (USACE). Anticipated environmental impacts of the diversions on the Lower Mississippi River and the receiving areas, induced impacts of shoaling on proposed and existing projects, impacts to the Mississippi River Levees, and potential induced flooding in developed areas are only a few of the issues that must be assessed to facilitate evaluation of permit applications and allow risk informed decisions concerning the implementation of proposed diversions.

This session will present the perspective and role of USACE in planning, permitting and implementing Lower Mississippi River diversions. The presentation will address the diversion related issues cited above, with emphasis on the status of proposed diversions and of the evaluation of the associated DA permit application and Section 408 requests, and issues identified and/or resolved to date.

Implications

The lower Mississippi River and the Louisiana coastal area are utilized by many different groups and interests for diverse purposes. USACE must take into account these stakeholder views

when evaluating permits for LMR diversions, and the major issues impacting the implementation of Mississippi River diversions.

USACE has received DA permit applications and Section 408 requests from the State of Louisiana for two diversions on the lower Mississippi River. In addition, the State has indicated their intent to pursue the implementation of several other Mississippi River diversions. The purpose of this session is to provide the USACE perspective of the status of evaluating the DA Permit application and the Section 408 request for water and/or sediment diversions on the Lower Mississippi River for the purpose of coastal restoration. The lessons learned to date from this process can be used to inform future coastal restoration actions.

Shelf Sediment Transport During Hurricanes Katrina and Rita

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Within the northern Gulf of Mexico, sediment from the Mississippi and Atchafalaya Rivers is actively building land on the Mississippi Delta, within Atchafalaya Bay, and at the Chenier Plain. The timescales over which, and mechanisms by which sediment travels from these rivers in the coastal ocean are not well understood. Sediment transport flux and direction during extreme storms are poorly defined due to challenges that plague both observing and modeling. This has motivated the development of a three dimensional hydrodynamic-sediment model for the Louisiana shelf using the Regional Ocean Modeling System (ROMS). This study analyzed modeling results for the year 2005, during which both Hurricanes Katrina and Rita struck the Louisiana shelf. The model used ocean boundary conditions from Hybrid Coordinate Ocean Model (HYCOM) and spatially-variable winds from North American Regional Reanalysis (NARR) dataset. Wave Watch 3 (WW3) from the NOAA Environmental Modeling Center provided wave parameters. Sensitivity tests of sediment erosion rate and settling velocity were performed, and modeling estimates were compared to radionuclide-based storm-deposit thicknesses and sediment accumulation on nearby marsh areas.

During both hurricanes estimated wave-induced shear stresses dominated wave-current combined shear stresses. Both the highest wave-current combined stresses and the maximum erosional depth on seabed (in the order of 10s cm) were located to the east of two hurricane tracks. Strongest landward windsgenerally occurred before the hurricanes made landfall, after which winds slowed and veered offshore. During Hurricane Katrina major sediment transport was estimated in the area surrounding the bird-foot Mississippi Delta and the transport was mainly shoreward. During Hurricane Rita, the estimated maximum erosion occurred on the middle shelf around 20-m isobaths between 93°W and 90°W. Seabed sediment texture also played a role in sediment transport.

Implications

This study showed the episodic nature of sediment transport in the northern Gulf of Mexico and illustrated that major hurricanes greatly impact sediment erosion and deposition. In the sensitivity test maximum erosional depth seemed to be more sensitive to erosional rate than settling velocity. Estimated sediment erosion was localized and mainly located along the eastern side of hurricane tracks. During both hurricanes major erosion occurred between the 5-m and 50-m isobaths and net sediment transport flux was landward. These results help us better understand how hurricanes disturb sea floor sediment and impact the nearby wetlands through longshore and cross-shore sediment erosion and deposition. This study is also relevant to wetland loss and coastal erosion issues along coastal Louisiana.

Ecodynamic solutions for the protection of intertidal habitats: the use of oyster reefs

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ABSTRACT

Tidal flats are worldwide at risk due to human disturbances and climate change. These habitats sustain coastal food webs and provide essential ecosystem services such as coastal protection. Their conservation and restoration is a major coastal management issue. Within the program "Building with Nature" (www.ecoshape.nl) we investigate the use of oyster reefs as eco-dynamic measures to protect tidal flats against erosion, which poses a serious problem in the Oosterschelde estuary (Netherlands). Oyster reefs are ecosystem engineers that influence tidal flow and wave action and therefore modify sediment transport patterns. Reefs dissipate wave energy and should therefore reduce erosion rates at the lee side of the reef. Additional to the reduction in erosion, these reefs enhance the local habitat around the reef and it is expected that the reefs sustain themselves through natural recruitment of young oysters.

Besides studying natural oyster reefs in the Oosterschelde to quantify the effect reefs have on their surrounding environment, we also constructed three pilot reefs in 2010 with the following dimensions: length x width x height = 200m x 10m x 0.20 m. The reefs consist of gabions filled with oyster shells (*Crassostrea gigas*), offering a stable substrate, that allows for the settlement of oysters, while minimizing shell loss. Measurements have been carried out to determine the effect on hydrodynamics (waves and tides), suspended sediment concentration and morphology. Biological measurements, like the recruitment on the reef, are carried out as well.

The concept is successful when reefs develop into self-maintaining, living oyster reefs which stabilize tidal flats. Monitoring of reef development and ecomorphological effects revealed site specific effects. Our study shows that knowledge about local hydromorphological conditions and a thorough understanding of the ecosystem engineering properties and habitat requirements of *C. gigas* are needed to implement this concept in management practices.

Implications

The aim of this study is to understand the effects of oyster reefs on hydrodynamics and wave characteristics, subsequently on sediment transport and finally on tidal flat morphology. The ultimate goal is to develop guidelines for the design of oyster reefs that result in a reduction in erosion and enhance the ecological value of the surroundings. In the US, millions of dollars are invested to restore and use oyster reefs on a large scale in coastal protection and habitat restoration. Our findings show that reef builders have an effect on both the abiotic and biotic environment, at a scale exceeding the size of the reefs. The implications of these findings for the use of oyster reefs in shoreline protection and habitat conservation are discussed. Also regulatory aspects, stakeholder involvement and future perspectives are discussed.

Changes in channel bar morphology and sediment infilling rates in response to dredging within the Lower Mississippi River

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Channel bars within the Lower Mississippi River (LMR) contain large volumes of sandy sediment and are now being utilized by the State of Louisiana as fairly large borrow sources for wetland creation and barrier island restoration. The dredging that occurs in these channel bar borrow areas takes place within permitted areas, as restricted by navigation and levee stabilization issues, and can reduce the bar elevation by tens of meters, locally. While it is expected that the sediment removed by dredging will be recharged by new sand supplied from upstream sources by suspended and bed load transport, little is known about the sediment infilling rates in borrow areas or the potential impacts of infilling on the channel morphology further downstream.

This study documents a time series of bathymetric change at three channel bars in the LMR (i.e., near River Miles 16, 50, and 61) where restoration-borrow projects have been completed or are ongoing. Bathymetric change is assessed using GIS analyses of single beam and multibeam sonar datasets, supplemented by geologic borings. Pre-construction surveys of the channel bar borrow sites are utilized to examine morphological change driven by the seasonal and interannual variability in river discharge. Results from the oldest dredging project (i.e., Bayou Dupont) suggest that sediment infilling can recharge a typical borrow area within ~2 water years. Infilling rates are not linear with the elapsed time after dredging, but are, in part, controlled by river discharge, with the largest values of observed infilling rates recorded during periods of relative low flow (i.e., < 14,000 m^3 s^{-1}). Pre-construction surveys show that spatially-averaged changes to bar morphology occurred at similar rates as that observed at the dredged bars.

Implications

The results of this study will be used in the parameterization and calibration of predictive numerical models of sediment infilling at channel bar borrow sites. The ability to accurately model sediment infilling gives coastal restoration planners the ability to schedule dredging at rates approximate to the expected infilling rates. This ability would allow individual channel bars to serve as sediment sources for multiple restoration projects without causing a significant change in bar size over the lifespan of the dredging activities. This ability would also help assess

the effects of dredging and the subsequent infilling processes on the downstream river channel due to disruptions in the natural fluvial sediment transport regime.

Extent and Degree of Shoreline Oiling in Louisiana 2010-2013: *Deepwater Horizon* Oil Spill

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Maximum shoreline oiling from the 2010 *Deepwater Horizon* oil spill was documented by Shoreline Cleanup Assessment Technique (SCAT) teams on 1,080 km of shorelines in Louisiana. This was approximately 61% of total shoreline oiling across the Gulf of Mexico. Maximum oiling in Louisiana was documented on 300 km of sand beaches (28% of Louisiana total), 731 km of coastal wetlands (68%), and 49 km of other shoreline habitats (4%). One year later, oil remained on 465 km of Louisiana shorelines (May 2011); two years later oil remained on 347 km of Louisiana shorelines (May 2012); and three years later oil remained on 334 km of Louisiana shorelines (May 2013). As of May 2013, this included 182 km of sand beach and 142 km of coastal wetland oiling. In addition, the degree of oiling also declined over time (oiling degree was defined by a combination of oiling width across shore, percent oil cover, and oil thickness). Louisiana shorelines described as heavily to moderately oiled went from 438 km at maximum oiling to 78 km in 2011 and 22 km in 2012-2013. Light, very light, and trace oiling accounted for 93% of all shoreline oiling in 2013. Declines in oiling extent and degree over time resulted from both shoreline cleanup operations under the response and natural oil weathering, degradation, and removal processes (natural attenuation). The flattening rate of change in oiling extent may reflect diminishing returns in shoreline cleanup and natural attenuation in some areas. In addition, an increase in trace oiling on sand beaches over May 2012-2013 may have been the result of periodic surface exposure and localized remobilization of oil that was formerly buried by natural processes. As of September 2013, cleanup under the response was continuing to address sand beach oiling in Louisiana.

Implications

Shoreline oiling data for Louisiana has been used extensively to support the on-going spill response, and will also be important for Natural Resources Damage Assessment (NRDA) and restoration planning under a variety of programs. These data also provide important background information for scientific research examining *Deepwater Horizon* oil spill impacts

and recovery. These data will also contribute to future oil spill planning and response efforts across Louisiana and the Gulf of Mexico.

Simulation of Storm-Surge Flood on Coastal Wetlands using the Immersed Boundary Method

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The immersed-boundary method (IBM) has been widely applied to fluid-structure interaction applications while the structures move or change shapes in a complicated fashion. The author has developed an IBM which adopts advantages from previous IBMs and was validated with many benchmark cases in various applications. Recently, the method has been extended to realize the coupling of small 1-D streams/structures to the 2-D shallow-water flow modeling. In this study, the IBM was implemented in software CaFunWave which was developed by LSU Center for Computation and Technology (CCT) for simulating storm surges, tsunamis, coastal nonlinear wave, wave-vegetation interaction, and breaking generated near shore circulation. Using CaFunWave as the base model, two types of scenario were simulated: 1) the water exchange between the horizontal-2D sheet flows on the wetland and the flows in the small-scale 1-D channels, which cannot be resolved with the grid resolution; 2) the structures such as dikes or levees in the modeling of the flooding water overtopping on those structures.

Implications

For the wetland restoration projects, accurate simulations of the wetland flooding are critical to the successfulness of the project. A large portion of the wetlands is flooded through small streams and channels. Due to the grid resolution issue, coupled 1-D and 2-D modeling is the current solution. An innovative coupling method was developed in this study to reduce the computational cost significantly without sacrificing the accuracy. The new model was incorporated into a web portal for simulation deployment and management, a product from the Northern Gulf Coastal Hazards Collaboratory (NG-CHC). The research is a collaborative effort between McNeese State University (MSU) and LSU CCT.

Analysis of Storm Surge and Wave Reduction by Restoration Projects in Barataria Basin, Louisiana

Haihong Zhao, John Atkinson, Hugh Roberts, Shan Zou

It is desired to develop an efficient procedure to accurately evaluate potential surge and wave attenuation for multiple restoration project configurations. To achieve this goal, a basin-scale model was developed for Barataria Basin as a pilot study. A mesh with the focus of the target basin and a sufficiently extended open/closed boundary was extracted from the full gulf scale ADCIRC mesh previously developed for *CPRA2012*. This basin-scale model was validated with both synthetic tropical storm conditions and winter storm conditions. By examining hydrographs and winds characteristics of over 300 theoretical tropical storms at given locations within the basin, the theoretical suite of tropical storms was reduced to a small group of representative hydrographs for project evaluation. The reduced mesh size and the reduced number of storm conditions allow more numerical experiments for evaluating the efficacy of individual project designs, with equal accuracy as the full ADCIRC/SWAN model but at substantially less computational cost.

Two restoration projects, the Barataria Pass to Sandy Point Pass Barrier Island Restoration and Belle Pass to Golden Meadow Marsh Creation Project were evaluated using the validated basin-scale model of Barataria Bay. For each project configuration, approximately ten representative storms were identified with varying peak surge heights, track angles and forward speeds that cover the range of storm scenarios that impact the basin. Following adjustments of mesh nodal attributes to implement various project configurations, multiple storm scenarios were simulated utilizing the subset of representative storms. Both projects result in storm surge and wave reduction to varying extent. It is also observed that negligible or negative protective function exists for some storm conditions. For instance, the marsh creation project reduces surge on its protected side but increases water level on the storm fronting side. The protected side and the storm-fronting side may vary with the storm direction. The reduction can be noticeable if a storm moves in the direction of the long extent of the marsh creation project. Barrier island restoration can reduce surge height immediately behind the island. However because it is a narrow line of defense, re-growth of surge and waves in the back bay is expected as the storm approaches inland areas. The restored barrier island chain provides a blockage of storm water intrusion into the larger basin to some extent. Therefore in the basin, a small decrease in peak surge level is observed between the project scenarios and the base scenarios without project implementation. The numerical experiments demonstrate the benefit of the proposed basin-scale model for effectively evaluating restoration projects.

Working toward a Sustainable Barataria

Corey T. Miller

Coalition to Restore Coastal Louisiana

Advances in data collection and modeling continue to build a better understanding of the physical processes that both threaten and offer hope for the future of Coastal Louisiana. This understanding informs decisions that affect plans for flood protection and ecosystem restoration. An equal effort to improve stakeholder engagement is necessary to communicate this knowledge and address concerns that arise. A pilot process is underway that tests a unique engagement strategy to build a better understanding of successful engagement practices when addressing issues of flood protection and ecosystem restoration.

The community surrounding the town of Jean Lafitte, La is as rich in culture as it is prone to flooding. Just 15 miles south of New Orleans and 30 miles from the open Gulf of Mexico, it is dependent not only on all the services the ecosystem provides but also several other economies supported by its location. This process engages residents of the Lafitte area to catalogue the suite of concerns in relation to community sustainability and planned coastal protection and restoration projects outlined in Louisiana's Comprehensive Master Plan for a Sustainable Coast (2012). Participants represent a broad variety of stakeholder interests and discussions explore concerns to determine if common solutions can benefit multiple needs across ecosystem restoration and flood protection. This session covers a brief overview of the process, highlighting some of the unique attributes and preliminary findings.

Implications

This process is one of three pilot engagement strategies funded with the specific purpose of providing best practices for engaging stakeholders of coastal communities in the context of ecosystem restoration and flood protection. The three pilots will be cumulatively analyzed to compile important lessons learned and a set of recommendations for future engagement practices. Additionally, the results of this effort will inform other on-going and planned engagement processes. The totality of these efforts aims to create a more informed and involved public so that stakeholder engagement may optimally support and benefit future coastal planning and implementation.

Incorporating New Processes: Sediment Distribution and Marsh Edge Erosion

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The understanding of the fate of sediment in the coastal zone of Southern Louisiana is critical to the planning, design and implementation of coastal restoration projects. This task group investigated the state-of-the-art techniques for modeling the distribution of mineral sediments in coastal environments to improve this aspect of the 2012 Coastal Master Plan Ecohydro model. The following aspects of the sediment distribution were considered: open water processes, marsh processes and marsh edge processes. Both hurricane and non-hurricane conditions were reviewed. It is proposed to compute the accretion of mineral sediment due to normal tide and wind effects (non-hurricane) on a continuous basis while the mean annual accretion due to hurricanes will be introduced once per year based on a look-up table with regional and marsh type classifications. Similarly, the contribution of the marsh edge erosion to the sediment mass balance will be estimated each year based on the marsh type and mean annual wave power; this computation will be completed in a Marsh Edge sub-model which will provide eh Ecohydro model with updated the open water to land ratios. The sediment will be treated in three classes: sand, silt and clay. The clay fraction will be partitioned into flocculated and colloidal particles. The flocculation effect will be a function of the local salinity computed by the Ecohydro sub-model. The open water sediment processes involve: deposition, re-suspension and transport. The Ecohydro sub-model with include the exchange hydraulics (inflows, outflows and storage) and a wave model to generate the re-suspension fluxes. It is assumed that the normal marsh sedimentation process is associated with inundation of the marsh with water carrying suspended solids from the open water; due to vegetative trapping, deposited sediments are only resuspended by extreme events. Remote sensing is being investigated as a means of validating the sediment distribution module of the Ecohydro sub-model.

Coastal Louisiana Barrier Island Morphology Modeling: A Hybrid Approach

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Predicting the evolution of Louisiana's barrier islands is a critical component of the Louisiana Coastal Protection and Restoration Authority's (CPRA) 2017 Coastal Master Plan. All of the landscape models to be utilized for the 2017 Coastal Master Plan will be capable of efficiently simulating 50-year time periods and predicting project effects at a basin-scale. The Barrier Island Model Development (BIMODE) component shall improve upon the 2012 Coastal Master Plan barrier shoreline model by including additional physical processes (e.g., overwash), improving the capabilities of predicting change in island morphology, and incorporating realistic event-driven morphodynamic responses.

The scope of work included a Literature Review; Model Approach Development; and Model Formulation, Coding, and Testing; along with working meetings, routine teleconferences, and reporting. The study area includes the Chandeleur Islands on the eastern side of the Mississippi River active Balize Delta and from Scofield Island to Raccoon Island on the western side of the Mississippi River active Balize Delta.

Based upon the detailed literature review, knowledge and experience from restoration project design and field data collection, and professional judgment, the BIMODE Team selected the following key physical processes, forcing functions, and geomorphic forms for inclusion in the model: Longshore Sediment Transport, Cross-shore Sediment Transport, Breaching, Inlets and Bays, Post-Storm Recovery, Subsidence, and Eustatic Sea Level Rise. Descriptions of the processes, functions, and forms along with their respective analytical and / or empirical formulations are presented.

Due to the spatial scale of the study area and the temporal scale of the landscape models, complex models that predict both longshore and cross-shore sediment transport are not viable. Therefore, a hybrid modeling approach is recommended to account for the key physical processes of longshore and cross-shore sediment transport. The longshore transport model

formulation will include a three step wave transformation process using available hindcast data to yield representative breaking wave conditions. These wave data will be used to estimate sediment transport rates employing the CERC transport formulation.

The cross-shore sediment transport formulation will include application of the one-dimensional model SBEACH that simulates cross-shore morphologic response in response to a storm event based on measurement derived, empirical equations. While the code will not be directly incorporated into the BIMODE model, the SBEACH model runs will be recalled through look-up tables to determine the likely output profile given the starting input profile and storm characteristics. Input profiles will be based on representative static submerged profiles from each of the regions along with combination of varying dune heights, dune widths and berm widths, some of which will represent natural barrier island profiles.

Based upon experience in restoration project design, SBEACH tends to under predict storm erosion which in some sense accounts for post-storm recovery processes. Because post-storm recovery processes are minimal for Louisiana barrier islands, the BIMODE Team recommends the post-storm recovery processes are captured sufficiently through application of SBEACH.

Barrier island breaching will be incorporated into the BIMODE model by determining critical thresholds of minimum barrier island widths and minimum width to island length ratios through application of the SBEACH model results and comparisons to historical data on barrier island breaching. Subsidence and eustatic sea level rise will be incorporated into the BIMODE model through manual adjustments following the guidance documents prepared by CPRA. Inlet and bay processes, specifically inlet expansion/enlargement, using equilibrium theory for inlet cross-sectional area as a function of tidal prism, will be incorporated into BIMODE using the same formulation employed in the 2012 barrier shoreline model.

The schematization of the BIMODE model outlines the recommended procedure on how the selected physical processes will be incorporated to develop the final output. The procedure includes reading in the profile and wave data inputs, determining longshore sediment transport, locating nodal points where sediment transport diverges, determining net erosion or accretion along each profile, and computing change in beach face profile specific to longshore transport; adjusting beach profiles to account for beach face profile retreat due to relative sea level rise, for silt loss, and for subsidence; accounting for cross-shore sediment transport for the given storm suite; eroding the bayward side of each profile; checking for and implementing breaching if the thresholds are met; and incorporating the inlet and bay model; and repeating these steps for the 50-year simulation period. Output will be cross-sections at each emergent profile in the format of a Digital Elevation Model.

Implications

The State's Master Plan focuses a strategic effort on restoring barrier islands and creating and sustaining marsh and wetland habitats. Applications of this work will support the 2017 Coastal Master Plan, improve the science and understanding of barrier island evolution, and enhance future project planning and design efforts.

Improving Fish and Wildlife Predictions

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In the 2012 planning process, the consequences of projects for fish and wildlife were evaluated with habitat suitability index (HSI) models. For 2017, a number of parallel approaches are being adopted to improve how fish and wildlife outcomes are estimated. Specifically, work is underway to:

- Simulate the effects of various restoration scenarios on estuarine community dynamics using a combination of Ecopath, Ecosim and Ecospace, including some improvements developed through comparisons with other models. This three-tiered strategy provides results based on a widely peer-reviewed method (Ecosim), as well as spatial output using an application on the scientific frontier (Ecospace). The resulting model will include adults and juveniles of a number of species of interest, and others linked to these species through trophic interactions.
- Use multivariate statistical methods and existing field data to develop relationships between fish and shellfish density (or other similar response variable) and key environmental variables. The ultimate goal of the multivariate analysis is to develop new, standardized equations that use estimates of fish/shellfish density as a response variable, and that can be used to replace the existing HSI approaches. The analyses will be conducted for brown and white shrimp, blue crab, Gulf menhaden, bay anchovy, spotted seatrout, largemouth bass, blue catfish, and oysters.
- Reevaluation of existing HSI models for mottled duck, green-winged teal, gadwall, wild-caught crawfish, and alligator to assess variables to be included, data and information available to support the selection of variables, and form of the suitability functions. In addition, a new HSI will be developed for brown pelican, as the 2012 Coastal Master Plan did not include this species.

The objective is to integrate or directly link these algorithms and approaches with the new Integrated Compartment Model.

Implications

These improvements in the estimation of ecosystem outcomes of master plan projects will enable CPRA and stakeholders to have a common understanding of the consequences of

different restoration and protection actions. The approach combines community assessment and habitat assessment to take advantage of model developments elsewhere and build on the availability of local data sets. As such, it provides a set of tools that may be useful for coastal planning and project assessment for years to come.

Developing Future Uncertainty Scenarios

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Future uncertainty is inevitable, especially when planning projects in a dynamic landscape for decades into the future. Moderate, Less Optimistic, and Moderate with High Sea Level Rise scenarios were considered in the 2012 Coastal Master Plan modeling analysis, which captured a range of plausible future environmental conditions. Considering newly available data and recent scientific and technical developments made since data were compiled (early 2010) to drive the 2012 modeling effort, it is prudent to revisit the future environmental scenarios included in the previous master plan. It is also prudent to conduct a sensitivity analysis to determine relative effects of these environmental variables on model output, so an informed decision can be made regarding the design of future environmental scenarios for consideration in the 2017 Coastal Master Plan.

All variables except marsh collapse threshold are carried forward from the 2012 effort. These include eustatic sea level rise, subsidence, storm intensity and frequency, precipitation, evapotranspiration, and river discharge and river nutrient concentration.

The first phase of this effort is to establish a range of values to be analyzed for each variable by incorporating the latest available information from the technical and scientific community. This includes drawing from recent journal publications, technical reports, newly collected or analyzed data, publically available global climate change models that can be downscaled to the region, and other such data and information. The second phase includes determining the sensitivity of the 2017 Coastal Master Plan Integrated Compartment Models to each environmental variable, and using this information to identify plausible scenarios. This will involve a suite of model runs designed specifically for this effort, followed by statistical analyses to determine source and magnitude of model sensitivity. Lastly, the team will use guidance from these two phases to design the 50-year future scenarios for consideration in the 2017 Coastal Master Plan modeling effort. The future scenarios will be developed and refined with input from CPRA and the stakeholder community.

Implications

Incorporating technically sound future scenarios in the 2017 Coastal Master Plan analysis will give CPRA and stakeholders a broader understanding of potential future conditions over the next 50 years. This will provide insights into how changing environmental conditions may impact near and long-term performance of coastal restoration and protection projects. Lastly, rigorous evaluations of project performance under various conditions will promote more robust programmatic planning, project design, and implementation of projects that are sustainable into the future.

The Water Institute of the Gulf Innovation Program

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The Water Institute of the Gulf is a not-for-profit, independent research institute dedicated to advancing the understanding of coastal and deltaic systems and to applying scientific and technological solutions for the benefit of society. The Institute was founded in 2011 to build collaboration with public, private, and academic partners to preserve and protect the US Gulf Coast environment, a major source of natural, human, and industrial resources. The Institute also aims to develop, share, and promote cutting edge technology in order to advance water management efforts worldwide. The world class science and engineering incorporated in the Louisiana 2012 Coastal Master Plan will guide policy decisions as the state continues to intensify its commitment to project construction. This level of progress has highlighted other areas where advancement is needed. As Louisiana's coastal program grows and more funds become available to fund large-scale efforts, a focus on applied science and engineering must continue to guide the program. The Institute administers and continues to develop a program designed to find answers to problems that the 2012 Coastal Master Plan identified as significant but for which solutions do not yet exist. In so doing, the Institute hope to identify cost effective and sustainable ways to address the coastal crisis.

Implications

By formalizing an open innovation process, the Institute is fostering a culture of innovation by encouraging and stimulating out-of the box thinking and then providing a formal evaluation mechanism. The program is anticipated to continue to evolve and expand in future years. The Institute is creating and strengthening linkages between existing government entities, Non-Governmental Organizations, Economic Development Organizations, Higher Education, and the private sector to foster a coastal innovation culture, and to leverage existing broader efforts and bring them into the coastal arena.

Atchafalaya River influences in west Terrebonne marshes

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Rising stages on the Lower Atchafalaya River appear to be pushing riverine influences further eastward into western Terrebonne marshes. Increasing velocities may also be more effectively transporting suspended sediments into the marsh. In recent years, mud flats comprised mostly of clay, have formed along the inside bends of some bayous and even in oil-field canals that serve as distributary channels. Slow infilling of some recently formed ponds and lakes also appears to be occurring.

In these areas beyond the active delta zone, observations suggest that riverine processes are slowly creating and maintaining a relatively solid marsh zone with little or no open water as currently exists in areas closer to the river. It appears that these processes are initiated by mineral sediment accretion in ponds and slack water areas receiving seasonal through-flow of riverine water. Aggressive vegetative growth and associated organic accumulation is then able to colonize mineral sediment deposits and complete the marsh "infilling" or closure process.

Depending on the sediment supply and time scale considered, marshes in the "filling" or healing process are characterized by no net loss or minor land gains. Marshes having lesser sediment input may experience varying degrees of reduced land loss depending on the quantity and duration of sediment and freshwater inputs. Rates of closure observed in west Terrebonne marshes are likely dependent upon fresh marsh vegetation. Lacking aggressive fresh marsh vegetation, brackish marsh closure rates may be slower and more mineral sediment required.

Implications

These west Terrebonne observations may help us understand the effects of anticipated large-scale Mississippi River sediment diversions. A better understanding of the natural marsh creation/maintenance processes may allow us to more efficiently create sustainable habitats and increase a Mississippi River sediment diversion's probability of success.

An ADH model to support the hydrologic restoration of Cole's Bayou, Teche-Vermilion Basin, Louisiana

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The Cole's Bayou marsh restoration site is located on the Gulf Coast of Louisiana in Vermilion Parish within the Teche-Vermilion Basin, immediately east and south of the Freshwater Bayou Canal. Wetlands in Cole's Bayou are experiencing land loss at a rate of 0.42% per year due to subsidence, sediment deficit, interior ponding and pond enlargement, and rapid episodic losses due to tropical storms. Additionally, significant interior marsh loss has resulted from saltwater intrusion and hydrologic changes associated with increasing tidal influence and changes in water quality. As hydrology in this area has been modified, habitats have become increasingly floatant marsh resulting in increased vulnerability to tidal energy and storm damages. One key component to hydrologic restoration is to increase freshwater and sediment inflow into interior wetlands by altering inflow channels and other areas near the head of the marsh. A hydrodynamic model of the Cole's Bayou project area and surrounding waters including Little Vermilion Bay, Freshwater Bayou, and Vermilion Bay was constructed using the ADaptive Hydraulics Model (ADH). ADH has proven to be a reliable tool for coastal, estuarine, and marsh modeling because of its ability to deal with intricate domains of varying scales, efficiently handle complex wetting and drying, and simulate hydraulic structures. Six data sampling stations were deployed to collect water level, salinity, and turbidity data necessary to develop and validate the model. Suspended sediment samples were taken hourly over a tidal cycle at each station during a frontal event, a high-wind event, and baseline conditions. Nutrient samples were taken monthly within the marsh. The field data combined with results from the hydrodynamic model will estimate the effects of hydraulic alterations of sediment and nutrient loading into the project area. This will enable managers to ascertain the impacts of system alterations on marsh creation within Cole's Bayou.

Implications

This project outlines a modeling framework for coastal marsh hydrologic restoration studies. The data collected, modeling tools utilized, and analyses conducted in this project provide a blueprint for future hydrologic restoration efforts. The ADH software has proven to be a robust tool for the hydrodynamic modeling of coastal waters and marshes. Additionally, the hydrodynamic model of Vermilion Bay and Freshwater Bayou will be useful for future projects in the Basin.

River Diversions: Mineral Sediment Input and Marsh Loss

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Recently, there has been debate regarding whether the Caernarvon Freshwater Diversion project was responsible for the extensive marsh loss caused by Hurricane Katrina in the upper Breton Sound Basin. In those debates, much attention has been placed on vegetation type and metrics such as root strength and length. Little attention has been given to soil conditions immediately below the root zone, especially the effects of long-term mineral sediment deprivation resulting from construction of Mississippi River levees.

Because of levee-induced sediment deprivation, marshes throughout the upper and middle Breton Sound Basin, and most of the interior Deltaic Plain marshes, are characterized by soils having very low bulk densities to depths of 24 cm and deeper. Hurricane Katrina/Rita impacts appear to have been greatest in interior low bulk density soil marshes (regardless of vegetation) compared to bay-rim marshes which usually have much higher mineral sediment content throughout the vertical profile. It is speculated that low soil bulk density may, therefore, be a major factor governing susceptibility to storm-induced marsh loss.

Soil cores from the Davis Pond Freshwater Diversion ponding area, and from western Terrebonne marshes, show that inputs of riverine sediments have resulted in the recent formation of new mineral soil marshes, increased soil bulk densities of existing organic marshes, and may even convert floating marshes to typical non-floating marshes. Such mineral sediment inputs may also be instrumental in the maintenance of existing marshes and may contribute to reduced marsh loss in far field influence areas.

2017 Model Improvement Plan Overview

Mandy Green[1], Natalie Peyronnin[1], Denise Reed[2], Ehab Meselhe[2], and Alaina Owens[2]

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The 2017 Coastal Master Plan will build upon the foundation established by the 2007 and 2012 Coastal Master Plans and will demonstrate the continued evolution of comprehensive coastal restoration and protection planning taking place in Louisiana. The 2017 Coastal Master Plan will include a well-defined decision-making process with clear, transparent, and repeatable results, and the plan will be based upon the best available science and engineering. The plan will include the Coastal Community Resiliency Program, a coast wide nonstructural and community resiliency program, which will utilize both physical and programmatic nonstructural measures to meet the flood risk reduction targets identified in the 2012 Coastal Master Plan. A more refined, comprehensive adaptive management strategy will be described in the plan.

The systems modeling effort utilized in the 2012 Coastal Master Plan will be maintained and improved to support the decision-making process for the 2017 Coastal Master Plan. Improvements to the 2012 models will focus on increasing the spatial resolution of the ecohydrology model compartments; integrating model components (ecohydrology, wetland morphology, barrier shoreline morphology, vegetation, and ecosystem outcomes), where possible, to reduce manual data transfer and increase efficiency; simulating additional physical and ecological processes such as marsh edge erosion and sediment distribution; and enhancing the methodology used for ecosystem outcomes. Fisheries modeling is expected to include both habitat suitability indices and a community-level modeling approach.

The 2017 Coastal Master Plan modeling effort will center on the outcomes of individual projects, how variations in project integration and implementation timing vary outcomes, and identification of keystone projects for each region. Multiple environmental scenarios will again be used for the 2017 Coastal Master Plan to ensure that projects are evaluated using the most current information available on environmental uncertainties such as sea level rise, subsidence, river sediment load and discharge, and storm frequency and intensity.

Implications

The 2017 Coastal Master Plan will continue to advance coastal restoration and protection planning in Louisiana. CPRA has moved high priority projects identified in the 2012 Coastal

Master Plan to advanced planning, engineering and design, and construction. The 2017 Coastal Master Plan will aid in sequencing projects to ensure that available resources are used efficiently and effectively to reduce economic losses from storm surge based flooding, promote a sustainable coastal ecosystem by harnessing the natural processes of the system, provide habitats to support commercial and recreation activities, sustain coastal Louisiana's unique cultural heritage, and promote a viable working coast. The 2017 Coastal Master Plan will provide coastal residents with more detailed information about what to expect over the next 50 years as we move forward with solutions that will restore the health of the Gulf region, create more resilient coastal communities, and preserve our nation's energy and economic security.

CPRA Coastal Community Resiliency Program

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[1] Coastal Protection and Restoration Authority (CPRA)

Louisiana's Comprehensive Plan for a Sustainable Coast (2012 Coastal Master Plan) is one of the nation's largest environmental planning efforts that, using a science-based and stakeholder-informed decision-making process creates a more sustainable Louisiana Gulf Coast and enables communities to adapt to a changing landscape. The Master Plan calls for $50 billion dollars over the next 50 years to build land and reduce flood risk for all Louisiana citizens; one-fifth of this funding ($10.2 billion) is reserved for implementing community resilience measures through a coast wide nonstructural program.

This session will detail the Coastal Protection and Restoration Authority's (CPRA) Coastal Community Resiliency (CCR) Program and provide more information on the goals, process, and ongoing activities of program development. The CCR program is a comprehensive coast wide effort that supports the advancement of both physical and programmatic nonstructural measures. Physical measures include elevation, flood-proofing, and voluntary acquisition. Programmatic measures include a range of actions addressing where and how land is developed to protect future development including: land use planning, ordinances, hazard mitigation planning, higher regulatory standards, building codes and enforcement, incentives, and public outreach and education strategies.

One of the goals of the CCR program is to enable policy makers and local communities to better understand areas of vulnerability, as well as adaptive capacity, to determine the most effective strategies for implementing nonstructural projects. To assist in this process, CPRA will be developing a data visualization and decision support tool based on an integrated database containing information on: current and future flood risks; the social, physical, and economic factors that make communities vulnerable; communities' adaptive capacity; and coastal flood risk reduction projects. The CCR decision support tool will be unique in its local applicability to coastal Louisiana, orientation toward community planning practitioners and interested citizens, and intuitive information visualization and user-oriented design.

Implications

The Coastal Community Resiliency Program encourages a broad range of strategies to reduce flood risk and support resilient communities across coastal Louisiana. Communities will be

better able to understand their current and future risks and also consider a range of adaptation options such as home elevation, residential/commercial flood-proofing, voluntary relocation, adopting land use plans or other locally appropriate planning tools. The CCR decision support tool will offer local officials, community advocates, and general citizens better understanding of their communities' physical and socio-economic vulnerabilities as well as their adaptive potential. The CCR tool offers a new user-friendly approach to the synthesis, presentation, and application/operability of data which enables users to interact with and harness the data in more meaningful ways.

Complexities of Resilience: Adaptation and Change within Human Communities of Coastal Louisiana

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Coastal ecosystems and particularly deltaic coastal ecosystems are among the most productive in the world, and this certainly is true of coastal Louisiana. The high natural productivity and diversity of ecological niches support a wide range of human activities. In coastal Louisiana, residents have a long history of fishing, hunting, cattle raising, and farming in a seasonal round of activities that limits their vulnerability to loss associated with any one activity. In more recent years, the oil industry added to the diversification with important employment and income opportunities for coastal residents. During boom times in the oil patch, farming and fishing declined in relative importance, but these activities continued to be practiced and remained as effective safety nets when the oil industry went into periodic decline.

Such resilience among residents of coastal Louisiana is increasingly challenged by a number of factors outside their control. These include eustatic sea level rise, increased strength of tropical storms, and land subsidence resulting in loss of wetlands. Communities and individuals are faced with several strategies as they face an uncertain future; some of these are more likely to retain "community" than others. In this paper we document how residents of coastal Louisiana are in the process of adapting to changing conditions. We document population mobility over the past thirty years to show that the people of coastal Louisiana already have been making difficult decisions to move, but have done so in a measured manner. We identify four different approaches that might be taken by coastal residents in the future, and argue that the role of science is to help people make the best decisions they can make.

Implications

Policy makers will be faced with difficult decisions as the Louisiana coast continues to change both through natural processes and coastal restoration efforts. This paper addresses the broader options available to communities, individual residents and to those whose decisions will affect these coastal populations.

Loss and Adaptation following the BP Oil Spill: Community Cohesion and Social Networks

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Research conducted on communities devastated by an oil spill indicates that communities often experience a degree of community corrosiveness, where members of the community will over time turn against one another instead of joining to assist one another. One year after the 2010 BP Oil Spill, data collected from 275 respondents living in 6 rural coastal communities indicates that the losses experienced by community members had a direct positive impact on their outreach to community members for dealing with their own response and recovery to the disaster. This article explores the sense of loss, connection to place and reliance on local social networks of support among adults affected by the BP Oil Spill. A keen sense of place among participants was revealed to influence the "loss" among rural participants who described changes to the landscape, economic restructuring, and the loss of shrimping and fishing as a way of life, among others. However, rather than turn on each other, residents indicated that they turned to each other in their time of need. These losses in the community are balanced against a strong desire to continue to live in places in which there are known social connections.

Implications

The investigation illustrates the power of place and its cultivation of social networks, and the need to recognize their importance in research concerning the impacts of oil spills on long term community recovery.

STUDENT PRESENTATION

The Making of an Inherently Resilient Community: How Drilling for Oil and Oystermen First Collided

Audrey Maass

Louisiana State University

Colten et al. described inherent resilience to be practices that communities engage in to cope with disruptive events. A community retains and passes down the practices associated with inherent resilience in their collective memory. The inherent resilience of a community is developed over time, yet the explanation provided by Colten et al. lacks a genesis of how this process developed as a result of the oil industry's entry into Louisiana. The foundations of these practices will be explored through historic court documents to find encounters between oystermen and oil spills. In addition to legal resources, I will also investigate newspaper articles and other historic sources to trace legal responses and public preceptions. Through these documents, I anticipate to find compelling evidence linking the responses to oil spills that occurred in the 1970s studied by Colten et al. with the events that occurred in the 1930s with new economic force of the oil industry. By identifying the emergence of the inherent resilience practices, this research will provide a basis for the initial responses to hazards. The initial response will help researchers further understand how cultures have adapted overtime to hazards.

Implications

Through exploring the genesis of inherent resilience, I hope to develop a link to Colten et al.'s documentation of responses to hazards by the communities in the 1970s. The ability to compare response to hazards created from oil extraction beginning through times that are more recent will provide an example of the adaptations that communities have made over time and how they have changed or improved. This adaptation process is relevant to the coastal restoration because it provides a community and individual level of effort made to ensure the ability to withstand the hazard. The processes employed at the local level in response to a hazard are critical in understanding and developing policy to mitigate future hazards. The practices employed can assist in shaping the government policies developed to protect or recover from a hazard in coastal Louisiana.

Modeling Land Use and Land Cover Changes in Coastal Louisiana Using Artificial Neural Network

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As one of the most vulnerable coasts in the continental USA, the Lower Mississippi River Basin (LMRB) region has endured numerous hazards over the past decades. The sustainability of this region has drawn great attention from international as well as local communities, wanting to understand how the region as a system will evolve under intense interplays between the natural and human factors. As an important indicator of processes on the earth surface, land use and land cover (LULC) changes reflect the results of the interactions between natural and human systems. This study utilized artificial neural network (ANN) to derive the transitional rules of LULC changes between 1996 and 2006 using 15 variables representing both human and natural factors. The derived transitional rules from the ANN were then applied in a cellular automaton to simulate future scenarios. The validation shows that the ANN model can predict the LULC changes with a satisfactory degree of accuracy. The simulation results indicate interesting trends of LULC changes in the ten years following 2006, including significant urban expansions in the northern part and continued land loss in the southern part along the coastline.

Implications

One of the most important aspects of this study is anticipating the future LULC scenario in the LMRB region according to the LULC changes observed in the past. The anticipation may provide valuable information for the management, planning and restoration of the vulnerable coastal region. Additionally, the outputs of the derived LULC model can serve as inputs for other natural and socio-economic models to achieve an integrated natural and human system analysis of the region.

Influences on Community Resilience: An Examination of Population Return to New Orleans Post-Katrina

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In late August 2005, Hurricane Katrina and subsequent levee failures produced catastrophic flooding in New Orleans, killing over fifteen-hundred residents, and forcing the evacuation of most of the local population. The authors examine patterns of repopulation within Orleans Parish as an indicator of community resilience to large-scale external disturbances. They pose two research questions: To what extent do patterns of recovery observed in natural systems after large disturbances yield insight into the recovery patterns of human communities? Also, what factors may account for variation in the resilience of coastal cities like New Orleans? The researchers analyzed mail-delivery data at the zip-code and census-tract levels in Orleans Parish before, and at monthly intervals after the storm through 2012, as an indicator of returning population. Cluster analysis of the data through 2008 yielded three distinct recovery patterns – "resilient", "resistant" and "susceptible" – similar to those of natural systems. Then, they used discriminant analysis to examine the 181 Census tracts of Orleans Parish and to estimate the relative influence of socio-economic and environmental factors of the neighborhoods on the rate of population return. They found that three factors – higher Katrina flood depths, greater percentage of African-American residents, and lower educational attainment – predicted patterns of population return for over 75% of the 181 Census Tracts within Orleans Parish. Of these three factors flood depth was, by far, the most important predictor of returning population, indicating that among those who experienced flooding of ten feet or more, even residents with sufficient economic resources to rebuild, within the first three years largely opted not to do so.

Implications

The findings yield evidence of similarities between recovery patterns of human and natural systems, thus, providing a useful, empirical categorization method to characterize coastal community resilience. Further, the study provides insights into the conditions under which coastal residents are more likely to return home following large-scale disturbances.

Louisiana's Coastwide Reference Monitoring System-*Wetlands* (CRMS)

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The Coastwide Reference Monitoring System-*Wetlands* (CRMS) is a state/federal partnership funded by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) and the State of Louisiana to monitor the effectiveness of individual restoration projects and the cumulative effects of the restoration program. CWPPRA has constructed more than 100 restoration projects using a variety of construction methods since its authorization in 1990. The CRMS design was approved by the CWPPRA Task Force in 2003 and construction of 390 monitoring sites that begun in 2005, was completed in 2007. Monitoring sites are located on private, federal, and state lands across Louisiana's coastal zone and are visited on a monthly basis to collect hydrologic and soils data, twice annually to collect elevation change data, and once per year for vegetation data. Aerial photography is collected approximately every three years for land/water analysis.

All data and products are available to the public and restoration professionals through a public website operated and maintained by USGS and CPRA. Feedback from the CWPPRA sponsors on utility of data summaries, visualizations, and improvements to tools are solicited annually and incorporated into the website. The CRMS analytical teams, consisting of scientists and information technology specialists, used ecological monitoring variables to create a Floristic Quality Index (FQI) for emergent marsh, a Forested FQI (FFQI) for forested wetlands, a Hydrologic Index (HI), and a Submergence Vulnerability Index (SVI). The data and indices are used to evaluate performance at the site, project, basin and coastwide scales. Monitoring reports produced on a three year rotation provide a more detailed evaluation of the performance of CWPPRA projects. This information is funneled back into the planning and design of future projects, is used to evaluate and adaptively manage constructed projects, and assist with close-out recommendations when the projects reach the year 20 life span.

Implications

Data collected through CRMS-*Wetlands* is used to evaluate the effectiveness of restoration projects and the CWPPRA program as mandated by the CWPPRA legislation passed in 1990. CRMS data and information inform the planning and design of future projects, is used to

evaluate and adaptively manage constructed projects, and to assist with end of project life recommendations when the projects reach the year 20 life span. The sites provide valuable information regarding wetland response to natural stressors such as drought, flooding, and tropical storms as well as manmade incidents. The indices developed from the data are presented in CRMS report cards which assess the condition of Louisiana's wetlands at multiple scales. In addition, the program provides data to fill information gaps and refine hydrodynamic and ecological models developed as part of the state's Master Plan.

Louisiana's Barrier Island Comprehensive Monitoring Program (BICM): Past, Present, and Future

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The System-Wide Assessment and Monitoring Program (SWAMP) being developed by the State of Louisiana, seeks the data necessary to develop management tools needed for a myriad of coastal management issues. The development of integrated multiple use datasets, has been the focus of the Barrier Island Comprehensive Monitoring Program (BICM) initiated by the Louisiana Coastal Protection and Restoration Authority (CPRA). Early development of BICM focused not only on integrated data collection along Louisiana's coast, but compilation and integration of existing data sets. For example, bathymetric survey data collected in 2006 served as a baseline for the program. Comparing this with earlier bathymetric datasets provided a basis for compilation of seafloor change over time and allowed immediate development of datasets for use in all aspects of Louisiana's restoration efforts.

The comparison of older data with newly collected data under the BICM program plays an important role in regional planning and ecosystem assessment. Additional information on sediment texture in conjunction with bathymetric data has not only aided in updating model geometries for project designs and ecosystem assessments, but also aids the development a much needed regional sediment budget which is an important component in development of a sediment management plan. A robust regional sediment management plan is key to well-planned and cost effective restoration efforts of Coastal Louisiana, and BICM will continue to provide data for future development of regional planning.

Implications

As CPRA moves to implement the 2012 Master Plan and continue to evaluate future actions, BICM will continue to provide necessary data and tools for planning, designing, and monitoring both individual projects and regional conditions at scales to allow for structured decision making and adaptive management of the Louisiana's barrier shoreline and it's restoration actions.

System-Wide Assessment and Monitoring Program

Richard C. Raynie

Coastal Protection and Restoration Authority

The Coastal Protection and Restoration Authority (CPRA) and its partners have allocated considerable resources and have made long-term commitments to restoration and protection of coastal resources in Louisiana. The Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) was implemented through the Coastal Wetland Planning, Protection and Restoration Authority (CWPPRA) to alleviate some of the challenges of project-specific monitoring and provide a robust framework with which to assess project and collective restoration program effectiveness. This programmatic monitoring allowed for streamlining and efficiencies in field work, improved data standards and comparability among stations, and a robust network of wetland stations to characterize ecosystem changes and high-resolution responses to environmental drivers.

Expanding on this concept, the Louisiana Coastal Area (LCA) Study proposed expanding this comprehensive wetland monitoring system to a System-Wide Assessment and Monitoring Program (SWAMP) which would build on CRMS-*Wetlands* to provide for similar programmatic monitoring for Barrier Islands and inshore and coastal waters. These were identified as the key components necessary to monitor and evaluate the LCA projects. The CPRA has developed and implemented the Barrier Island Comprehensive Monitoring (BICM) program, which was initially funded through the LCA Science and Technology program. However, a "Waters" analog to CRMS-*Wetlands* has not been developed to date, and CPRA is currently working with The Water Institute of the Gulf to evaluate and refine the SWAMP framework to provide additional programmatic monitoring guides for other critical restoration and protection parameters.

Implications

Efficiencies of scale and leveraging opportunities from multiple programs have been realized with CRMS-*Wetlands* and BICM. Restoration programs such as the Coastal Impact Assistance Program (CIAP) and LCA have utilized data from these programs; the 2012 revision to the state's Master Plan has heavily utilized data from CRMS-*Wetlands* sites for its decision support tools; and events such as the 2008 hurricanes Gustav and Ike, and the 2010 MC252 Oil Spill have utilized data from CRMS-*Wetlands* and BICM to document environmental baselines conditions and impacts from these events. Expanding this concept to incorporate restoration

AND protection needs of CPRA, and the associated improvements in data standards and data availability, will improve availability and access to the data necessary to plan, evaluate, and adaptively manage coastal resources.

From Boat-to-Fork: Lessons Learned from Market-Based Adaptation in Delcambre

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Across the United States, the resiliency (ability to adapt, while maintaining continuity in the face of change) of commercial shrimping communities is challenged by natural and human-made extreme events, fluctuations in shrimp populations, and competition from cheap foreign imports, as well as the rising prices of gas and other operating costs. This research compares the adaptive strategies of two shrimping communities. One case consists of commercial shrimpers in Delcambre, Louisiana; the second consists of a community of commercial shrimpers in Two Rivers, North Carolina. Data was collected through interviews, field observations, and document review.

Delcambre shrimpers have shown remarkable adaptation by implementing market mechanisms that supply seafood straight from the boat of fishers to the fork of consumers. These market adaptations assist smaller-scale fishing firms that are disproportionately affected by market volatility caused by natural or human-made disasters, environmental conditions, or price competition. At the same time, the shortened supply chain between producer and consumer creates extended social networks and broader social identification with and support of the local economy, increasing the resiliency of Delcambre shrimpers. The resiliency of Delcambre shrimpers stems from the support of governmental and non-governmental agencies, access to natural and infrastructural resources, and, most importantly, motivation at the local level.

The case of Delcambre shrimpers contrasts sharply with the experience of shrimpers in Two Rivers. Similar to Delcambre, the livelihoods of small-scale shrimpers in Two Rivers are threatened by extremely low dock prices, high operating costs, and socio-economic and environmental transformations. However, in addition to these factors, Two Rivers shrimpers also face local political and economic forces that minimize the importance of commercial fishing, and as a result decrease the resiliency of fishing communities. The adaptive strategies among Two Rivers shrimpers consist of household reorganization and changes in targeted fisheries, gear, and, at the extreme, occupations.

Implications

This research has program and policy implications for facilitating community resiliency. The comparison of Delcambre and Two Rivers illustrates different forms of natural and human

resources and institutional, organizational, and social support important in successful market-based adaptation and community resiliency. This research is relevant for all communities under pressure from environmental and socio-economic transformations, as well as governmental and non-governmental agencies hoping to facilitate successful adaption. Communities and agencies are not only supplied successful and unsuccessful cases of adaptation and their consequences for the resiliency of communities, but also gain insight into effective utilization and leveraging of natural, human, organizational, and capital resources.

Community Elevation: A Case Study of Delcambre, LA

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Delcambre, Louisiana, inundated with storm surge from hurricanes Katrina, Rita, and Ike began to elevate the housing structures of their community. What started as a few houses on the streets in the lower end of town turned into an adaptation implemented by more than half of the homeowners' in the community. This research begins by presenting a typology of elevation strategies used by homeowners, mapped using GIS to show the locations of the different elevation strategies implemented. With this strategy successfully implemented in the housing sector of the community, leaders initiated a directive to begin work on improving the community's economic recovery. In the spring of 2013, the parish government issued a request for proposals, the objective of which was to stimulate economic activity while assisting in providing a new, elevated grocery store since the town's grocery had been closed since 2005 as a result of Hurricane Rita's destructive storm surge. The lack of a grocery store created a hardship on the citizens; caused a revenue crisis for town government that lost its primary sales tax base and has been a major hindrance to other efforts relative to the recovery of the community. There is a consensus among the citizens that a grocery store and other retail outlets are necessary to Delcambre's recovery. This research will assess the impact of the elevation of housing and the grocery store and other small businesses of Delcambre on the town's overall long term recovery from the hurricanes.

Implications

There was much criticism in the years following hurricanes Katrina, Rita, Gustav and Ike concerning the amount of funding going into the recovery of disaster impacted coastal communities. The adaptation of elevation strategies by the community of Delcambre stands as an example of the successful implementation of a community elevating itself out of harm's way from future storm surge. Through the assistance of individual homeowner elevation grants and Community Development Block Grant program, this community stands today more resilient that it was before the disaster and has increased its likelihood significantly fewer damages and a quicker recovery from future disasters.

Adaptive Land and Water Management on the Coast: From Agriculture to Aquaculture in Pecan Island, LA

Kari Smith[1] and JoAnne DeRouen[1]

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The history of coastal Louisiana involves environmental changes and human adaptations to those changes. Pecan Island, Louisiana is surrounded by low lying marsh land prone to frequent flooding. Yet, its inhabitants have a long history of cattle farming. Ranchers convert wetland habitat to dry pastures for cattle grazing by constructing secure impoundments with low levees and pumping stations. As the dry soils of the newly created pastures oxidize and consolidate pastures subside below mean water levels. The levees prevent water from entering the pastures, but when breached by a storm surge these levees prevent water from returning to the Gulf of Mexico. If the surge incapacitates an impounded system, the pasture is abandoned to open water. This process of first turning wetlands to dry land then having them revert to open water has been repeated across large sections of Louisiana's southwestern coast.

This presentation reflects upon the research underway to examine agricultural land that has become hydraulically impounded as possible sites of intervention for aquaculture and other economic generators. The research questions include: What is the willingness of landowners to adapt to land loss and other coastal change by implementing new land and water management strategies? How has built infrastructure (levees, impoundments, etc.) impacted rates of coastal land loss, water movement and water quality? Can adaptive solutions such as aquaculture be used to create marsh work in these coastal areas? What would the design of such a solution look like? The research methodology includes the identification of appropriate impounded sites using geospatial analysis, conducting in-depth interviews with current land owners, hosting design charrettes to vet design proposals, and conducting water quality assessments.

Implications

The objective of this research is to determine if an alternative economic model (i.e., a transformative solution) could be used by landowners where they can adapt to land loss by moving from agriculture to aquaculture and restoring marsh areas. The implication of this research for future planning and implementation is the study of how communities adapt current land and water management strategies to changing environmental conditions.

Innovative Stormwater Management Strategies to Create a Sustainable Region

Cedric Grant

New Orleans, Louisiana

The Greater New Orleans Urban Water Plan began as an infrastructure reconnaissance study and has evolved into an infrastructure reinvestment plan built around water-based urban redevelopment. Thanks to a diverse and skillful team of architects, engineers and urban planners, the Urban Water Plan outlines a brighter future for the City of New Orleans through water management, leading to reduced flooding and subsidence. Through the important infrastructure investments outlined in this plan, we can make New Orleans a better place to live that is not only safer, but economically stable, by working with our environment instead of against it.

New Orleans and its surrounding parishes face unique challenges in water management going forward as water does not recognize political borders and we must explore creative ways to implement projects across parish and jurisdictional lines. Under the Urban Water Plan, we speak in one clear voice that we accept the challenge that we must learn to live with water.

Funding the Urban Water Plan is critical towards our region's long-term sustainability. The Greater New Orleans community at large needs buy-in to this vision. Therefore, community outreach and education are key components to the success of the plan. Further, the development of public-private partnerships will be important to achieving our shared goals of creating a sustainable environment that is resilient for our children and their own children in the future.

The City of New Orleans is committed to building a stronger and smarter region that through innovative water management strategies. The Greater New Orleans Urban Water Plan is our opportunity to create a template for water management that can serve as an international model of resiliency – a model leading to an enhanced quality of life, improved safety and maintained economic stability.

Implications

The Greater New Orleans Urban Water Plan can work in tandem with the 2012 Louisiana Coastal Master Plan and other master plans and processes. As a roadmap for addressing the region's urban water challenges, the plan builds upon existing flood protection systems (levees

and wetlands) by broadening the concept of “multiple lines of defense” to include urban water management.

Innovative Stormwater Management Tools to Address Our Flooding and Land Subsidence Issues

David Waggonner

Waggonner & Ball Architects
New Orleans, Louisiana

The Greater New Orleans Urban Water Plan focuses on water within the levees of three distinct "hydrological basins" in St. Bernard, Jefferson, and Orleans Parishes, and employs a layered framework as a base for re-examining the region's past and re-imagining its future. Located on the Mississippi River Delta near the Gulf of Mexico, survival in the region requires constant awareness of the forces of water, with "multiple lines of defense" to protect against high water in the Mississippi, hurricanes approaching from the Gulf of Mexico, and intense rainfall due to a subtropical climate. The barrier islands, wetlands, and other natural features of the Louisiana coast protect the region from the direct impact of hurricane storm surges. The federal levees and floodwalls at the project area's perimeter protect human settlement from high river waters and hurricane storm surges. Within the levees, complex systems of canals, pipes, and pumps protect against flooding caused by rainfall. These systems are inadequate to the challenges posed by a changing urban landscape and climate, and are the primary cause of subsidence in the region. The Greater New Orleans Urban Water Plan focuses on water within the levees—primarily stormwater, surface waters, and groundwater—and a new approach to managing the region's water resources.

In the Greater New Orleans of tomorrow, stormwater, surface water, and groundwater are managed together, as resources with which to enhance public spaces, revitalize neighborhoods, strengthen habitats, and provide opportunities for economic growth. Proposed retrofits strengthen the function of existing water systems, make use of undervalued water assets, and enhance key corridors. The Urban Water Plan is a comprehensive vision for the region in the 21st century, built as much on each basin's history, geology, and geography, as it is on shared challenges and opportunities.

Implications

The Greater New Orleans Urban Water Plan can work in tandem with the 2012 Louisiana Coastal Master Plan and other master plans and processes. As a roadmap for addressing the region's urban water challenges, the plan builds upon existing flood protection systems (levees

and wetlands) by broadening the concept of “multiple lines of defense” to include urban water management.

Louisiana's 2012 Coastal Master Plan, the City of New Orleans' Master Plan and the Greater New Orleans Urban Water Plan: Integrated Flood Protection and Building Resilient Communities

Mark Davis

New Orleans, Louisiana

A premise of the Greater New Orleans Urban Water Plan is to better integrate public and private actions into a comprehensive approach to managing stormwater and groundwater. The City of New Orleans is moving in this direction with the incorporation of stormwater management into the New Orleans Master Plan and the accompanying Comprehensive Zoning Ordinance. Further, in 2012 the State of Louisiana approved an update of its Coastal Master Plan. The plan is grounded in the recognition that the on-going collapse of Louisiana's coastal ecosystems poses a survival threat to the entire lower third of the State, including the Greater New Orleans region. Critically, the Coastal Master Plan acknowledges that community sustainability is dependent on the successful integration of coastal conservation and restoration, structural protection such as levees, and nonstructural measures such as elevation, building codes, and land use planning. By acknowledging the existence and nature of both risk and opportunity, the Master Plan can guide and reinforce actions such as those set forth in the City's Master Plan, including integrated water management.

The region is ripe with opportunities for infrastructure renovation and landscape repair: from legacy infrastructure like hidden unattractive canals that can be transformed into attractive and accessible waterways, to thousands of vacant lots and public rights-of-way that can provide space for water storage and create amenities and economic opportunities along the way. Over the next 50 years, inaction will cost our community nearly $8 billion in stormwater flood damage, a conservative $2.2 billion in subsidence damage, and another $600 million in avoidable insurance costs. Stormwater best management practices can reduce load demands on our aging infrastructure, clean the water, cool the air, create recreational amenities, contribute to raising the standard of living for all residents in an equitable way, and provide valuable real estate development opportunities.

Implications

The Greater New Orleans Urban Water Plan can work in tandem with the 2012 Louisiana Coastal Master Plan and other master plans and processes. As a roadmap for addressing the region's urban water challenges, the plan builds upon existing flood protection systems (levees

and wetlands) by broadening the concept of “multiple lines of defense” to include urban water management.

Persistence and Change – Mapping Community Resilience in Coastal Louisiana, 1930-2010

Scott A. Hemmerling

The Water Institute of the Gulf

Throughout the twentieth century, observed climate changes, major episodic events, and changing economic and social conditions have altered the landscape of coastal Louisiana in innumerable ways. Stresses and disturbances to ecosystems and ecosystem services have forced adaptation in resource-dependent human communities across the coast. In alternating pulses, humans have migrated toward the coast to harvest wetland, estuarine, and marine resources, and they have relocated landward in the face of coastal hazards or resource depletion. This long-term pattern demonstrates that mobility and adaptation are two of the most deeply entrenched traditions of the coastal population.

In some cases, these adjustments have resulted in an increase in community resilience, and in other cases, populations may begin to exhibit symptoms of insufficient resilience. Communities in which the economy is based on single crop, commodity-based agriculture often exhibit a reduced level of resilience. Cypress harvests in the Atchafalaya and Maurepas swamps, for example, gave rise to thriving mill towns that collapsed in the 1930s due to extensive deforestation. Other communities are able to maintain resilience through economic and technological adaptation and population migration. Sugar cane has persisted as a crop throughout the twentieth century, but supports fewer planters, laborers, and grinding mills today. This economic shift has contributed to rural-to-urban migration of former laborers even though sugar cane remains an economically important crop and still covers much of the natural levees in the lower parishes.

Historically, community population shifts have reflected ecological, cultural, political, and technological dynamics. Population adjustments and community-level economic adaptations have followed each system disturbance. An examination of the historical demographic shifts that have occurred in response to external triggers can allow community planners and coastal scientists to identify and work with communities that may have, through an increased frequency of external shocks, suffered a loss of adaptive capacity.

Implications

Coastal ecosystems, ecosystems services, and the communities that depend on them are constantly threatened by climate change and other stressors. Research has suggested that an

increased rate of exposure to perturbations and disturbances may reduce a community's resilience to future events. Additionally, communities that have developed a high degree of adaptive capacity through time may show an increased ability to respond and adapt to these external events. An understanding of the cumulative impacts of environmental and economic change on the human population and the ways in which communities have responded to change is vital to effective coastal land use management and coastal restoration and protection planning.

A Method for Knowledge Integration and Mapping to Inform and Enhance Future Coastal Planning and Implementation Efforts

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Making more informed coastal restoration and hazard mitigation decisions has become increasingly important given limited resources available for restoration and hazard mitigation projects, and the increasing magnitude of marsh degradation and loss across the Gulf of Mexico coast. An interdisciplinary team of physical and social scientists, State and Federal agency coastal managers, and fishers/resource harvesters of affected coastal communities collaborated on related studies with the goal of aiding restoration and hazard mitigation decision making by engaging local ecosystem knowledge holders in the process. Together they investigated the feasibility and benefits of integrating the traditional ecological knowledge (TEK) of coastal populations with geospatial technology and scientific datasets to assess how the integrated knowledge that results might inform project planning for coastal restoration and hazard mitigation.

Through these collaborative efforts, a more comprehensive and transferrable method of assessing localized stakeholder priorities and translating that information into a format compatible with existing coastal hazard mitigation and restoration decision-support tools was developed. The process developed involves recording TEK in a natural, egalitarian setting which is then converted into Geographic Information Systems (GIS) models that can be incorporated into the existing decision-making processes. This is achieved by using Remote Sensing (RS), science-based datasets, and GIS to produce mapping products that represent the local fishers' and harvesters' TEK.

Implications

The collaborative team developed a method for effective stakeholder engagement and a process for producing coastal restoration and hazard mitigation mapping products from information derived and prioritized with TEK. Moreover, the researchers used the stakeholder

engagement process to help address the general lack of understanding by physical scientists and managers/decision-makers of the value that TEK offers and to illustrate how TEK helps to bridge the communication gap that typically exists between scientists and traditional knowledge holders as the ecosystem is altered through coastal restoration projects, as well as hazards such as relative sea level rise, storms, flooding, etc. This collaborative approach that includes stakeholder groups will provide a "partnership" of knowledge to improve future coastal planning and implementation from what would be done without the TEK.

Community Resilience and Oil Spills in Coastal Louisiana

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The persistence of communities along Louisiana's coast, despite centuries of natural and technological hazard events, suggests an enduring resilience. This paper employs a comparative historical analysis to examine "inherent resilience," i.e., practices that natural resource-dependent residents deploy to cope with disruptions and that are retained in their collective memory. The analysis classifies activities taken in advance of and following a series of oil spills within Wilbanks' four elements of community resilience: anticipation, reduced vulnerability, response, and recovery. Comparing local inherent resilience to formal government and corporate resilience enables the identification of strengths and weaknesses of these different categories of resilience. It also helps answer the questions: What forms of inherent resilience capacity existed prior to the formulation of formal contingency plans? How have communities drawn upon their own capabilities to survive without the infusion of massive external assistance? Have externally managed contingency planning procedures integrated or bypassed inherent resilience?

Implications

With increasing emphasis by government agencies to bolster community resilience, this work identifies inherent resilience as locally sustained practices that formal capacity building efforts can target as a way to engage with pre-existing locally based capabilities and thereby fortify both formal and inherent resilience.

Field Observations in Support of Modeling Salt Wedge Dynamics and Lateral Sand Bar Dynamics in the Lower Mississippi River in Louisiana

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The Mississippi River Hydrodynamic and Delta Management Study is carrying out a major river channel observational and modeling program (MShydro). The field data collection campaign carried out by the CPRA team, which began in Spring 2012, is focused on two major regions in the lower river in Louisiana—lateral sand bars in the reach that is being considered for emplacement of relatively large river diversions as part of the State's 2012 Master Plan, and the lowermost reach where salt wedge processes are important. Lateral bar studies are designed to examine the suspension of bar sands at higher riverine discharges (e.g., >600,000 cfs). It is this suspension process over large dunes that serves as the major supplier of sand in the upper water column where it can potentially be captured by river diversions. The CPRA study focused on bars in the Bonnet Carre Spillway reach, and in the reach near Point a la Hache (river mile 52 to 39). Results will be presented examining bar evolution through bottom mapping, velocity surveys and measurements of suspended load and bedload dynamics. The salt wedge studies are focused on the reach downriver of Ostrica (rm 24) in lower discharge periods (e.g., <300,000 cfs). The study is in support of 1D and multiD modeling to determine whether water withdrawals as part of future diversion operations will increase the extent and duration of salt wedge penetration in the river channel, potentially impacting sediment trapping and shoaling of the navigation channel. In this sub-study, the observational campaign utilizes (1) acoustic Doppler and CTD/turbidity/LISST profiler studies to map wedge extent, (2) coring and geochronological studies to examine fine-grained sediment storage below the salt wedge, and (3) time-series studies using boat-based profilers and uplooking, bottom-mounted acoustic sensors, to examine tidal and discharge controls on wedge behavior.

Implications

Field observations collected as part of the MShydro project are a critical aspect for developing predictive numerical models that properly capture Mississippi River behavior. Data is utilized to (1) setup model grids using bathymetric/topographic mapping data, and to (2) calibrate and validate hydrodynamics and sediment transport parameters in the models. These models will be utilized for testing various restoration scenarios, particularly relating to the impact on the

river of larger water and sediment diversions. Field observations also are valuable to identify important physical processes that are not yet incorporated in numerical models.

Field Data Collection Effort Under the Mississippi Hydro Project

Thad Pratt
U.S. Army Corps of Engineers Research and Development Center, Coastal Hydraulic Laboratory

Historically, the Mississippi River (MR) played a significant role in providing sediment, nutrients, and fresh water to support Louisiana's coastal wetlands. As a result of dam and levee building during the last century, the suspended sediment load decreased, dramatically perturbing the balance between land building and loss in coastal Louisiana which occurs through subsidence and water/wave action. It is critical to evaluate and analyze methods of maximizing retention of this sediment so as to sustain a healthy deltaic coastal ecosystem. However, such effort is not possible without comprehensive field measurements (complemented by numerical modeling) of critical physical processes that govern the flow of water and sediment in the lower River. As has been evidenced in recent work involving measurements made in the lower River, between Belle Chasse and Venice, at Bonnet Carré and Old River Control, and the vicinity of West Bay Diversion, field measurements like those proposed here are critical for advancing understanding and comprehension of complex processes and for development of computational modeling tools for the lower MR, specifically in regard to large-scale river diversion scenarios. To date, a significant barrier to building realistic hydrodynamic and especially sediment transport models for the lower MR, has been the limited field data for the study reach. Complications arise in utilizing data extrapolated from the upper MR system in model development, due to: 1) decreased river surface gradients, 2) tidal modulation of river velocities, 3) saline wedge penetration, and 4) changing channel bed characteristics. These factors severely challenge the integrity and reliability of modeling and analysis efforts in the lower MR. It is important to collect additional field data in order to expand spatial and temporal coverage of high-quality comprehensive data sets over what has been done to date. These data are crucial to the success of this study.

Implications

Field data collection is a critical aspect for developing reliable multi-dimensional numerical models for the lower Mississippi River. These data are essential for model setup, calibration and validation of models used for evaluation of different restoration scenarios. Field measurements are also crucial for advancing understanding and comprehension of the complex physical processes associated with river hydrodynamics, sediment transport and morphology.

MRHDMS Data Delivery and Visualization on LCA.GOV

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The Mississippi River Hydrodynamic and Delta Management Study (*MRHDMS*) included a myriad of partners working together to collect, process, and analyze massive amounts of hydrological, biological, and physical data along the Mississippi River and its tributaries. A data management team was formed to help manage and apply long-term value to the collected data. The LCA website (*www.lca.gov/Projects/22*) is used as the primary data visualization and dissemination mechanism for the MRHDMS project. In support of the MRHDMS project, a new web map was designed and implemented to support both new and legacy data existing within the project area. The mapping application was designed around the data standards developed by the MRHDMS data management team. Within the MRHDMS project, the commitment to data standards promoted a convenient spatial data discovery mechanism to move between web-enabled spatial data and corresponding raw data files. As MRHDMS priorities drive web-enabled data availability, applicable data types are being displayed on the web map after the data is transformed into a standards compliant form through a series of data management processes. The mapping application will ultimately contain references to all MRHDMS data such as water quality data, multibeam bathymetry contour data, acoustic Doppler current profiler (*ADCP*) observation points and transect data, and bottom-grab grain size data.

Implications

The MRHDMS project represents one of the largest data collection efforts ever undertaken along the Lower Mississippi River. The ability to easily visualize and attain entire river sections of data has the potential to be very beneficial to project planners, resource managers, and the scientific modeling community. By providing a well-organized and intuitive data platform, the MRHDMS team is promoting the use of MRHDMS data to aid in essential future river project decision-making. Through cooperation with CPRA and USACE, the MRHDMS Data Delivery team works to create a user-friendly interface to help users traverse extremely large datasets in an efficient and practical manner.

Geomorphic Assessment of the Lower Mississippi River, Old River to Head of Passes

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The Geomorphic Assessment component of the Mississippi River Hydrodynamic and Delta Management Feasibility Study documents the historic trends in hydrology, sedimentation, and channel geometry in the lower Mississippi River. The assessment focuses on but is not limited to the river reach from Old River Control Complex to Head of Passes, and the time period from 1960 to the present. The geomorphic assessment tasks include data compilation, geometric data analysis, gage and discharge analysis, dredge record analysis, sediment data analysis, and development of an events timeline. Integration of the analysis results from each task allows the lower river to be characterized by observed morphologic processes on a reach by reach basis.

Temporal and spatial variability of the river channel geometry was evaluated, and erosion and deposition patterns and trends were determined for the study reach. Specific gage records constructed at key river gage stations provide insight into long-term trends of channel adjustment through aggradation or degradation. A probabilistic sediment budget developed for the study area presents the sediment transport capacity for sub-reaches while accounting for the uncertainties inherent in the measured sediment data. The impacts of dredging and other river engineering activities were evaluated to gain additional insight into interpretation of study results.

The geomorphic assessment highlights the importance of considering spatial and temporal variability when assessing morphologic trends. Morphologic trends on the Lower Mississippi River typically can occur over decadal timescales. Consequently, there is considerable uncertainty with assessments that only cover short time periods. Therefore, investigators must be cautious when assuming that short term recent trends reflect future conditions.

Implications

The geomorphic study is a seamless portion of the overall LCA MRHDMS and not merely as an isolated step that concludes with a transfer of data sets. The knowledge base acquired through the geomorphic assessment is a critical component of subsequent modeling and data collection efforts. The wider contribution provided by the geomorphic assessment is to establish the system context which will:

- Identify data gaps and the need for additional data;
- Support assessment of diversion alternatives and uncertainty;
- Aid in the interpretation of numerical model results;
- Anticipate potential long-term maintenance issues; and
- Allow the opportunity to propose a post-project assessment of the system and recommend a monitoring protocol for the project.

Adaptive Hydraulics-SEDLIB Modeling of the Riverside Impacts of Sediment Diversions in the Lower Mississippi River

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The Mississippi Hydrodynamic and Delta Management Study is a collaborative effort between the Army Corps of Engineers and the State of Louisiana to investigate flow and transport processes in the Lower Mississippi River, and how these processes can be most effectively managed. A significant aspect of this effort involves the investigation of the effects of various proposed management actions on flow, sediment transport, and morphologic change in the Lower Mississippi River.

One of the tools that has been employed to investigate these riverside effects is the Adaptive Hydraulics Model (AdH), coupled with the SEDLIB sediment transport library. AdH is a finite element numerical model with dynamic adaptive meshing capabilities. For this application, it is implemented in 2-dimensional (depth-averaged) mode. The SEDLIB sediment transport library is a multi-grain size, cohesive and cohesionless sediment type, sediment transport and morphology module. When linked to a depth-averaged hydrodynamic model, SEDLIB employs semi-analytic methods to account for the effects of vertical sediment stratification the water column; hence, it is considered a quasi-3D sediment transport model. Both of these tools have been developed at the Army Corps of Engineers, Engineer Research and Development Center, in Vicksburg, MS.

This paper details the results of AdH-SEDLIB simulations of the riverside effects of two proposed sediment diversions in the Lower Mississippi River. These diversions (the Mid-Barataria and Mid-Breton Diversions) are two of the sediment diversion projects proposed as part of the Louisiana Coastal Protection and Restoration Authority (CPRA) Master Plan. The modeled impacts of the proposed diversions on riverside hydrodynamics, sediment transport, and channel morphology are discussed.

Implications

Sediment diversions must be designed in such a way that navigation interests are minimally impacted. As such, the effects of sediment diversions on river channel morphology are a significant constraint to sediment diversion design. The numerical investigations discussed in this paper provide insight into the types of riverside morphologic impacts associated with sediment diversions, and hence yield information that can be used to inform sediment diversion design decisions.

Three-Dimensional Hydrodynamic and Sediment Transport Modeling of The Lower Mississippi River below The Bonnet Carré Spillway

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The focus of this paper is the 3-D unsteady flow simulation of sand transport in the Lower Mississippi River from downstream of the Bonnet Carré Spillway (RM 126; RK 203) to the Head-of-Passes (HOP, RM 0; RK 0). The period of interest includes hydrological years 2008 to 2011. The model is designed to assess and evaluate coastal restoration strategies. The existing conditions are simulated and the introduction of diversions is tested.

Pereira (2011) developed a three-dimensional ECOMSED model for the reach between Belle Chasse (RM 76; RK 122) and Main Pass (RM 4; RK 6) and simulated different diversion scenarios. In this study, the area of interest has been expanded (RM 126; RK 203 to RM 0; RK 0) to cover all locations under consideration for introduction of diversions. Delft3D, a code that allows a wider range of sediment transport and morphology formulations than ECOMSED, is used. The hydrodynamic/sediment transport model is applied to obtain information on the sand loads in the River, natural outlets and diversions.

The model is able to reproduce the suspended sand load measurements at peak flow (880,000 to 1,200,000 cfs; 25,000 to 35,000 m^3/s) but tends to underestimate the sand transport at low flow (<700,000 cfs; 20,000 m^3/s). However, most of the sand load is associated with peak flow and the model performs well for these conditions. The results agree well with the vertical sand concentration profiles and transect and vertical velocity measurements at different flow conditions.

The sand load in the main stem decreases as we travel downstream, mainly due to the presence of outlets and the subsequent loss of stream power. At high flows, the sand load values drop more than 50% between the Bohemia Spillway area (RK 51; RM 32) and the Head-of-Passes (RK 0; RM 0).

Implications

This study provides insights on the impact of potential river diversions in the Lower Mississippi River on three main resources available in the system: flow, energy and sediment. In particular,

this work covers alterations on outflows, sand loads and morphology due to the introduction of river diversions.

The main strength of this work is allowing the analysis of the full reach considered for the introduction of diversions, with a length of 202 km (126 miles) while including the level of detail provided by a three-dimensional model. The model permits a good evaluation of the global impacts on the area of interest, provoked by the introduction of a single diversion or a group of diversions.

Numerical Modeling of Sediment Diversions in the Lower Mississippi River

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Sediment diversions are considered and assessed as a strategy to connect the Lower Mississippi River to the surrounding bays and estuaries. In this study, numerical models are used to evaluate and compare the efficiency of diversions to capture and divert sediment and to study its impact on the morphodynamics of the Lower Mississippi River. The diversions are planned to operate at maximum capacity during the flood season, when the non-cohesive material (sand) is entrained into the water column and transported as suspended load.

This study includes the application of three-dimensional high resolution local models to an existing diversion of at the Bonnet Carré Spillway (RM 128), and potential sites being considered for diversions on both banks of the river: Upper Breton Sound (RM 90 to RM 80), Mid-Breton Sound (RM 68 to 58), Mid-barataria (RM 65 to RM 58). The numerical modeling is done using the open-source three-dimensional morphodynamic model Delft3D.

This research investigates the possible impact of the operation of one or several diversions on the sediment transport and morphology of the river and outfall channel. The analysis includes low and high flow conditions. The analogue model of the Bonnet Carré Spillway is used to help develop reliable models of future diversions.

Implications

Sediment Diversions are a restoration strategy that can be applied to build land in coastal Louisiana and other areas with large alluvial rivers. This study is investigates the critical parameters that affect the ability to capture and convey sediment to the receiving basins. Specifically, the study focuses on identifying suitable locations for the diversion intake, invert elevation, intake angle, and size. The models are developed, calibrated and validated with base on field data collected specifically with the resolution and level of detail needed to take advantage of the model capabilities.

Hydrodynamics and Salinity Modeling in the Lowermost Mississippi River and Delta

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The State of Louisiana's Master Plan calls for partially diverting the flow of the Mississippi River to Louisiana's estuaries, to transport mineral sediments in sufficient quantities to build land and help sustain coastal habitats. One of the many unanswered questions is weather the reduction in water in the main channel of the Mississippi would cause a change in the flow distribution among the distributary channels, and subsequently influence the salinity in the lowermost river and proximal receiving basins. Using a three-dimensional hydrodynamic and salinity transport model we test several hypothetical scenarios of diversions and resulting water and salinity balance, and examine the role of tides, wind stress and sea-level-rise in modulating currents and resulting flow and salinity distribution. We simulate hydrodynamics and salinity within the lower river and delta, and develop a numerical framework by which we can study interactions of the lowermost river and delta with proximal basins (such as the Barataria Bight, Breton Sound, etc.), and evaluate dynamics associated with the interaction of these systems during intermediate and low flow conditions in the river, combined with influence from wind stress, tidal straining, relative sea level, and changes in flow balance resulting from upstream diversions.

The model was calibrated and validated with observations of tides within the river and proximal basins, and salinity from observations conducted in the lowermost river during low flow conditions, where the presence of a salt wedge was reported and documented. The model reproduced tidal elevations and flow distribution in the distributary channels very well, and showed that flow distribution at low and intermediate flows is modulated significantly by tides. Furthermore, the model showed that the presence of a salt-wedge interacts with the distributary channel flow, influencing further the flow distribution in distributary channels and hence the resulting salinity flux into proximal basins.

Implications

With increasing loss of water and sediment as a result of diversions, the residual water in the main channel of the Mississippi River will be more susceptible to modulation by tidal currents, wind stress, and hence a likely change in the flow distribution at the distributary channels. This could have implication on the net sediment flux through the lowermost Mississippi River and delta, and as a result the salinity in the proximal basin may change. Moreover, salinity in

nearby receiving basin will also be reduced due to the introduction of lower salinity water from diversion, and ultimately, there might be a feedback between this re-distribution of water in the Mississippi River and receiving basins.

Utilizing Mississippi River Sediment as a Renewable Coastal Restoration Strategy

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The restoration and sustainability of the wetlands of coastal Louisiana hinge on the re-establishment of reliable sediment pathways to the marshes. The construction of Mississippi River Flood protection levees has deprived the wetlands of seasonal flooding of freshwater and associated sediment from the river. Restoration of these sediment pathways (or their surrogates) is critical to the wetlands. The two main approaches to accomplish this are: through the direct dredging of the Mississippi River and pumping of sediment into the marshes; and through sediment and freshwater diversions from the Mississippi River. This presentation examines the use of Mississippi River sediment as a reliable, renewable, and sustainable resource to directly restore wetlands and how this historical source of sediment can be reintroduced to critical areas through the design and construction of efficient sediment delivery pipeline systems.

In strategic areas of critical need, which simply cannot wait for the introduction of natural deltaic processes through diversions, the immediate placement of sediment is needed. The Mississippi River represents a sustainable and renewable source of critically needed sediments. Successful delivery of sediment from the river begins with identification and delineation of borrow areas within the river, design of dredging programs for these areas that take into account the numerous constraints (both physical and regulatory), the design of a delivery system or pipeline, and the successful placement of sediment for marsh creation. These design considerations, the benefits realized through the bundling of portfolios of projects for construction, and the regulatory and stakeholder environment in which the design must occur are discussed.

The use of Mississippi River Sediment as a renewable resource will be examined in the context of recent projects and modeling efforts that focus on borrow area availability, sustainability, and dredging constraints in the Mississippi River.

Implications

The future of coastal restoration and protection in Louisiana requires the rapid restoration of strategic regions that are already critically degraded and simply cannot wait for the benefits of diversions to be realized. One of the only potential rapid land building technologies to fill in areas of wetland that are collapsing into open water is through the use of sediment placement

for marsh creation. Finding sufficient, economic, and renewable/sustainable sources of this sediment is of vital importance to restoration and coastal protection efforts. Understanding where to dredge the sediment, the constraints, the opportunities for coordination between projects, and how to move this sediment over greater distances from the Mississippi River is a key element for current and future projects as part of the larger coastal master plan.

Borrow Area Monitoring and Management (BAMM) Program for Coastal Restoration in Louisiana

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With an exponential increase in restoration projects that focus on developing a sustainable ecosystem, it has become imperative to place emphasis on the exploration of potential sand/sediment resources and to manage the limited sediment resources for a cost effective and sustainable coastal restoration. To meet this goal, a Louisiana Sediment Management Plan (LASMP) was developed. The Borrow Area Monitoring and Management (BAMM) program is an integral part of LASMP.

The main objective of BAMM is to understand the evolution of borrow pits over time, especially the infilling (rate and types of sediment) and gradient of the pit-slopes as well as impact of dredging the potential borrow area over wave climate, sediment transport regime and on water quality. During the various phases of this program, geophysical and geotechnical surveys were conducted at eight borrow areas. Water quality (dissolved oxygen) was measured at six borrow areas. In addition, inventories of existing borrow areas in coastal Louisiana and their respective design characteristics and past hypoxia readings has been developed. As the project progresses, borrow area modeling, and data processing and interpretation of measured dissolved oxygen concentrations will also be undertaken. The combined information gathered during these efforts will be analyzed and will be used to provide recommendations on borrow area design.

Two of the six borrow areas surveyed for hypoxia are located offshore, but many of the current marsh creation and restoration projects in Louisiana specify that fill sediment will be obtained from borrow areas designed within interior lakes and bays. The use of “inland” borrow areas is governed by numerous restrictions and/or regulations. Most of these regulations focus on vertical and horizontal dredging limits. The impacts of these aspects of borrow area design on wave heights and energies, the surrounding marsh environment, and hypoxia are also not clearly understood. Therefore, the scientific basis of these restrictions and/or regulations needs to be investigated to determine whether these borrow area design constraints are justified.

Implications

The cost and the success of a project are influenced by the sediment selection process. Thus, a more thorough understanding of available sediment resources would allow for more successful planning and management strategies. BAMM, which aims to contribute to the protection and preservation of sediment/sand deposits, requires inter-agency coordination. This is, in part, to ensure that identified sand/sediment resources will not become inaccessible by oil and gas infrastructure. Detection and analysis of hypoxic conditions may help refine the depth of cuts prescribed during dredging of borrow areas, especially in more susceptible locations including those inland.

Building Land in a Delta from River-Sediment Diversions: Constraints, Potential, and Examples in the Mississippi River Delta

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The natural building of land in a coastal river delta is controlled by interacting rates of sediment supply from a river, retention of sediment in the receiving basin, and the combined effects of eustatic sea level rise and local subsidence. Temporal and spatial patterns in these interacting controls may be complex. Sediment supply is influenced by river stage and local hydrodynamics. Sediment retention is controlled by sediment type, waves, currents, morphology, and vegetation in the receiving basin. In the Mississippi Delta, subsidence rates generally increase downstream. For design and construction of manmade river-sediment diversions to build land, further constraints include a range of human needs.

The primary objective of this study will be to evaluate these controls, particularly the effects of sediment properties, waves, currents, and basin morphology, in the context of recent studies completed in the Mississippi River Delta (West Bay, Bonnet Carre Spillway, Lake Lery), and two ongoing receiving-basin studies for the Lower Breton Sound and Lower Barataria Bay river-sediment diversions proposed in Louisiana's Coastal Master Plan.

Implications

In order to most effectively build land from river-sediment diversions, we must efficiently use all sediment resources at hand. We must minimize loss terms such as subsidence, and maximize supply terms such as sediment discharge and retention. By studying examples for which these controls have been documented and sediment accumulation quantified, we can identify possible mechanisms for optimizing diversion design.

Effects of Freshwater Inflow on Fish and Shrimp in the Receiving Basin of a River Diversion.

Kim de Mutsert

George Mason University

Methods to restore Louisiana's estuaries include the reintroduction of Mississippi River water through freshwater diversions to wetlands that are hydrologically isolated from the main channel. The receiving basins can be expected to undergo ecological changes with the inflow of freshwater. One major diversion, Caernarvon, was studied to assess the effect of freshwater inflow on estuarine nekton (fish and shrimp) in the receiving basin, Breton Sound. With a field study and multivariate analyses was determined that salinity is the main driver of change in the nekton community. With a Before–After–Control–Impact study was determined that as a result of the opening, salinity in the impact area decreased, and the nekton community structure in the estuary changed significantly. Species of economical or ecological importance either increased in biomass or exhibited no response to the opening of the diversion. Higher abundances of small fish were observed in the area receiving freshwater flow, which is an indication that the area serves as a refuge from marine predators with a lower tolerance for low salinities. Because a salinity gradient was established, aquatic habitat was available to nekton species from a wide spectrum of salinity tolerances. Trophic subsidy from Mississippi River water may be in part responsible for the mostly positive changes; a combination of stable isotope and caloric density analyses indicated an increase in caloric content of nekton close to the diversion, which corresponded with a shift in the carbon source of the estuarine foodweb. An ecosystem model was built which corroborated the finding of the field study, and can be used to test the ecological effects of different flow regime scenarios. The model showed that if higher salinity areas remain in the receiving basin, as was the case with the Caernarvon flow regime, nekton species will remain and redistribute within the estuary.

Implications

Including river diversions in coastal restoration should not be discouraged because of presumed negative impacts on fish and shrimp. The ecosystem model can be used to help determine what freshwater flow regime existing estuarine nekton communities can tolerate, or what species-specific fish and shrimp biomass changes can be expected in the receiving basin.

STUDENT PRESENTATION

Sedimentary Dynamics of the Lower Mississippi River and Implications for River Diversions

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The sedimentary system of the Mississippi River is examined to determine how to utilize the sedimentary resources of the river to maximize land-building capabilities of diversions and minimize adverse effects to navigation. Field studies of the sedimentary dynamics of the lowermost 200 km of the river were carried out during spring floods from 2009-2013. The morphology of the Mississippi River in the region of interest is characterized by a series of alternating sand bars several km long divided by bend segments featuring little alluvial cover, resulting in a dynamic sedimentary system. Bed material (grains > 175 um) is sourced within a river reach as a function of local flow conditions (e.g., bed shear stress, bedform-induced turbulence) leading to a correlation between bed-material transport (in traction and suspension) and water discharge, while the transport of finer material (washload) is largely the result of upstream controls (e.g., basin runoff, hysteresis). These distinct pathways for sediment transport lead to a temporal divergence in sediment discharge maxima, whereby washload discharge peaks early during flood waves and bed-material discharge peaks with water discharge. Throughout a spring flood season, extended periods of high water discharge lead to supply-limited bed-material transport, and extreme water discharge events (e.g. May 2011) can have incongruent rates of bed-material discharge. Spatially, bed-material transport is concentrated within the lower portion of the water column over sand bars, while finer material is more homogenously distributed throughout the channel.

Specific results related to diversion design were observed at Alliance (RK100) and Bonnet Carre (RK204). A dredged sand bar near Alliance was observed to have been replenished with over 200,000 tons of sand during 2010-2011. While a substantial amount of sediment capture was measured during the Bonnet Carre Spillway opening in 2011, the subsequent loss of stream power led to shoaling downstream of the spillway.

Implications

Assuming that river diversions seek to maximize sediment-to-water capture ratio, the observation of two distinct pathways for sediment transport must be taken into account in the structural and operational design of diversions. Due to the spatially homogenous fine

distribution, the siting of diversions designed to capture this material is flexible; however these diversions must be operated during the peak fine discharge of rising flood waves. The location of diversions designed to maximize sand capture is more critical; these diversions should be sited near sand bars and designed to tap into deeper regions of the flow where suspended bed-material concentrations are greatest. Observations of the refilling of the bar near Alliance indicate that material removed by diversions may be renewable at annual time scales. It is important to reduce the quantity of water captured by diversions, such that the shoaling effects of the 2011 Bonnet Carre Spillway opening can be minimized.

Lower Mississippi River Sediment Diversions: Delta Building & River Impact Assessment Tool

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The Lower Mississippi River is flowing through Louisiana with an abundance of freshwater and sediment. These resources, valuable to the neighboring ecosystems, are confined to the leveed river until released through the passes where they are lost to the deep waters of the Gulf of Mexico. With the realization that the sediment starved deltaic basins to river's east and west are sinking and facing ever rising sea-levels, projects are proposing to re-connect the river to the delta plain and utilize the river's resources. It is vital that we use a holistic system approach on these projects where we not only evaluate the basin-side impacts of a single diversion but also account for its impacts on the Lower Mississippi River system and other existing and proposed projects.

To evaluate the system holistically, a box model was created to schematize a sediment and water balance for the Lower Mississippi River below Belle Chasse based on a paper by Mead Allison. The box model can display possible impacts both within the river and the receiving basin of a single diversion or the cumulative impacts multiple diversions. It is capable of estimating delta growth through geometric evolution of a truncated cone or uniform width in the receiving basins based on equations by Robert Dean and can calculate the impact on available freshwater and sediment within the Mississippi River in 1-mile increments.

A key advantage of the box model is its computational efficiency allowing for quick comparisons of long-term simulations of multiple diversions in just a couple of minutes. The box model's delta formation extents correlated well to those produced from the LCA Myrtle Grove Sediment Diversion and Land Building Analysis's Deflt3D results conducted by CPRA. The box model's performance will be evaluated alongside additional physically processed based modeling results as they become available.

Implications

With such an emphasis on river diversions today and the absence of a thorough assessment on the cumulative effects Mississippi River diversions have on the river system as a whole, including projects and stakeholders utilizing the river's resources, Louisiana could potentially negatively affect river navigation and unintentionally negatively impact other projects intended to restore and rebuild the coast. With this tool, we can rapidly evaluate the impacts from a single diversion on the river as well as the impacts of multiple diversions on the river and each other.

A Comparative Assessment of nutrient dynamics in the Caernarvon diversion, Bonnet Carré Spillway and Wax Lake Delta: Implications for Sediment Diversions

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In order to help stem the inordinate loss of wetlands occurring in coastal Louisiana, restoration activities have been refocused from simply connecting the adjacent marshes and coastal basins with the river to more effective sediment-delivery diversions. Our group has been investigating the nutrient dynamics, in particular, the removal of nitrate in the two large surface water diversions for the past decade; Caernarvon and Davis Pond. In addition, our nutrient dynamics research has also been applied to the 2008 and 2011 Bonnet Carré spillway openings, which operates at ~ 25 times greater flow rate compared to the other diversions. They are very different systems including the receiving basin; vegetated marsh for the large surface water diversion vs open water estuarine for the Bonnet Carré spillway. While denitrification dominates nitrate removal in the large surface water diversions, algal production dominates the N loss processes in the Bonnet Carré. These two different systems can provide us with important information for a better understanding of the nutrient dynamics associated with planned sediment diversions. Additionally, our recent work in the Wax Lake Delta, as a proxy for sediment diversion, provides information on both proximal and distal effects of a sediment diversion on the geomorphic setting of coastal Louisiana. The physical and financial difficulties of directly delivering sediment to a number of areas along the coastal will have to be balanced by benefits to the receiving basin and related coastal processes. The Wax Lake Delta system can provide us with reasonable expectation for how a future sediment diversion might operate.

Implications

This comparison among diversions will help set the stage for how a sediment diversion into an open basin might operate in terms of nutrient reduction and potential benefits to wetlands.

The NFIP: Program Overview and Fallout from the 2012 Reform Act

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The National Flood Insurance Program (NFIP) was created by Congress in 1968, making flood insurance available to people in communities that manage development so as to reduce future flood damage. The program offered policies at subsidized rates to properties built before a community received its initial Flood Insurance Rate Map (Pre-FIRM properties), and at grandfathered rates to properties built in compliance with a FIRM, basing those rates on risk-at-construction, rather than risk shown on a later FIRM.

Subsidies, grandfathering, and regulations have contributed to the NFIP now struggling with a growing inventory of flood-prone structures. A 2004 reform act that targeted repetitive loss properties was marginally successful, but today 2% of policies account for 30% of claims. Enormous payouts in Hurricanes Katrina, Rita, and Sandy so burdened the program that in July 2012 Congress took drastic action to "right" a program that appeared, perhaps wrongly, to be unsustainable over the long haul.

The Biggert-Waters NFIP Reform Act of 2012 (BW-12) directs FEMA to discontinue subsidies and grandfathering and to impose those changes on existing policy-holders. By October 2013, FEMA had initiated implementation of all requirements related to Pre-FIRM policies and has developed the tools it needs to implement the phase-out of grandfathered policies, beginning in late 2014. Premium increases are higher than predicted for policyholders who built to code and for policyholders who bought Pre-FIRM homes last year, unaware their flood insurance would sky-rocket at their first renewal potentially forcing them out of those homes.

Direct and indirect impacts of the reforms have been analyzed; legislative efforts to forestall implementation have gained traction and support. Even if some reforms are reversed, BW-12 has disclosed – creating opportunity to address - issues with the NFIP, the FIRMs, development standards, insurance rate setting, and the role of private insurers in administering the program.

<u>Implications</u>

The Biggert Waters Act of 2012 substantially impacts coastal and inland states that have large floodplains and extensive levee systems, imposing severe economic distress on their communities. As enacted, NFIP reform threatens the existence of many communities and potentially alters the imperative for protecting areas that will soon be depopulated by the

trickledown effect of increased flood insurance premiums – unaffordable homes and declining business viability. Where communities survive, their public resources will be diminished and diverted, rendering them less capable of contributing financially to coastal projects. Louisiana must address and resolve the many issues with flood insurance and floodplain regulation that have come to light because of BW-12.

Building a Coalition for Sustainable Flood Insurance

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The National Flood Insurance Program (NFIP) was designed in 1968 to offer affordable flood insurance to property owners to protect themselves against losses from coastal and riverine flooding. However, recent changes to the National Flood Insurance Program threaten to harm the very people the program was designed to protect. The Biggert-Waters Act of 2012 phases out subsidized and grandfathered rates for flood insurance policies which will lead to higher premiums for policy-holders. Properties built in accordance with FEMA requirements and applicable building codes may be considered out of compliance – even if the property at issue has not been subject to flooding. Complicating the problem is the roll out of inaccurate and incomplete FEMA maps that are inflating risk unnecessarily. The confluence of these two issues is causing rates to skyrocket 2000-3000% in some cases for property owners who have built just as the government required.

If unchecked, the consequences are clear and devastating. Owners will lose everything, values of unsellable properties will plummet, bank mortgages will go into default, local tax bases will erode, and economies will be eviscerated. Ironically, this will ultimately destroy NFIP itself, as policyholders will leave the unaffordable program in droves.

This session will discuss how dramatic premium increases are affecting homeowners, business owners, and industry across Louisiana and the nation. It will also discuss proposed legislative solutions to systemically rethink flood and catastrophic insurance is offered, and finally, it will talk about the national coalition that has been developed to promote these solutions.

Implications

The Biggert Waters Act of 2012 will negatively impact policy holders across coastal and riverine America. Action steps to date include the forming of a national coalition to address and advocate for affordable flood insurance, reform Biggert-Waters, and propose holistic solutions to catastrophe insurance.

Addressing Concerns of BW-12 Through the Community Rating System

Monica Farris

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As a result of the Biggert-Waters Flood Insurance Reform Act of 2012, many homeowners and business owners throughout the country will see a significant increase in their flood insurance rates. These significant increases may lead to the foreclosure of homes and businesses impacting entire communities. One way to address these increased rates is through the implementation of activities prescribed through the Community Rating System.

The Community Rating System (CRS) is a voluntary program that rewards communities who are participating in the National Flood Insurance Program (NFIP) and enforce floodplain management activities that go above and beyond the NFIP's minimum requirements. The goals of the activities promoted by the CRS include the reduction of flood damage, support of the NFIP and support of a comprehensive approach to floodplain management. Participating communities are rewarded for the implementation of such activities with reduced flood insurance premiums for the residents of that community.

CRS communities can receive credit for the implementation of nineteen different activities that fall under the categories of public information; mapping and regulations; flood damage reduction; and warning and response. The more credit earned by a community, the better the class ranking of that community and the higher the premium discounts received by residents. Discounts can be as high as 45% for residents in Class 1 communities.

As of May 2013, the highest class achieved by a Louisiana community is a Class 6. Through enhanced support of CRS activities and the increased participation of communities in CRS Users' Groups, communities can achieve higher class ratings; ratings that reflect increases in risk reduction and decreases in flood insurance rates.

Implications

Options for homeowners and business owners are limited as to how they can reduce the negative impacts of the Biggert-Waters Flood Insurance Reform Act of 2012. The Community Rating System (CRS) stands as an option for communities to address concerns related to increased flood insurance premiums on a community wide basis. Support for the implementation of CRS activities can lead to the development of a comprehensive floodplain

management program and reductions in flood insurance premiums. Moreover, CRS activities such as elevation of structures, public education and outreach, land use planning and the implementation of stronger building codes reflect the importance of a comprehensive nonstructural program as described in Louisiana's Comprehensive Master Plan for a Sustainable Coast.

A New National Weather Service Storm Surge Warning and Inundation Graphic

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[1]NOAA/National Hurricane Center

Hurricanes such as Katrina, Ike, and more recently Isaac and Sandy, have shown that communicating the storm surge hazard remains a challenge. Some people continue to emphasize the wind hazard and are not sufficiently equipped to make sound decisions regarding preparation and evacuation ahead of an approaching storm. The National Weather Service issues hurricane wind, rain-induced flood, and tornado warnings to cover the other main hazards associated with tropical cyclones, but no such explicit tool is used to communicate the risk of storm surge, the one hazard that has the potential to take more life and cause more damage in any event.

The need for improved communication has been highlighted by recent storms such as Sandy and Irene, which affected areas not normally accustomed to hurricane strikes. Even in a more experienced location like southeastern Louisiana, some people were surprised when storm surge from Isaac flooded areas that remained dry during Katrina.

The National Weather Service has engaged in a decade-long discussion to improve the communication of the storm surge hazard—accelerated, perhaps, by recent hurricane events. Working with social science researchers, the National Hurricane Center has engaged its users and partners to determine the best approach. This research concluded that an explicit storm surge warning, accompanied by high-resolution storm surge inundation graphics, was supported overwhelmingly by the emergency management and broadcast meteorologist communities, and that these tools would have the greatest potential to increase the understanding and awareness of, and response to, the storm surge hazard. The National Weather Service has aimed to implement an experimental storm surge inundation graphic in 2014, and experimental tropical cyclone storm surge watches and warnings by 2015. This presentation discusses the road taken and the path forward for improving storm surge communication via the Storm Surge Warning and additional storm surge products.

Implications

As the dynamic coastal processes continue to change the Mississippi River Delta landscape, the risk to storm surge will also change. With land loss, risk will increase for populations, farther and farther inland. As coastal land is restored, risk for these same populations will change.

Regardless of the success or failure of coastal restoration, the landscape will change. Because of the important role land, vegetation, and open water play in modulation storm surge, accurate and up to date data will be essential for the National Hurricane Center to effectively forecast storm surge risk. The impact of storm surge, in terms of human life and economic prosperity has been demonstrated over the past decade. An investment in good geospatial data will help protect it.

Morphodynamic Assessment of Sediment Diversions

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The project outlined herein focuses on developing numerical morphodynamic tools that can be used in planning and managing a system of sediment diversions. These numerical tools are validated through a carefully designed field observation program in the supply (Riverine) and receiving sides. The field observations on the riverine side include supplying bathymetric grid information for model setup, and water and sediment dynamics information about the channel water column and bed. Data collection in the receiving basins focuses on an improved understanding of the local-scale stratigraphy and geotechnical characteristics. These data will be utilized in the morphodynamic models to derive erodibility coefficients and loading coefficients of the evolving splay. Given that the surficial compaction rates (cm/y) may exceed rates of elevation change induced by sea-level rise or deeper subsidence, these factors will have a major influence on the land-building rates derived by the numerical models. Studies of hydrodynamics and morphodynamics of modern, active splays will be utilized as an analog to calibrate the receiving basin models, since the diversions are not yet constructed.

The morphodynamic models (Delft3D, 2012 Master Plan Eco-Hydraulics, Vegetation, and Wetland Morphology) developed here will be used to identify suitable (from both riverine and receiving basin points of view) diversion sites, assess the near term and long term morphological response of the river to diversions, capture the wetland building and wetland sustaining potential for each individual diversion as well as multiple diversions, provide insights into the time evolution of the delta formation; especially the early, near-range erosion phase, provide insights onto the coordination and management of each individual diversion and the full suite of diversions, as well as capture the impact of morphological changes and sea-level

rise and subsidence on receiving-basin water level, and hence, the potential impact on the sediment delivery of diversions.

Implications

The field observations and morphodynamic models developed herein will provide scientifically sound information to the planning process of a system of sediment diversions. Such tools will provide valuable insights and guidance to manage, coordinate, and operate a system of sediment diversions to maximize the land-building potential.

Development of Models and Tools for Planning for Sediment Diversions in a Systems Context

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In order to build a system of sediment diversions to efficiently and effectively build and maintain land, CPRA must develop the models and decision-support tools to properly plan, operate and adaptively manage sediment diversions. These models and tools would vary in complexity from coastwide planning models, such as the Master Plan models, to high resolution physically-based multi-dimensional models at each diversion location, to community engagement. Building off the work of individual projects, such as the Lower Barataria Sediment Diversion and the Lower Breton Sediment Diversion, CPRA has initiated the development of basin-wide three-dimensional models within Barataria and Breton Sound Basins. The basin-wide models will be able to provide information on hydrology, morphology, and water quality not only for operations at one diversion site, but also for basin responses to multiple diversion operations. These models supported by field observations along with other research and analysis tools are being developed to reduce uncertainties on key stakeholder issues including fisheries, nutrients, and socio-economic effects. The tools and research projects will enable input from stakeholders. These research activities are not only imperative for project planning, but also for management, operations and adaptive management of these important ecosystems and coastal communities. This presentation will provide an up-to-date status on the development of a system of models and tools that will support the on-going development, operations and management of sediment diversions.

Implications

Models and decision-support tools that are based in the best available physical and social science are essential to proper planning for coastal restoration projects, specifically sediment diversions. These tools are also a key to the operations and management of multiple diversions within a systems context. This presentation highlights the commitment of CPRA to the development of comprehensive basin-wide multi-dimensional models for Barataria Basin and Breton Sound Basin to inform planning and management decisions.

Calcasieu Salinity Control Measures (CS-065)

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The Calcasieu Salinity Control Measures project (CS-065) is one of several hydrologic restoration projects in the *2012 Louisiana's Comprehensive Master Plan for a Sustainable Coast (Master Plan)* and is currently being funded as part of the oil spill restoration plan. The purpose of the project is to manage salinities being introduced into adjacent water bodies through the Calcasieu Ship Channel to reduce the rate of wetland loss in the surrounding wetlands. The project intends to construct features to prevent saltwater from entering Calcasieu Lake through the Calcasieu Ship Channel. These features would control salinity spikes and would be constructed in a manner that would allow for the continued functioning and ideally improvement and increased viability of the Calcasieu Ship Channel and the Port of Lake Charles. The study area begins at the eastern rim of Sabine Lake, extends to the western rim of Grand Lake, and continues north above the Gulf Intracoastal Waterway from the Gulf of Mexico. As it was originally conceived in the *Master Plan*, the project would protect between 3,047 acres to 21,648 acres of wetlands, depending on the sea level rise scenario analyzed, and cost approximately $405M. As part of the planning process, the team will further refine the *Master Plan* project by evaluating various alternatives, comparing impacts from each alternative to the future without project condition, and then choosing the best alternative in order to achieve or exceed the desired restoration goals as outlined in the *Master Plan*. The project is expected to choose the best alternative (tentatively selected plan) by Fall 2014.

Implications

This project will quantitatively assess the salinity propagation into the Calcasieu Ship Channel and surrounding region, quantify the resultant effects on the regional wetland morphology and vegetation, and provide location-specific data to support the modeling efforts of the project. The resulting information will be used for this project, but can be used for other restoration activities in the area.

Houma Navigation Canal (HNC) Lock Complex (TE-113)

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The Houma Navigation Canal (HNC) Lock Complex is located in the vicinity of the city of Houma, Terrebonne Parish, Louisiana, and is part of the Morganza to the Gulf of Mexico Hurricane Protection Project. The HNC Lock Complex is also a key component of the Increase Atchafalaya Flow to East Terrebonne Project. The HNC Lock Complex is a hydrologic project with its primary purposes being flood control, salinity control, freshwater distribution, and navigation. The structure will stay closed except for navigation access. Operations of the structure will be crucial to meeting the project purposes.

During the feasibility design phase, various lock sizes and configurations were evaluated to determine which was the most feasible. The feasibility of constructing the lock and floodgate structures using float-in technology was evaluated relative to using traditional cast-in-place methods. In addition, different types of floodgates were also considered (sector, barge, horizontal hinged). Meeting with stakeholders, reviewing feasibility design alternatives, and discussing project goals and purposes have given good input for determination of the final design and operation of the structure. Stakeholder discussion included design constraints, environmental benefits, existing features, relocation of levee projects, basin wide modeling, synergy with basin projects, protection and restoration, economics of final construction costs, mitigation, navigation access, and future operations and maintenance of the structure.

Implications

Demonstrate hydrology with the ability to control and distribute freshwater beneficially throughout the Terrebonne Basin and how the structure is part of a larger, systematic restoration program. Demonstrate storm surge protection ability. Show how coordination between stakeholders and ensuring stakeholder needs are met on a large structure while reducing costs and minimizing adverse impacts of the structure. This will provide valuable information to coastal managers for planning of future coastal protection and restoration project and programs.

Increase Atchafalaya Flow to Terrebonne Project

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The Terrebonne coastal marsh system is critically starved of freshwater, sediment and nutrients, resulting in extensive wetland loss. If left unchecked, it could potentially result in collapse of the entire wetland system in the region significantly increasing the exposure of communities in Terrebonne, St. Mary and Lafourche Parishes to the risk of surge from tropical events.

The Increase Atchafalaya Flow to Terrebonne project will utilize freshwater and sediment from the Atchafalaya River in order to build, sustain, and maintain wetlands within the Terrebonne Basin. The study area encompasses over 900,000 acres, including coastal marsh south of the GIWW at Morgan City eastward to the Houma Navigational Canal and Houma. The project concept as described in the 2012 Master Plan includes dredging to increase the potential conveyance capacity of GIWW and installation of a bypass structure at the Bayou Boeuf Lock. This is intended to convey sediment laden Atchafalaya River water farther into Terrebonne percolating southward into the wetlands. The dredge material will be beneficially used to create a further 1,900 acres of marsh south of the GIWW.

The project was recommended in the first implementation period of the 2012 Master Plan, and is projected to build, sustain, or maintain 13-27 square miles (8,300-17,300 acres) of land over 50 years. Contingent to the success increased introduction of sustaining sediment and freshwater into the system is the ability to not only optimize internal distribution within the system but also the retention of freshwater and reduction of penetration of storm surge and saltwater intrusion from the south. Currently, this project is in the planning/pre-engineering phase and is evaluating various alternatives. A selected plan is expected in Summer 2014. Additionally, this project is included in the list of projects to potentially be funded as part of the oil spill restoration plan.

Implications

This project will provide large-scale ecosystem restoration to an area of coastal Louisiana that is currently mostly isolated from freshwater and sediment inputs from the Mississippi and Atchafalaya rivers. Over the next 50 years significant land loss is expected across much of the study area negatively impacting the coastal ecosystem and increasing the risk of exposure of St

Mary, Lower Terrebonne and Lafourche communities to the Gulf of Mexico. This project will function synergistically with many other coastal restoration projects proposed in the study area including the HNC Lock Complex.

Stable isotope and nutrient analysis to determine sediment sources in the Río Cruces Estuary

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The geomorphic evolution of the Rio Cruces Wetland after the earthquake 1960 Valdivia earthquake shows a series of complex (yet predictable) spatial and temporal patterns within the study area. The environmental sequences recorded sediment cores from the site can be related to other environmental processes and issues, including: historic changes in water quality; point-source and non-point source contaminant loading; sediment transport and depositional patterns; and historic land use change. This presentation evaluates the changes in the relative contributions of different sediment sources over time in the post-earthquake recovery of this large estuarine wetland.

The key to understanding the system is to understand the stratigraphy. The timing and magnitude of the sediment contributions from the various different sources is important to contextualize any changes (or lack thereof) recorded in the core data. The diverse aspects (resuspension of sediment by waves, tributary sediment influx, urban sediment discharges, etc.) of the depositional record and changing sedimentation rates since 1960 are discussed.

Stable isotope and nutrient analysis were used to determine the most likely sources of sediment. For example, nitrate observations demonstrate ongoing sediment inputs from the sides-tributaries, with a strong signal from agricultural runoff, while the main stem of the Rio Cruces is largely clean. Observations of PO4 suggest a surface input, as in NO3, with highest values downstream from a sewage outlet for the town of Valdivia. Comparison of Carbon isotope values (δ13C) from core tops and core bottoms also demonstrate the influence of tributaries, which follows a logical progression, with high input terrestrial carbon post-earthquake, followed by increasing phytoplankton production. Core $\delta^{15}N$ values show an upland vegetation signal of about 1 per mille, increasing by about +3.5 per mille downstream from cattle ranching operations. The combined influence of these diverse sources of information is then used to derive a more complete sedimentation history for the wetland.

Implications

The natural geomorphic response of this system was sedimentation on the former floodplains, eventually returning the geomorphology to its pre-earthquake condition. While this system presents an extreme example of sedimentation driving response of a coastal ecosystem to disturbance, the wetland system created by the earthquake provides an ideal environment to

study vegetation and sediment response to changes such as subsidence or sea level rise. Studies of environmental change often need to include the establishment of relative and absolute time sequences in deposited materials through the analysis of sediment core samples, while at the same time determining the source of sediments that are driving change in the system. The approach used in assessing the Rio Cruces response is flexible enough to be adapted to studies of coastal wetland response in a diverse array of habitats and geographic locations.

Sediment coring and post-earthquake recovery estimates in the Río Cruces Estuary

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The May 22nd 1960 Chilean earthquake caused extensive subsidence in the coastal and landward areas in the vicinity of Valdivia, Chile. The subsidence deepened coastal rivers by 1-2 m, creating extensive shallow banks (now wetlands) in many rivers including the Río Cruces. The geomorphic response of the Río Cruces Wetland to the initial disturbance was evaluated, and sediment accumulation histories from cores were used to predict the recovery towards pre-1960 conditions. Sediment cores from the subtidal areas of the Río Cruces were lithologically described then analyzed for particle-size distribution, microfossils, and 210Pb, 137Cs dating.

Four main facies were identified in the sediment cores: pre-earthquake floodplain soils; tsunami or flood units; post-earthquake adjustment, and fluvial sediments. Based on the core data, the shallow banks along the Río Cruces will shoal in less than 100 yrs (<50 yrs from present). The time estimates for recovery to a floodplain state are estimated to be in the 100–200 yr range due to uncertainty in compaction rates of the organic rich sediment. Based on these estimates, the submerged mid-lower reaches of the Río Cruces are at the limit of being a good seismic recorder and it is possible that this setting would under represent large events if they had recurrence intervals less than several centuries.

Based on these examples it appears that tidal range has an effect on recovery times, with low to modest tidal ranges having lower aggradation rates compared to the larger tidal settings. However, sediment composition is also predicted to be an important modifier, with high OM content sediments slowing recovery time due to high rates of autocompaction with the transition to a subaerial setting.

Implications

Our findings show how wetland sedimentary response to base level changes can change over time. Sedimentation was rapid in the first several years after the earthquake, gradually declined into the 1970s, increased in the 1980s, and increased further after the late 1990s. The increase in sedimentation since the 1980 s could be due to changes in land-use in the Rio Cruces watershed (deforestation and agriculture) which may have caused nutrient loading and increased Eutrophication. In addition, wetland succession is also likely playing a part, with

increased emergent macrophytes (e.g. Juncus) causing increased baffling and trapping of sediment that might otherwise be exported downstream. Understanding the wider implications of the response of coastal wetlands to both isostatic and eustatic changes in base level is an essential part of wetland management and remediation efforts.

STUDENT PRESENTATION

Salt marsh-mangrove structural gradients: Implications for restoration within a shifting ecotone in Louisiana and across the Northern Gulf of Mexico

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In the northern Gulf of Mexico, climate change is expected to result in mangrove range expansion at the expense of salt marshes, which could affect some ecosystem goods and services. To determine how soil properties and processes may be affected by mangrove expansion and forest development, we compared plant-soil interactions across mangrove structural gradients in three different ecotones: one each in Texas, Louisiana, and Florida. At each ecotone, we sampled 9 different mangrove sites that spanned the mangrove forest structural gradient, utilizing height as our criterion, as well as 3 salt marsh sites (in relatively close proximity) (36 total sites). At each site, we quantified plant community composition and structure in different strata, as well as soil physicochemical and porewater properties at multiple depths. Our findings suggest substantial differences between the three ecotones, likely resulting from regional variations in major abiotic factors. The Florida ecotone has highly organic soils and maintains the most developed forest, with some black mangroves attaining heights greater than 8 m. The tallest mangroves in Louisiana's deltaic-dominated ecotone were slightly greater than 4 m in height. Finally, Texas's low-precipitation ecotone has higher porewater salinities, a salt marsh plant community that is dominated by succulent halophytes, soils with low levels of organic matter, and shorter mangroves less than 4 m in height. Of the three locations, mangrove forest development (i.e., increase in height) in Texas appears to be exerting the largest impact on soil development (i.e., promoting soil organic matter development). These findings enhance our understanding of how mangrove expansion into salt marsh may impact ecosystem goods and services.

Implications:
Coastal wetlands support a suite of ecosystem goods and services (e.g., storm protection, shoreline stabilization, habitat for wildlife, nutrient cycling, carbon storage). Mangrove expansion into salt marsh may affect some of these goods and services. By examining the salt marsh-mangrove ecotone in three different locations across the northern Gulf of Mexico, our research will help inform coastal managers and scientists of the ecological changes associated with mangrove restoration and mangrove range expansion.

Black mangrove (*Avicennia germinans*) restoration ecology: Understanding tolerance limits to guide restoration

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Black mangrove (*Avicennia germinans* (L.) L.) grows at its North American latitudinal limit within coastal salt marshes of Louisiana, USA, where further expansion is believed to be limited by the occurrence of periods of freezing temperatures. The earliest reported observations of black mangroves in Louisiana date to at least 1938 when they were observed in barrier island salt marshes. They have since expanded northward into southern salt marsh habitat as well.

When black mangrove is included in coastal salt marsh creation projects in Louisiana, a choice must be made as to whether containerized seedlings are used as the planting unit, which can be costly on a large scale. Black mangrove propagules, or younger seedlings, may represent a less expensive restoration method, particularly on a coast subject to periodic freezing episodes. To enhance restoration success via propagule dispersal or younger transplanted seedlings, potential differences in physiological tolerances of black mangrove life history stages to low temperature and environmental stressors typical of restoration sites were investigated. Results regarding cold temperature tolerance indicate that life history stages ranging from dispersal stage (propagules floating in salt water) to stranded stage and seedling stage all display similar tolerance to chilling. However, freezing events (-6.5 C) were most detrimental to stranded propagules because of tissue damage and subsequent fungal infestation, whereas dispersal stage propagules were least affected because of apparent insulation provided by frozen salt water. Other results indicate that 6-month and 18-month old seedlings have similar tolerance to elevated substrate salinity levels, water table depth and hydrologic regime. An average water table depth of -15 cm to -30 cm below the soil surface appears optimal for above- and belowground production. We have also identified the range of elevations (hydrologic regime) in field sites where natural propagule establishment and survival have been observed. Therefore, several life history stages may be effectively utilized under different suites of restoration scenarios and environmental constraints.

Implications

Black mangrove is often considered a desirable component of the target plant community at salt marsh restoration and creation projects within its range. Establishment success of any plant species is greatly enhanced when a thorough knowledge of the species tolerance limits to key environmental factors is available to guide project design. This presentation will discuss our current knowledge of the environmental conditions required for the successful establishment, survival and growth of black mangrove. Of these factors, marsh platform elevation is typically the most important since it determines the site hydrology. Successfully establishing woody species at a restoration site at the same time that herbaceous species are being planted can be very difficult. At Louisiana sites where both smooth cordgrass (*Spartina alterniflora*) and black mangrove are desired, it may prove most efficient to establish the smooth cordgrass first. If a viable source of black mangrove propagules is present in the area, natural establishment of black mangrove may be possible. Similarly, human-assisted dispersal of propagules into an established smooth cordgrass marsh may be a more cost-efficient means of establishing black mangrove than planting black mangrove seedlings.

STUDENT PRESENTATION

Effect of elevation and soil properties on black mangrove (*Avicennia germinans*) survival and growth in a created tidal saline wetland

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In tidal saline wetlands, plant community development and restoration outcomes are greatly influenced by site elevation and soil properties. Elevation strongly influences critical tidal wetland abiotic regimes (e.g., inundation and salinity) which govern the distribution and abundance of wetland plant species. Soil properties also influence abiotic conditions and the availability of resources needed for plant survival and growth. Black mangrove (*Avicennia germinans*) is often employed in tidal saline wetland restoration efforts due to its high salinity tolerance and capacity to provide important ecosystem goods and services. However, the optimal abiotic conditions required for black mangrove survival and growth have not been fully investigated in Louisiana.

The influence of soil properties and elevation on black mangrove survival and growth was investigated on a Louisiana tidal saline wetland restored with dredged material and planted with black mangrove and smooth cordgrass (*Spartina alterniflora*) seedlings in December 2012. We established sampling plots in two distinct areas of the created marsh platform, both along elevation gradients. In one area, we utilized a geostatistical sampling design (plot clusters stratified along parallel transects). In the other area, we used a stratified random sampling design. Transplant survival and live and dead vegetative cover was visually estimated. We also collected soil cores for soil physicochemical analyses (geostatistical area only) and determined the elevation of each plot. Preliminary results suggest that black mangrove survival co-occurred in association with smooth cordgrass in the intertidal elevations and extended slightly upslope, but then decreased rapidly to zero at a distinct elevation threshold. Higher elevation sites were either bare or colonized by succulent halophytic vegetation.

Implications

Black mangroves are an important component of Louisiana's coastal wetlands that provide many important ecosystem services, including storm protection and provision of habitat. Successful restoration of coastal wetland habitat is dependent on achieving the appropriate environmental conditions needed for plant establishment and growth. By identifying the suite of soil and elevation

characteristics required to optimize the establishment and survival of black mangrove and other plant species in created wetlands, results from this research can be used to improve the design protocols for Louisiana's current and future coastal wetland restoration and creation efforts. The findings from this research will also serve as baseline data for continued monitoring of this site to identify longer-term changes in elevation and plant community composition.

Variability in the Socioeconomic Effects of the BP Oil Spill: Ethnographic Findings from Gulf Coast Communities by Place and Economic Sector.

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The environmental effects of the 2010 BP oil spill are well known and are being extensively researched. By contrast, socio-economic effects on Gulf Coast communities are receiving relatively little scientific attention. This paper presents findings by applied anthropologists conducting a multi-year ethnographic study of the spill's socio-economic effects in selected coastal parishes and counties in Alabama, Mississippi, and Louisiana. Results from the first two years of fieldwork (2011-12) show wide variability in short-term effects along several axes. Communities experienced different patterns of change, influenced by proximity to the spill and fisheries closures but also due to pre-existing characteristics of population and economic structure, experiences with prior disasters, and types of social organization. Economic sectors and sub-sectors felt the effects of the spill in a variety of ways over time, with differences between the seafood harvesting and processing sectors, the offshore oilfield and shipyard/fabrication industries, and more or less skilled and/or mobile workers. These effects interacted dynamically in real places among real people. For example, two neighboring businesses might experience greatly differing effects based on their connections to an economic sector. Or, two people employed in one economic sector might experience different effects based on where they lived, their job status, or their interactions with particular social networks. Using scientific data generated through ethnography, this paper describes socioeconomic effects of the oil spill not generally captured by statistical demographic measures or quantitative surveys, including short-term change and information about social relationships, the broader context, and socio-economic categories and processes invisible to statistical reporting.

Implications

The socio-economic effects of the BP oil spill varied not only with proximity to the Gulf and ties to the commercial seafood industry, but through a variety of factors including the economic sector people worked in and their place in that sector, participation in and exclusion from social networks, success or failure in securing compensation, and the mix of livelihoods available in a given community. This study came to these findings through a community-based team ethnographic methodology. Ethnography is a scientifically valid methodology for collecting

socio-economic data on the effects of oil spills and other processes creating social change in coastal Louisiana. Ethnography produces scientific data not generally captured by frequently used methods like surveys and statistics. Research organizations that invest in long-term relationships with community partners create the conditions for the longitudinal study of social change processes in coastal communities. Such longitudinal data is critical to regulatory and scientific bodies' mission of understanding the human dimensions of coastal degradation and restoration.

Living Amid Uncertainty: Social Effects of the *Deepwater Horizon* Disaster

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Many social and economic effects of the *Deepwater Horizon* oil spill stemmed from – or were exacerbated by - the ongoing uncertainty associated with the disaster. Questions surrounded every aspect of the disaster, from the technological issues such as cause of the explosion and the efficacy of various efforts to stem the flow of oil, to the biogeochemical ones such as the fate of oil and dispersants in the Gulf of Mexico, to the socioeconomic ones such as who would be compensated for spill-related losses, when, and how. Lacking a clear, agreed-upon authority or expert to whom to turn, each individual, household, organization, and community was forced to sort out for itself who and what to believe, and to adopt a perspective and then justify or legitimize it. Questions about whether or not to eat seafood or invest in a local business persisted long after the spill and continue to create conflict and increase divisiveness. The authority gap also opened the doors to many new people and perspectives. During the first year after the explosion, the cacophony of voices coming from every direction – from petroleum and seafood suppliers to international environmental organizations and attorneys – was overwhelming for many and added to the stresses of this event. Over time, as the global media shifted its attention elsewhere, quieter, more moderate voices could be heard. Still, ongoing litigation, a sluggish economy, and huge sums of money directed at research highlight ongoing uncertainty regarding the claims process, the condition of major Gulf fisheries, human health and mental health effects, the fate of deepwater petroleum exploration and production, and more. This presentation describes and analyzes the social effects of uncertainty on those living and working in small coastal communities in the first three years following the Macondo well blowout.

Implications

Oil spills cause environmental effects which, in turn, create significant social and economic impacts. Equally significant, though, are the effects of the *management* of the spills and their effects, by both designated and self-appointed authorities. Understanding the nature and extent of those effects can inform policy and practice in planning for and responding to future spills.

Finding Patterns and Drawing Conclusions: The Challenges of Measuring Social Effects

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The social effects of the *Deepwater Horizon* disaster on coastal communities depend on factors such as the location of the community; whether or not oil came ashore nearby; the social and political dynamics in the community; prior experience with oil spills and contamination from industry activity; the mix of industries and sectors within those industries that dominated local economies; the role of community members in the cleanup; the community's connections to regional, state, and national resources; and the ethnic makeup of the residents. For example, the ability of individuals and communities to secure resources in the wake of the disaster was affected by the states in which they lived and whether or not they were classified as Native Americans or undocumented immigrants. Add that the disaster began during the worst recession the region had experienced in decades and followed years of unusual economic activity tied to post-hurricane rebuilding, and it is clear that the challenges of measuring the social effects of this disaster are many. This presentation provides a brief history of the foundations of social impact assessment (SIA) and early 20th century efforts by U.S. social scientists to create and use techniques such as social indicators to provide bias-free information to policymakers and bureaucrats. It then discusses the challenges that led to rejection of deterministic approaches and in favor of more open and interpretive understandings of social impacts and uses the study of the social effects of the *Deepwater Horizon* disaster to illustrate what can and cannot be understood through demographic, ethnographic, and community-based participatory approaches.

Implications

Understanding and responding to the social effects of major oil spills and other disasters, as well as the effects of coastal restoration efforts, requires accurate information about those effects. Researchers and policymakers must be aware of and take into account the strengths and limitations of various approaches to gathering and analyzing such data.

Finding Patterns and Drawing Conclusions: The Challenges of Measuring Social Effects

The social effects of the *Deepwater Horizon* disaster on coastal communities depend on factors such as the location of the community; whether or not oil came ashore nearby; the social and political dynamics in the community; prior experience with oil spills and contamination from industry activity; the mix of industries and sectors within those industries that dominated local economies; the role of community members in the cleanup; the community's connections to regional, state, and national resources; and the ethnic makeup of the residents. For example, the ability of individuals and communities to secure resources in the wake of the disaster was affected by the states in which they lived and whether or not they were classified as Native Americans or undocumented immigrants. Add that the disaster began during the worst recession the region had experienced in decades and followed years of unusual economic activity tied to post-hurricane rebuilding, and it is clear that the challenges of measuring the social effects of this disaster are many. This presentation provides a brief history of the foundations of social impact assessment (SIA) and early 20th century efforts by U.S. social scientists to create and use techniques such as social indicators to provide bias-free information to policymakers and bureaucrats. It then discusses the challenges that led to rejection of deterministic approaches and in favor of more open and interpretive understandings of social impacts and uses the study of the social effects of the *Deepwater Horizon* disaster to illustrate what can and cannot be understood through demographic, ethnographic, and community-based participatory approaches.

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Caminada Headland Beach and Dune Restoration, the First Use of Ship Shoal Sand for Restoration

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Over the last century, the Caminada Headland has experienced significant shoreline erosion and land loss to its marsh, beach, and dune habitats as a result of storm overtopping and breaching, saltwater intrusion, wind and wave induced erosion, sea level rise, and subsidence. To address this significant shoreline erosion rate, averaging >35ft/yr, the CPRA is utilizing Coastal Impact Assistance Program and 2008 State Surplus funds to create dune and beach habitat. High quality beach compatible sand will be transported approximately 27 nautical miles from Ship Shoal in Federal waters to the Caminada Headland. This is the first time that Ship Shoal sand is being used for a restoration project.

The purpose of the Project is to protect and preserve structural integrity of the barrier shoreline and restore hydrologic conditions, ecosystem processes, and habitats. Restoration will protect and sustain significant and unique foraging and nesting areas for threatened and endangered species. Adding sand to the headland also provides a sediment source to sustain barrier beaches adjacent to the Headland.

Placement of sand began in August of 2013 and is expected to be complete by May of 2014. Project features include placement of approximately 3.3 million yd^3 of material to restore 31,000 ft of beach and dune. The typical dune width is 290 ft with a target elevation of +7 ft NAVD 88 and the typical beach width is 65 ft with a target elevation of +4 ft NAVD 88. The sediment is being mined from Ship Shoal with a cutterhead dredge, placed in scow barges, and then transported to Belle Pass where it is being suctioned out of the barges and pumped onto the headland.

Implications

Ship Shoal, estimated to contain >900 million yd^3 of sand, is a unique feature on the otherwise muddy Louisiana shelf. Given the need for sand to restore shorelines and wetlands in coastal Louisiana, the shoal has been studied for decades and designated by Bureau of Ocean and

Energy Management (BOEM) as a Significant Outer Continental Shelf Sediment Resource protecting it from future infrastructure development. Much of the sand within Ship Shoal cannot presently be mined due to existing oil and gas infrastructure. To use this Federal sediment resource the CPRA negotiated a lease with BOEM. This project represents the first time this resource or any offshore shoal has been mined and used for coastal restoration purposes in Louisiana.

Cameron Parish Shoreline Restoration

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The Cameron Parish Shoreline Restoration Project site extends from the Calcasieu west jetty, westward about 8.7 miles to just west of Holly Beach. The project shoreline is retreating 5- 30 ft/yr. Along much of the shoreline, the sand chenier, which acted as a barrier between the Gulf of Mexico and 40,000 acres of freshwater wetlands and infrastructure, is severely or completely eroded. Because of the extensive erosion, Highway 82/27 is the only barrier that separates the Gulf from the wetlands and uplands for much of the project site. CPRA is utilizing 2007 and 2008 State Surplus funds to deliver and place sand for shoreline restoration with the goal of having the shoreline position in 20 years, to be at or seaward of the current shoreline position along the project site. To accomplish this, CPRA will transport high quality beach compatible sand from Sabine Banks sand shoals, approximately 20 miles offshore. This is the first time that Sabine Banks sand is being used for a restoration project.

Collection and delivery of sand will be accomplished by two ocean-going hopper dredges that will dock inland on the west side of the Calcasieu Waterway and then have the sand in their hopper pumped out through pipelines for placement along the shoreline. There will be no dune construction but rather a sand berm ranging in width from approximately 150 feet to 300 feet, with a maximum height of 5.5 feet, NAVD 88, with sand fencing constructed along the landward edge of the berm. Placement of about 2 million cubic yards of sand began in August of 2013 and is expected to be complete by February of 2014.

This presentation will discuss the project implementation along with challenges and lessons learned from design, permitting, and construction.

Implications

The implications for future coastal planning and implementation are discussed in the lessons learned pertaining to design, permitting, general project management, and construction challenges for coastal restoration using offshore borrow sources. The body of work put forth by the project team, designers, and constructors, can and will serve as a primer for future similar

projects. Additionally, groundwork is in place to utilize and expand two high-quality borrow sites within the Sabine Banks area which contain in excess of 8 million cubic yards of sand. Mining and obtaining this sand will require entering into a lease agreement with the Bureau of Ocean Energy Management (BOEM).

Compactional Subsidence and Barrier Island Restoration: Caminada-Moreau Headland Subsidence Study

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The Caminada-Moreau Subsidence Study (CMSS) was conducted in cooperation with Applied Coastal Research and Engineering, Gahagan & Bryant, LSU (Coastal Studies Institute), and CPRA to evaluate the geological framework of deltaic deposits at the Caminada-Moreau Headland and monitor the impact of fill placement (approximately 5 million cubic yards (mcy) of Outer Continental Shelf (OCS) sand) on the rate of compactional subsidence for approximately 100 feet of the geologic column. Geologic borings were obtained at four locations, and geodetic survey measurements are being collected to monitor subsidence associated with various depth horizons at three of these locations within the beach restoration design template. Benchmarks were established using geodetic GPS procedures (+/- cm-level accuracy) and will be monitored for the next two years to document subsidence trends associated with beach restoration. The project encompasses four phases which include an evaluation of the existing geological profile; an evaluation of existing and predicted subsidence prior to and after restoration; the installation of 10 subsurface anchor monuments; and precise monitoring of changes in benchmark elevations after beach restoration. Subsurface benchmark locations for monitoring site A were installed at 23 ft, 45 ft, and 66 ft below the ground surface. Benchmark locations for monitoring site B were installed at 22.5 ft, 52 ft, 68 ft, and 91.5 ft below the ground surface, and measurements for monitoring site C are being recorded for benchmark elevations at 26.5 ft, 44.3 ft, and 88 ft below site elevation. This study is being funded by CIAP (Coastal Impact Assistance Program) as part of the Performance Evaluation and Science Monitoring Project. This is a first-of-its-kind study as no direct measurements of subsidence and its partitioning with depth have been attempted to date in the nearshore or barrier island shorelines of south Louisiana.

Implications

Barrier island restoration is a significant component of the restoration strategy listed in the 2012 Master Plan, providing dune and backbarrier marsh habitat for storm surge and wave reduction for interior marsh habitat. A primary question regarding this and other beach

restoration efforts in Louisiana relates to subsurface compaction associated with sediment overburden on compactible deltaic deposits. Although greatest compaction is expected within near-surface mud layers, quantifying differences in compaction at various locations within the shallow geologic section provides a method for assessing compactional subsidence associated with beach restoration projects. This information is critical for designing placement elevations to maintain post-construction elevations that meet environmental requirements for restoration. Also, these data should be invaluable for calibrating/validating compactional subsidence models for use with future beach restoration projects along the barrier island shorelines of south Louisiana (e.g., Rosati, 2009).

STUDENT PRESENTATION

Using the late Holocene stratigraphic record to guide Mississippi Delta restoration: 3. Constraining subdelta progradation rates

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While it is well acknowledged that land-building in the Mississippi Delta was punctuated by avulsion events that have occurred every 1-2 kyr throughout the middle to late Holocene, little is known about the rate of subdelta progradation following these avulsions. The development of optically stimulated luminescence (OSL) dating presents an opportunity to determine the age of fluviodeltaic sediments, which was previously extremely challenging with radiocarbon dating. OSL directly dates clastic sediment deposition based on the last light exposure of buried quartz grains and is therefore highly suitable for resolving this knowledge gap.

In this study, we develop an OSL dating strategy for river-mouth bar deposits and use OSL dating to constrain the progradation rate of the Lafourche subdelta in the Mississippi Delta. New field data for the Lafourche subdelta are presented as lithologic cross sections and interpretations of depositional environments, showing dramatic changes along Bayou Lafourche. In the upstream reaches, sedimentation occurred primarily by overbank deposition which produced a succession of mud-dominated fluvial facies that overlie a discontinuous layer of peat. In the downstream reaches, Bayou Lafourche prograded into a shallow bay environment which produced a sand-rich succession similar to that seen in the modern Wax Lake Delta, with shell-rich pre-delta bayfloor muds at the base, overlain by laminated prodelta silty muds, then a 2-3 m thick homogenous layer of mouth-bar sands bounded at the top by fluvial overbank deposits. We use OSL dating to constrain the beginning of upstream overbank sedimentation by sampling sediments directly above the peat layer. In the downstream reaches, a sampling strategy is employed to date the deposition of mouth-bar sands by taking multiple samples from various depths within these sandy units. From these results, we estimate the progradation rate of the Lafourche subdelta.

Implications

The broader goal of this work is to provide information that can guide Mississippi Delta restoration efforts by quantifying an important metric of delta evolution. The progradation rate of the Lafourche subdelta may indicate the progradation rates that can be expected in emergent land in the region. This can apply to land-building in the Wax Lake Delta as well as at

engineered river diversion sites. Through the use of the late Holocene stratigraphic record, we provide information about progradation rates in the Mississippi Delta over centennial timescales; timescales which are significantly longer than the annual to decadal range of data available for modern, active systems.

STUDENT PRESENTATION

Spatial and Seasonal Variability of Sediment Respiration and Nutrient Fluxes in a Developing Subdelta: the Wax Lake Delta Atchafalaya River Delta Estuary

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The Wax Lake Delta [WLD] is one of the few areas of land gain in coastal Louisiana, and in its unmanaged state, is one of the best models for land creation by a river diversion. To gain a better understanding of the interaction of land-building and biogeochemical processes in developing river deltas, we evaluated the spatial and temporal variability of sediment respiration and nutrient fluxes and potential controls on these processes in the WLD and Atchafalaya River Delta Estuary [ARDE]. Sediment/water cores were collected across a range of depositional environments by sampling at 12 sites along three complementary transects. All three originated from the same deltaic channel and extended either offshore through the ARDE up to ~ 25km offshore of the sub-aerial delta; up the channel and onto a developing mouthbar island; or out of the channel and onto a sub-aqueous ridge. Benthic fluxes were quantified on four occasions to evaluate the influence of river discharge and temperature on rates: May of 2012 and 2013 to contrast period of peak seasonal river discharge (and intermediate temperatures) during years of low flow (2012) and above-average flow (2013); August 2012 during low river discharge and higher temperatures; and October 2013 when water temperatures are comparable to spring but river flow is low. Sediment respiration rates and net nutrient fluxes were calculated from the change in dissolved oxygen and inorganic nutrient concentrations over the 24 hour incubations. Preliminary results indicate that benthic respiration rates increase as water moves away from the central deltaic channel along all three transects in all seasons. These changes are driven by changes in sediment organic matter quantity and quality (% organic C and N). Sediment respiration is primarily controlled by sediment organic matter quantity and quality and increases with temperature within a given depositional environment.

Implications

Large-scale river diversion projects are planned as a primary restoration tool to combat land loss in coastal Louisiana. Yet, the interactions between sedimentological environment and biogeochemical processes are poorly understood. We address this current knowledge gap by examining the spatial and seasonal patterns and controls on sediment respiration, a key regulator of nutrient cycling and indicator of ecological functioning. This approach allows us to

identify environmental (and seasonal) conditions that may improve water quality in a delta-restored system. For example, water quality is likely to be related to organic matter fluxes and lower temperatures, which typically coincides with annual spring peak discharge of the Mississippi-Atchafalaya River System. As a natural analog for land created by a river diversion, the observed conditions in the WLD and ARDE can be utilized to more accurately predict the biogeochemical functioning of diversion-created deltaic systems.

STUDENT PRESENTATION

Benefit-Cost Analysis for Hazard Resilient Construction and Retrofitting Techniques

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Designers and builders have a vital role in reducing the financial impact caused from natural hazard events through improved design and construction. Significant information about best practices and code-plus practices exist, but little information is available to evaluate the extent to which implementation of these practices is economically advantageous to owners over a variable number of years of building ownership or occupancy. This presentation will discuss analysis methodologies to calculate benefit-cost ratios of hazard resilient construction and retrofitting techniques by comparing expected loss reduction (benefit) with the cost of improved construction components and techniques. Wind and flood hazards and commonly-employed enhanced construction techniques will be considered to identify and rank practices based on benefit-cost ratios, calculated for increasing years of occupancy. Building information modeling (BIM) is used to rapidly apply the analysis methodologies to multiple configurations of single family buildings to develop generalized benefit-cost data for code-compliant and code-plus wood-framed homes. Loss reduction analysis will utilize the Hazus Wind Model and commonly used flood depth-loss functions, such as those developed by the U.S. Army Corps of Engineers. The methodology and analysis persuaded may be extended to the community scale through application to multiple building occupancies.

Implications

Mitigation recommendations for retrofitting existing structures, and utilization of code-plus designs for new structures, aid in the creation of more resilient housing that provides the benefit of loss reduction for natural hazards. However, these techniques have costs that need to be considered (in term of the future benefits) for rational decision-making. Underlying motivation is to reduce the long-term cost of wind and flood through an analytical economic assessment to identify the relationship between the cost and benefits of a specific hazard resilient construction or retrofitting techniques.

STUDENT PRESENTATION

Larval Crab Distribution in the Gulf of Mexico

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Pelagic dispersal involves travel over large distances in a harsh environment, which leads to high larval mortality. Despite the risks of predation and encountering an inhospitable environment long-distance pelagic dispersal is common in marine invertebrate and fish species. Blue crabs, *Callinectes sapidus*, begin their larval (zoeal) phase offshore from the adult's home estuary and circulate through the northern Gulf of Mexico for approximately 30 days before settling near shore. During that time the zoea undergo seven to eight molts.

From zooplankton sampling in 2010 and 2011, we mapped the spatiotemporal distribution of zoeal stages of *Callinectes* in the northern Gulf of Mexico. The distribution of zoea from our samples gives us previously unknown information about the offshore life history of these crabs, including the distribution of different size classes and the seasonality of the spawning events. Blue crab larvae are distributed along the coast of Louisiana from near shore up to the 50 miles offshore limit of our sampling.

Implications

This research relates directly to the economically important coastal blue crab fishery of Louisiana. In a dynamic coastal environment the impact of pollutants and changing climate will be varied and hard to predict. The offshore stage of the blue crab is not well understood and this research expands the knowledge of the dispersal process and spawning areas, increasing our ability to effectively manage the crab fishery and spawning grounds now and in the future.

STUDENT PRESENTATION

Influences on Household and Community-Level Mitigation Efforts and Adaptations to Coastal Hazards in Louisiana

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Abstract:
The presentation will summarize the results of a survey of approximately 100 residents and local officials who attended workshops and/or requested copies of the Louisiana Coastal Hazard Mitigation Guidebook (Wilkins, et al. 2008). The objective of the research is to provide insights into the conditions under which residents and local officials of south Louisiana communities are more likely to adopt and successfully implement measures of adaptation to and mitigation of coastal hazards. The research questions posed are both theoretically sound and thoroughly practical. First, given that these individuals have demonstrated an interest in reducing exposure risks, why do some follow through with action and others do not? What contextual factors – like wealth, education, or experience with flooding – may make it more likely that residents will act? Also, what types of actions are more likely to be implemented? A second set of questions will address practical aspects of how best to deliver technical information to residents of coastal communities.

The guidebook is designed to give local stakeholders the technical information necessary to implement specific risk-mitigation and adaptive measures. The measures range from householdlevel strategies such as strengthening existing structures, to collective, non-structural measures including land-use and hazard mitigation planning. The survey will examine respondents' knowledge about coastal hazards, impressions of the guidebook, and the extent to which they have adopted measures to make themselves safer. The presentation will include the results of multivariate regression analyses, with dependent variables representing the level of implementation of adaptive measures derived from the survey. The independent variables or "influences" are drawn from the social-ecological resilience literature and will include measures

of “exposure” to coastal hazards (such as damages from previous storms), socioeconomic vulnerability of respondents, and community and individual “capacity to adapt” (such as the tax base and total parish government budget, and the knowledge of respondents).

Implications:

The research results will further both theoretical and applied knowledge of human responses to increasing coastal hazards, and will help inform future educational and community engagement efforts of the Louisiana Sea Grant College program and other NGOs working to enhance the capacity for resilience among coastal communities.

STUDENT PRESENTATION

Tidal Modulated Flow and Sediment Flux through Wax Lake Delta Distributary Channels: Implications for Delta Development

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In this study, a depth-averaged Delft3D model of the Wax Lake Delta was developed to simulate flow and sediment flux through delta distributary channels. The hydrodynamics and sediment transport were calibrated using existing measurements of velocity and sediment concentration across multiple distributary channel transects taken during a single flood event. The calibrated model was then used to simulate full spring-neap tidal cycles with several representative flow and sediment flux boundary conditions, with grain size variation in suspended load represented using two fractions. Flow and sediment flux results through various distributary channel cross-sections were examined for spatial and temporal variability with the goal of characterizing delta development processes at the scale of a single bifurcation and along the entire channel network over the range of modeled tide and flow conditions.

Since its subaerial emergence after the 1973 flood, the Wax Lake Delta has grown through seaward channel extension, subaqueous mid-channel bar formation, and channel bifurcation. The formation of relatively stable bifurcations in the delta has controlled the resulting channel network and subaerial landscape development. Model results at two particular bifurcations with varying degrees of asymmetry are examined in light of proposed equilibrium conditions. The flow and sediment flux distributions at both bifurcations show variability through the tidal cycle and at different input discharge magnitudes.

Additionally, the trends in flow, velocity, bed shear stress, and sediment transport are examined along primary distributary channels from the delta apex to the receiving basin. Here we show that tidal modulation of currents and backwater effects influence suspended sand transport in the distributary channels, and acceleration during ebb-tide has the capacity to suspend sand in the most distal reaches during lower flows. The basinward-increasing transport capacity in Wax Lake Delta channels indicates that erosive channel extension could be an important process even during non-flood events.

Implications

The role of tides and variable flow regime in Atchafalaya Bay delta development has been traditionally downplayed in favor of a river-dominant view where deposition during extreme floods is primarily responsible for the resulting morphology. In this study of the Wax Lake Delta, the tidal range and varying flow influence the balance between erosional and depositional delta growth and the resulting delta channel network. The Wax Lake Delta is one of the few land-building locations along the eroding coast and is frequently cited as a model for the potential efficacy of sediment diversions. Proposed pulsing diversion operational schemes would isolate diversion-built landscapes from riverine flow and sediment input for most of the year, increasing the influence of non-flood processes whose effects on delta development are not as well understood. Modeling of these processes in existing deltas can increase the understanding of their influence on the subaerial land development from diversions.

STUDENT PRESENTATION

Decadal trends in nutrient input from four major rivers in southwest Louisiana to the Gulf of Mexico

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Nutrient enrichment has been considered as one of the most important causes for the summer hypoxic conditions in the near-shore waters of the northern Gulf of Mexico. While many studies on nutrient loading from the Mississippi-Atchafalaya River have been conducted, little is known about nutrient inputs from other coastal rivers in southern Louisiana. In this Study, long-term (1980-2009) daily discharge and monthly water quality data were collected from the U.S. Geological Survey and Louisiana Department of Environmental Quality to investigate the decadal trends in nutrient input from the Sabine, Calcasieu, Mermentau and Vermilion Rivers into the Gulf of Mexico. River gauge stations and water quality monitoring locations were chosen based on their long-term data availability and proximity to the coast. A log-linear regression model was developed to estimate daily, monthly and annual loads of total Kjeldahl nitrogen (TKN) and total phosphorus (TP) of the four rivers. Our study found that the Mermentau and Vermilion Rivers draining intensive agriculture areas had significantly higher TKN and TP concentrations when compared with the Sabine and Calcasieu Rivers. TKN and TP mass inputs of these rivers varied largely over the past 30 years, and the input of TKN was much higher than the input of TP. TKN and TP fluxes were much higher from Mermentau River basin (~940 kg km^{-2} yr^{-1} TKN, ~200 kg km^{-2} yr^{-1} TP) and Vermilion River basin (~1080 kg km^{-2} yr^{-1} TKN, ~360 kg km^{-2} yr^{-1} TP) than those combined from the Sabine River and Calcasieu River basins (~710 kg km^{-2} yr^{-1} TKN, ~60 kg km^{-2} yr^{-1} TP). In the past 20 years, TKN and TP fluxes from the Mermentau and Vermilion River basins declined by 10-40%, suggesting that agricultural best management practices may have prevented nutrient leaching.

Implications

This study provides insights into the long-term nutrient inputs from the Sabine, Calcasieu, Mermentau and Vermilion Rivers. The information can help develop effective basin nutrient management strategies to protect Louisiana's coastal ecosystems.

STUDENT PRESENTATION

Total Organic Carbon loading from Louisiana's four major coastal watersheds to the Gulf of Mexico

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Riverine transport of organic carbon to the oceans plays a significant role in the global carbon cycling. The input provides crucial sources in food web of estuarine ecosystems. In this study, we utilized long-term (1980-2009) records on river discharge and total organic carbon (TOC) concentration of the Sabine, Calcasieu, Mermentau and Vermilion River to assess interannual variability and decadal trends of carbon input to Louisiana's southwest coast. Rating curves were developed for each of the four coastal rivers to estimate daily, monthly and annual loads of TOC. Our study found that in the past 30 years, Mermentau River has the highest TOC concentration (mean: 10.5 mg/L) when compared with Sabine (mean: 8.4 mg/L), Calcasieu (mean: 7.3 mg/L) and Vermilion Rivers (mean: 9.2 mg/L). No significant difference in TOC concentrations was found between the 1980s, 1990s and 2000s for all the four rivers. TOC inputs of the rivers varied largely over the past 30 years, and the variation was primarily flow regime dependent. On an annual average, the Sabine River discharged 5.4×10^4 t TOC during the 1980s, 7.7×10^4 t TOC during the 1990s and 5.9×10^4 t TOC during the 2000s into the Gulf of Mexico. The Calcasieu, Mermentau and Vermilion Rivers showed a much lower annual TOC delivery, when compared with the Sabine River - Calcasieu River: 3.6×10^4, 2.9×10^4 and 2.2×10^4 t TOC during the 1980s, 1990s and 2000s, respectively; Mermentau River: 2.7×10^4, 3.0×10^4 and 2.7×10^4 t TOC during the 1980s, 1990s and 2000s; Vermilion River: 1.3×10^4, 0.9×10^4 and 0.9×10^4 t TOC during the 1980s, 1990s and 2000s. This paper discusses the long-term trend in the TOC loadings and their implications to estuarine ecosystems in southwest Louisiana.

Implications

A long-term description of carbon loading to Gulf of Mexico is important for future management of the Sabine, Calcasieu, Mermentau and Vermilion Rivers. Results gained from this study will provide important insights into the decadal trends in carbon loading from these four rivers into the Gulf of Mexico, helping develop effective management strategies for protecting Louisiana's coastal ecosystems.

Student Presentation

A Hurricane Impact History of Frenier Louisiana from Sedimentary Processes

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Hurricane Isaac caused widespread flooding in coastal communities along Lake Pontchartrain, including areas spared from flooding during recent storms that exceeded Isaac's intensity. To understand the history of flooding in these areas, the event layer attributed to Isaac must be described to distinguish the source of similar event layers in the sediment record.

Cores were taken along the shoreline of Lake Pontchartrain in Frenier, Louisiana. The coring locations were forested swamps that remain above the water table through much of the year. Cores were analyzed using loss-on gnition and XRF to determine sediment composition, and a laser diffraction grain size analyzer to obtain grain size. Cores were dated using Lead-210/Cesium-137 and Carbon-14 dating techniques. Sediment deposited by Isaac had a larger grain size and less organic material than sediment not associated with flooding events. The mean grain size calculated for each centimeter of non-event layers is between 35-50 microns.

The three-centimeter deposit from hurricane Isaac coarsens upwards from 52 to 106 microns. The storm layer associated with Hurricane Isaac has a sharp contact with the organic-rich silt below it. Lab analysis identified another layer similar to the Hurricane Isaac storm layer in organic material concentration and grain size. This older storm layer occurs at depths between 8 and 17cm in different cores from the area. The mean grain size of the secondary event layer is 76 microns. The lower layer's contact with surrounding sediment is not as sharp as the Isaac layer, and has likely been disturbed by bioturbation.

The characterization of sediments deposited by Hurricane Isaac serves as a modern analogue for describing past flooding events. The presence of additional layers with similar characteristics suggests that the flooding of LaPlace on the same scale as what occurred during Hurricane Isaac may have occurred several other times in the recent past.

Implications

Understanding the flooding history of LaPlace is key in moving forward with flood protection planning for communities on the southwest shoreline of Lake Pontchartrain and the southern half Lake Maurepas. A strong storm surge affected the community of Frenier and pushed water into homes and businesses north of US-61 in LaPlace. The strong surge driven by wind deposited sediment in the shoreline of Lake Pontchartrain, which was the source of the water. By analyzing the stratigraphy present along the shoreline, a return period can be calculated for intense storm events such as Isaac that caused flooding in LaPlace. A return period for such events is critical in the planning of levees, as well as building guidelines for developing new areas. Dating constraints on past events can also aid in assessing the impact of flood protection efforts elsewhere in the Lake Pontchartrain basin and coastal Louisiana.

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STUDENT PRESENTATION

Assessing Coastal Community Resilience in Louisiana and the Netherlands: Conceptual and Methodological Challenges

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The investigation of coastal vulnerability and resilience, and the interaction of multiple actors and processes, is an important evolving science, with implications for improved policy development through better understanding of the dynamics of sustainability and environmental health. The study addresses two fundamental questions: How should community resilience be measured? Also, which indicators of community resilience are more "generalizable" to other regions and nations? The study expands the Resilience Inference Measurement (RIM) model developed by Lam and Reams et al. to quantify sources of resilience among U.S. Gulf Coast counties, to assess resilience levels among thirty coastal communities in the Netherlands. The results will support the professionals of the Rhine delta in their daily work to mitigate major coastal hazards such as super storms and floods. Many similarities exist between the deltaic regions of Louisiana and the Netherlands and extensive data collection by the Dutch Census allows for the measurement of key indicators of coastal community resilience. The project compares and contrasts the two deltaic environments by examining the linkages between three types of players or stakeholders: individuals, business owners, and organizational policy makers. Linkages are also made among the seven sectors of Netherlands community organization: water safety (protective infrastructure, land use, and public safety), ecosystem, energy, business, and social sectors. To explore these interactions, researchers will analyze the patterns, functions, and changes in each subsystem (e.g., ecosystem functions), and provide an assessment of what practical measures can be made to maintain the functions. The goals of this study are to develop an accurate model to be applied to public education, administration, and outreach efforts in the Netherlands, and also to gain further insight into sources of local, regional, national and international coastal resilience.

Implications

Coastal resilience studies are important for addressing impacts from future climate change and sea level rise. As Lam and Reams et al. have developed the RIM model for the Gulf coast states, it is important to expand the study to vulnerable coastal areas across the world. As we develop

models to explain multi-regional socio-economic and ecosystem interactions, advancements in vulnerability and resilience modeling will lead to advancements in the quantifiable indices for measuring resilience and vulnerability.

STUDENT PRESENTATION

Evaluation of global climate change, hurricane impacts, and subsoil subsidence on Louisiana's dynamic coastal landscape

Malay Ghose Hajra, Ph.D., P.E.[1], and **Kimberly V. Landry[1]**

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Over a period of several thousand years, Louisiana's coastal landscape was formed by sediments deposited from the Mississippi river and its tributaries mostly during the flooding months of the year. However, coastal property development, global climate change, sea level rise, increased number and intensity of hurricane and storm events, coastal land subsidence, loss of barrier islands, oil and water extraction, and other natural and man-made factors have resulted in high rates of wetland loss, water quality degradation, decline in fisheries and reduced storm surge protection in southeast Louisiana. The loss of marshland in coastal Louisiana has also exposed significant infrastructure to open water conditions and has degraded the wildlife habitat of nearby areas. Published data indicate that areas of coastal Louisiana as well as the Mississippi River basin has an annual marshland loss of about 16 square miles (Louisiana's Comprehensive Master Plan for a Sustainable Coast 2012). Construction of levees and storm-damage-risk-reduction systems along the banks of Mississippi River has minimized the supply of fresh water, sediment, and nutrients into the coastal areas. With disappearing wetlands, the region is losing its first line of defense to hurricane activities and storm surge events. This phenomenon is worsened by the increased subsidence rate of soft alluvial coastal deposits in southeast Louisiana.

This presentation will summarize the major storm events reaching the coastal areas of Louisiana in the last fifty years. General characteristics of each storm event will be studied in relation to global and nearby atmospheric weather conditions, water temperature in the Gulf of Mexico, barometric pressure, location of landfall, maximum sustained wind speed, maximum recorded storm surge, duration and magnitude of rainfall, and other factors. The change in Louisiana's coastline will also be presented in relation to each major storm event and regional subsidence of subsurface soil. Economic and social implications of major storms will be compared and presented in terms of revenue loss and loss of population and coastal property.

Implications

The presentation will evaluate economic and cultural impacts of the major storms affecting the coast of Louisiana in the last fifty years. The research will also present information about global

climate change and regional subsidence of subsurface soil in this region. All this information is critical to the future planning of and implementation of coastal restoration efforts.

STUDENT PRESENTATION

Wind Effects on Nonlinear Interactions of Shallow Water Waves

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Hurricanes generate high waves in the ocean and high surge on the coast at landfall. Highly nonlinear waves propagate on the elevated water surface and reach flooded area under strong winds. A better understanding of wind effects on nonlinear waves is desirable.

Boussinesq-type wave models are capable of simulating wave propagation from relatively deep water to the beach, including the swash zone. Chen et al. (2004) incorporated wind effects into a Boussinesq-type model by parameterizing the momentum flux from the air flow to the surface waves. Following Jeffrey (1925), the wind effect can also be modeled as a local pressure gradient, which is related to the local surface curvature, at the air-water interface. Both methods are implemented into a Boussinesq-type model. Compared with the laboratory data on shoaling waves with wind (Feddersen and Veron, 2005), our results indicate that the wind-induced air pressure gradient model performs better in simulating the variation of skewness and asymmetry during wave shoaling with different onshore wind speeds.

The Boussinesq-type model incorporating the air pressure gradient model is then used to study the wind effects on near-resonant triad-interactions of gravity waves in shallow water. Both opposing wind and following wind are considered. Wind is applied to waves propagating over a flat bottom. Focused on near-resonant triad interactions, we examine the influence of wind on the beat-length, and the energy exchange among different wave components, as measured by the ratio of the energy in higher harmonics to the energy in the primary wave.

We find that compared with the wind stress method, Jeffreys' pressure model is more effective in changing the wave shape. The beat length of triad interaction is not affected by wind. The observed energy increase in high harmonic can be explained by wind-induced wave height increase.

Implications

A good understanding of wind effects on nonlinear waves is crucial for numerical simulations of coastal processes under storm conditions. Our work, a Boussinesq-type wave model incorporated with wind effects, provides a promising tool for the study of nearshore wave propagation and horizontal circulation with strong winds. In addition, wind-wave attack is a

main cause of marsh edge erosion. Our method is capable of simulating the nonlinear interaction of shallow water waves under wind, which can be used to determine waves and currents near the marsh edge for the estimation of wetland erosion and land loss on the gulf coast.

STUDENT PRESENTATION

Consolidation properties of mud from Lake Lery and relevance to wetland restoration

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Fine sediments (i.e. mud, a mixture of particles finer than 63 microns) have physical properties that vary spatially and temporally during deposition and consolidation. These locally varying properties influence sediment strength and erodibility, both of which are critical parameters for many restoration projects in the Mississippi Delta. However, little work has been done on the consolidation and erodibility of fine Mississippi River sediment, which represents the largest fraction of sediment carried by the Mississippi. Studying the properties of these sediments will yield insightful data that will help with recovering and rebuilding land on the coast.

The purpose of this project was to determine the relationships among settling rates, shear stress, and sediment concentrations for fine Mississippi sediment. Mississippi River sediment deposited in Lake Lery, fed by the Caernarvon Diversion southeast of New Orleans, were collected by surface grab samples. Sediment settling time versus concentration at varied initial sediment concentrations were tested along a settling column and recorded over a fifteen day period. Shear stress results were performed at several different shear stress regimes in a gust erosion dual core microcosm system. Preliminary results show a concentration-dependent exponential decline of consolidation rate versus time. We expect consolidation state to be a strong control on erodibility. Bulk density and critical-shear-stress profiles will be compared with current sediment consolidation models.

Implications

The results from this project will help coastal planners more accurately predict how sediment from river diversions deposits and strengthens over time. An improved understanding of sediment compaction leads to more accurate estimates of how much sediment will be retained in diversions to build land and that minimize sediment loss attributed to marine transport.

STUDENT PRESENTATION

Evaluation of settling velocity of fine-grained dredged sediments used in coastal restoration projects

Malay Ghose Hajra, Ph.D., P.E.[1], and **Gregory Mattson, II, E.I.[1]**

[1] University of New Orleans

Coastal property development, sea level rise, geologic subsidence, loss of barrier islands, increasing number and intensity of coastal storms and other factors have resulted in water quality degradation, wetlands loss, reduced storm and surge protection, ground settlement, and other challenges in coastal areas throughout the world. One of the goals towards reestablishing a healthy coastal ecosystem is to rebuild wetlands with river diversion or sediment conveyance projects that optimally manage and allocate sediments, minimally impact native flora and fauna, and positively affect the water quality. Restoring the marshes through deposition of dredged material from adjoining ocean, navigation canals and river beds and subsequent reestablishment of emergent wetland vegetation will help to protect the coastal properties and infrastructure systems from accumulated damage due to elevated water levels and storm surge forces as well as create a sustainable coastal environment to booster vital economic, social, and recreational opportunities for thousands of coastal habitants. Engineering properties and material characteristics of the dredged material and foundation soils are input parameters in several mathematical models used to predict the long term behavior of the dredged material and foundation soil. The sedimentation characteristics and settling velocity of the dredged sediments as well as their effects on the time rate of settlement of the suspended solid particles and underlying foundation soil depend, among other factors, on the (a) grain size distribution of the dredged material, (b) salinity (fresh, brackish, or saltwater environment) of the composite slurry, and (c) concentration of the solid particles in the slurry. This presentation will summarize the results from laboratory experiments performed on fine grained dredged sediments obtained from multiple coastal restoration projects in Louisiana. The effects of salinity and particle concentration on the sediment's settling velocity will be evaluated.

Implications

Proper characterization of the dredged material and foundation soils is of utmost importance in the correct design of a coastal restoration and land reclamation project. The research findings will contribute to the cost-savings, time-savings, and improved outcomes of Louisiana Coastal Restoration project implementation in the following ways:

1. Improvement of the mathematical models used in developing the Louisiana Coastal Master Plan will be accomplished by using engineering parameters of dredged sediments from Louisiana Coastal areas rather than using literature values.
2. Depending on the flocculation characteristics of the diverted sediments, it may be possible to alter the salinity of the slurry and thus decrease sedimentation time of the dredged material. This information will help in quantifying the optimal amount of dredged slurry needed for a marsh creation project, thereby minimizing waste of dredged material.
3. The improved mathematical models will be able to optimize the sequencing characteristics of the diversion process, thereby reducing the uncertainty of the long term predictions.
4. The proper characterization of the dredged material will help optimize the design of containment dikes used in marsh creation projects, which will save project time and cost.

STUDENT PRESENTATION

Investigation of relationship between wave power and shoreline retreat in Terrebonne Bay, southern Louisiana

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The marshland in southern Louisiana is a vital resource that many people and wildlife depend on. A detailed study of the marsh edge retreat rate and the wave power approaching shore is sought. With this information a correlation is desired to allow users to predict retreat rate given incoming waves. Over a period of 12 months shoreline surveys were completed along with the deployment of wave gauges to determine the wave power directly in front of the marsh edge. These results can then be directly compared to historical records as well as predictive models.
Terrebonne Bay was chosen for this research because it has experienced one of the largest wetland loss rates among Louisiana estuaries. The shoreline surveys were carried out roughly every three months and a continuous wave record was obtained between two consecutive surveys. The dataset is then used to compute the wave power that is directly associated with the amount of shoreline retreat over that period of time. These results will be presented along with a historical shoreline retreat rate versus wave power correlation. Aerial photographs will be used to obtain long term retreat rates over the past 10 or more years. After characteristic long term retreat rates are obtained for multiple points along the marsh edge the incident wave power at each of these corresponding locations will be hind casted. This hind casting will be completed using historical wind and bathymetry data as input into a Delft 3D FLOW and WAVE (SWAN) model.

Implications

The empirical relationship between the marsh edge retreat rate and the wave power allows for the prediction of wetland erosion for a given wave condition. The benefit of this will be to allow for a quantitative result to be obtained and included when running long term forecast models where erosion is thought to occur. Initially this will be used for Terrebonne Bay but similar methodology should allow subsequent characteristic curves to be developed for other estuaries.

STUDENT PRESENTATION

Eighty-year variability of river discharge from the Mississippi-Atchafalaya River System (MARS) and the Amite River to the Gulf of Mexico

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River engineering and climate change can both greatly affect river discharge to coastal margins, regions which are often prone to the twin problems of subsidence and climate change-induced global sea level rise. These problems make coastal regions vulnerable to catastrophic consequences if a significant decrease in land-building sediment transport occurs. In this study, we analyzed the eighty-year variability of river discharge from the smaller Amite River, which empties into the Gulf via Lake Ponchartrain, and the two major distributaries of the Mississippi River: the Mississippi main stem and the Atchafalaya River. These three rivers are the major sources of sediment supply to the Gulf of Mexico. Our focus in this paper was characterizing extreme discharge events since it has been suggested that these types of events are major factors in the transport of large sediment "pulses" to the Gulf. Daily river discharge data from the 1930s to 2012 was examined for its temporal variation and extreme values. We found that the "managed" rivers (the Mississippi and Atchafalaya) exhibited extreme discharges that were a small multiple of their mean discharges while the "unmanaged" river (the Amite) had extreme discharges many times larger than its mean value. Correspondingly, the managed rivers exhibited peaks that tended to be very close to the maximum discharge values, for a given time period, while the unmanaged river had peaks that were approximately half of a given period's peaks. Lastly, we found that river engineering activity caused a "smoothing" of the flow duration curve for the MARS rivers. This work is the first part of a more comprehensive study that examines sediment transport variability as well as hydrometeorological effects on river discharge.

Implications

The supply of fresh water and sediment is essential for coastal land building as well as coastal ecosystem nourishment. This study provides insights into extremes and long-term variability of river discharge to the coastal margin and thus provides an additional input to Louisiana sediment and flood management policy making. These findings will also be of use to ecosystem modelers and those working to restore and enhance coastal ecosystems.

STUDENT PRESENTATION

Citizen science group provides *In situ* data and enhanced experiences for NASA DEVELOP interns

Ross Reahard[1,2,3], Amber Jones[2,3], Jason Jones[2,3]

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Within NASA's Applied Sciences Program, the DEVELOP National Program recruits top students, recent graduates, and early/transitioning career professionals to conduct interdisciplinary research projects that apply NASA Earth observing satellite data to address community concerns regarding environmental and public policy issues. Each DEVELOP project is designed to form partnerships with local, state, federal, and/or international organizations who can benefit from the capabilities of NASA remote sensing products in conjunction with other geospatial data and GIS technology. With the common goal of bridging the gap between Earth science and society, a collaboration with citizen science organizations and DEVELOP began in May 2013 when Liz Barry of the Public Laboratory for Open Technology and Science (PLOTS) and DEVELOP management began discussing potential ways to collaborate. Three months later, PLOTS and NASA DEVELOP began working together on a prototype project entitled "Utilizing NASA Earth observations to analyze the relationship between climate and gas flaring in the Americas." The project employed NASA satellite data to help assess current petroleum exploration and extraction practices, investigated the reciprocal effects of natural gas flaring and climate, mapped favorable vs. non-favorable atmospheric conditions for flaring activities, and contributed enhanced decision support regarding improved gas flaring practices. During this collaboration, PLOTS staff and DEVELOP interns worked together to acquire and visually display *In situ* emissions spectra from a petroleum refinery in Chalmette, Louisiana, using PLOTS' DIY gas emissions spectrometer and Spectral Workbench platform. Experimental methods for using the spectrometer for long-distance data collection were tested, and preliminary data were collected. By providing crowd sourced technology and data to enhance decision support tools, citizen science organizations like PLOTS align well with DEVELOP's mission to provide experience, training, and the development of society's next generation of scientists.

Implications

NASA DEVELOP's continued collaboration with citizen science groups like PLOTS is capable of aiding future projects related to coastal restoration. For instance, one DEVELOP project planned

for 2014 involves reforestation in southern coastal Louisiana. While this project will rely heavily upon satellite data products such as vegetation indices and land use/land cover maps, “boots-on-the-ground” field work will also be necessary. In situ NDVI (a vegetation index) and field-collected geo-tagged photos for site characterization are just some of the land-based measurements that can provide ancillary data for validating satellite-based mapping products. Collaboration with PLOTS using their inexpensive DIY science tools (e.g., the Infragram camera) will help provide these ground-based observations. Additionally, introduction to the broader coastal citizen science community and hands on field experience for NASA DEVELOP participants will help train these next generation Earth scientists in working to safeguard our coastal resources in the future. Such activities can also help DEVELOP projects to be designed more effectively to meet the needs of organizations involved in coastal protection, restoration, and decision making.

STUDENT PRESENTATION

The human-mediated flow of phosphorus in Louisiana's dynamic coastal landscape

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We explore the interrelated dynamics of population migration, economic instability, and human-mediated phosphorus (P) flows in coastal Louisiana. Accounting for P and improving human P use efficiency are critical tasks given the finite global supply of phosphate rock and widespread eutrophication. We use material flow analysis to examine P fluxes in the Upper Pontchartrain Basin for two 5-y time periods (2001-2005 and 2006-2010) to capture the effects of fertilizer economics and population growth partially driven by the impact of Hurricane Katrina in the lower basin in 2005. Mass balances encompass human-mediated P fluxes in food production and consumption subsystems across agricultural, developed, and forested landscapes. Increases in fertilizer and oil prices were correlated to drastic reductions in locally purchased P fertilizer (78% decline between periods). Total P input to the consumption subsystem increased from 1775 to 1937 Mg P y^{-1} between periods due to the influx of new residents, which has been characterized by decentralized settlement that limits P recycling. Overall societal P efficiency increased from 23% to 34% due largely to reduced fertilizer inputs. Leakage to the Pontchartrain Estuary and the Mississippi River represented 18-24% of total system P input, while the vast majority of P accumulated within soils, wastewater systems, and landfills. We discuss basin trends and management implications.

Implications

Successful adaptation to environmental change will require confronting multiple unfolding challenges in concert. Coastal regions vulnerable to sea level rise and tropical storms will likely also be influenced by resource limitation in an uncertain future. Our work provides an integrated assessment of economics, population trends, and nutrient cycling that will help local environmental managers find ways to reduce nutrient pollution in the short term and envision a more prosperous "future coast." A historic opportunity exists to encourage future coastal development characterized by synergies between local agriculture and human habitation to promote energy efficient nutrient recycling. The effect would be a decreased reliance on

expensive imports and uncertain future global phosphate rock supplies, along with the mitigation of current and future eutrophication.

STUDENT PRESENTATION

Limitations of hydrologic regime on *Schoenoplectus* spp. survival and establishment: Implications for marsh restoration

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As the demand for fresh water, bank stabilization, and protection from sea-level rise becomes increasingly important, so does the need for accurate and successful wetland restoration and management. Both designer and self-design restoration theory place an emphasis on restoring the proper hydrologic regime and elevation in order to facilitate plant establishment in marsh restoration/creation efforts. Our research investigates the effects of environmental stressors common in modified wetlands (i.e., high soil bulk density and altered elevation/flooding regime) on several species and life history stages of emergent wetland plants. *Schoenoplectus acutus* and *S. californicus* are fresh to brackish macrophytes that are ideal for implementation in marsh restoration in a variety of areas throughout the United States and world. However, information regarding these species' tolerance to flooding regime and soil physicochemical conditions is limited. A field transplant study at a tidal marsh restoration site indicated that both hydrology and soil compaction play important roles in constraining plant survival and expansion. *S. californicus* exhibited superior performance in terms of survival, growth, and expansion compared to other transplanted species in the field setting. We also conducted an experiment in an artificial tidal mesocosm consisting of the two *Schoenoplectus* species, two life history stages (seedlings and adults) subjected to each of four flooding regimes (100%, 60%, 40%, and 25% exceedence). After one growing season, differences in tolerance to flooding between species and life history stage became decidedly evident. Soil in units exposed to longer durations of flooding was significantly more reduced ($p<0.01$). Overall, adults performed more successfully than seedlings. Seedlings of both species suffered complete mortality when subjected to 100% flooding. Adults of both species exhibited reduced survival and growth when exposed to complete inundation; however *S. californicus* appears to be more tolerant to flooding stress than *S. acutus*.

Implications

Our analysis of the effects of hydrologic regime on soil physicochemistry and plant morphology/physiology has established flooding limitations for these species at different life history stages. This information can be implemented to improve the success of future wetland

planting efforts. Our improved understanding of the ecology of these species should aid in anticipating the extent of marsh development in systems with an elevational /hydrologic gradient. Moreover, field observations and a greenhouse experiment investigating the effects of soil bulk density suggest that once established, these species have the potential to modify their local environmental conditions (elevation and soil physicochemistry). Finally, this research has important implications for predicting the response of *Schoenoplectus* spp. dominated marsh to hydrologic modification, whether due to anthropogenic manipulations or sea-level rise.

STUDENT PRESENTATION

Dispersant effect in enhancing the droplet and particle formation by bursting bubbles

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The Deepwater Horizon oil spill is one of the largest marine oil spills in U.S. history. It has been estimated that 4.9 million barrels of crude oil were released into the Gulf of Mexico and 1.8 million gallons of dispersants were used to disperse the oil. Based on the oil budget calculator, 20% of oil was skimmed or recovered, 5% burned, 25% evaporated/dissolved, and the rest dispersed inside the water column. However, since all possible transport processes were not explicitly characterized, the exactness of the oil and dispersant mass balances is still debatable.

In this study, we investigate the contribution of aerosolization by bursting bubbles as one of the potential transport vectors for transferring oil and dispersant compounds to the atmosphere. Oceanic sprays are the dominant source of particulate matter in the atmosphere, which are capable of producing 3.5×10^{12} kg of particulate matter per year. We utilize a bubble column reactor, equipped with annular shear sparger, to produce an abundance of small sized bubbles. These bubbles produce droplets upon bursting at the air-salt water interface. These droplets are further dried up and lifted to the top of the column where they are collected as particles either by an electrostatic precipitator or by an isokinetic sampling nozzle.

We injected both oil and different mixtures of oil and dispersant into the column and measured the ejection rate of alkanes through the dissolution in ethyl acetate and analysis of the resulted solution by GC-FID/GC-MS. Our results show the volatility independent ejection of oil material by bursting bubbles to atmosphere. We can also clearly see the enhancement in ejection rate of oil material when dispersants are used. This is particularly significant for non-volatile compounds, which emphasizes the need to further study sea-spray aerosols as a possible transport vector for spilled oil on the sea surface environment.

Implications

This study shows that oceanic whitecaps can contribute to the transportation of oil and dispersant material to the atmosphere in the form of inhalable micrometer sized particles. These particles can bypass our body's natural defenses in the nose and throat and get into our lungs, which can therefore cause serious health problems. The size of the particles generated in the reactor is comparable to the ones produced by oceanic white cap bubbles, which range predominantly from 0.1 to 10 μm. The smaller particles are of more interest as they are subject

to potential long-range transport and thus have implications for both the off- and onshore environment.

STUDENT PRESENTATION

Influence of barrier island loss on the distribution and survival of brown pelicans in coastal Louisiana

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Louisiana's coastal barrier islands have provided important historical roosting, feeding, and nesting sites for brown pelicans (*Pelecanus occidentalis*). Brown pelicans show strong fidelity for their natal island. Loss of barrier islands in coastal Louisiana has the potential to be highly detrimental to a species where so few suitable nesting habitats remain. Between 2007-2009, 539 pelicans were banded on Wine Island, LA which has completely eroded into the ocean, and 575 pelicans were banded on Raccoon Island, LA. Weekly band resightings took place March 2013 through July 2013 over 14 different islands in three distinct regions of coastal Louisiana, Terrebonne Bay, Barataria Bay, and Cameron Parish. We resighted fewer birds that were born on Wine Island than on Raccoon Island. The banded birds from Wine Island were equally distributed across four islands, but the banded birds from Raccoon Island were mostly located on the island of their birth. Preliminary results support past work indicating that adult pelicans tend to return to the island of their birth. However, when their natal island is lost, our results suggest that while some birds redistribute themselves to other nearby colonies, others appear to be lost from the regional breeding population. If confirmed by additional data, these findings suggest that the loss of a barrier island means loss not only of a colony site that helps support the regional population, but also of the future reproduction of some of the pelicans that were born on that island.

Implications

This research suggests that barrier islands provide important breeding locations for endangered and threatened seabirds. The loss of such islands may negatively impact the populations of these colonial seabirds. In Louisiana, coastal sea level rise is higher than the worldly average which causes extensive barrier island loss. This puts pressure on researchers and conservations to find ways to protect these delicate ecosystems before they are lost forever. The conservation of Louisiana barrier islands is imperative to the long term survival of breeding colonial seabirds.

STUDENT PRESENTATION

A Fluorometer-Based Method for Determination of Biochemical Oxygen Demand

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Many natural water bodies on the Gulf Coastal Plain experience oxygen depletion due to high temperatures, sluggish flow, and high organic substrates. As the main indicator for organic pollution, development of a technique for rapid estimation of biochemical oxygen demand (BOD) is necessary for cost-effective monitoring of water quality conditions. While several studies reported the usefulness of fluorescence technique in predicting 5-day BOD (BOD_5) of wastewater and river waters, little is known about the predictability of fluorescence for BOD of natural waters that are constantly exposed to the mixture of chemicals compounds in the U.S. Gulf Coastal Plain region. This study was conducted to determine the numeric relationship between fluorescence and BOD for a shallow urban lake that is widely representative of lake environment on the Gulf Coastal Plain. From October 2012 to August 2013 *in-situ* measurements at the studied lake were made every two weeks on fluorescence and other water quality parameters including water temperature. Water samples were taken for 5-day and 10-day BOD (BOD_{10}) laboratory analysis with and without incubation. The results showed a clear seasonal trend of BOD being high during the summer and low during the winter. There was a linear, positive relationship between fluorescence and BOD, and the relationship appeared to be stronger with BOD_{10} (r^2 = 0.83) than with BOD_5 (r^2 = 0.72). Fluorescence reading declined each day with BOD, suggesting that die-off of phytoplankton has been the main consumption of oxygen, and that the fluorescence method can be especially effective for predicting BOD in eutrophic waters.

Implications

Biochemical oxygen demand of natural water bodies on the Golf Coastal Plain is among the most important measures needed for assessment and management of water quality. If BOD can be estimated rapidly in the real time monitoring by a cost-efficient technique like fluorescence that delivers an indication of polluting level in one minute, it would be of great value to environmental monitoring and regulation to assess the degree of organic pollution and then take actions quickly.

STUDENT PRESENTATION

Long-Term Dynamics of Dissolved Oxygen in a Coastal Plain Shallow Lake

Zhen Xu[1] and Y. Jun Xu[1]

[1]School of Renewable Natural Resources, Louisiana State University Agricultural Center

More than 50% of Louisiana's watersheds are listed as impaired for their low dissolved oxygen (DO) levels. These water bodies are naturally prone to oxygen depletion due to sluggish flow, high temperatures, and high organic substrates. Compounded with this is the nutrient enrichment that causes algal blooms further exacerbating the problem of dissolved oxygen supply. In early 2008 we began to monitor DO changes in a 183-acre shallow lake in Baton Rouge, in order to investigate biochemical dynamics at the process level. An environmental monitoring buoy (EMB) was deployed in the center of the lake, recording real-time (15-min intervals) DO and other water quality parameters including water temperature, pH, turbidity, chlorophyll and specific conductivity. In addition, bi-weekly in-situ measurements on the same water quality parameters were conducted at various locations across the lake. This long-term data provides insights into the inherent nature of water bodies on the flat Gulf Coastal Plain, and the opportunity to develop a process-based model that predicts fluctuation of DO levels. This paper presents the long-term DO data and discusses the model development, contributing factors, and the application of the model.

Implications

Dissolved oxygen may be the most critical parameter for water bodies because its solubility is essential for aquatic organisms. Much concern on the health of water bodies in Louisiana is directed to the low DO condition. Despite numerous studies of DO in the past several decades, our ability to predict DO change for small water bodies is limited, which, however, can be of great usefulness to water quality management.

STUDENT PRESENTATION

Numerical modeling of surface waves over submerged flexible vegetation

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Flooding caused by storms and hurricanes is a major hazard in many coastal areas. The low elevation of coastal areas makes lands and infrastructures vulnerable to inundation by storm surge and wave impacts. Coastal wetlands, serving as a buffer zone between open water and dry lands, can reduce storm surge and waves and protect coastal infrastructures. This work presents a model for simulating surface waves over submerged flexible vegetation. This model treats the plant stems as an array of deformable beams and solves the Navier-Stokes equations and the beam equation. The coupled fluid and vegetation models simulate the deflection of stems under the wave-induced forces and the wave energy loss attributable to the interaction of oscillatory fluid motion and plant stems.

Waves and vegetation are fully coupled at each time step. The vegetation motion is solved accounting for drag, inertia, damping, restoring, and gravitational forces. The resistance force due to flexible vegetation on the flow is modeled by the quadratic law, with the velocity-dependent stem height determined by the finite deflection beam equation. A fourth order finite element scheme is utilized to solve the governing equation for stem deformation. The wave-induced drag force is calculated based on the relative horizontal velocity. A horizontally one-dimensional, non-hydrostatic model in the σ-coordinate is developed for modeling waves through vegetation. The momentum transfer across the interface of the water and canopy is taken into account by the LES (Large Eddy Simulation) method. The numerical results are compared with analytical solutions for single swaying vegetation and laboratory data for a patch of swaying vegetation. Detailed results will be presented at the conference. Funding for the research has been provided by the National Science Foundation.

Implications

Coastal wetlands play an important role in protecting coastal infrastructures by serving as a buffer zone between open water and dry lands. The interaction between waves and vegetation fields involves complex processes due to the coupling between the waves and vegetation motion. This coupled model allows estimating the drag force exerted along the vegetation field as a function of the relative velocity between the fluid flow and the vegetation motion. The model is capable of reproducing wave damping and the velocity field inside and outside the vegetation meadow, and can help improving our understanding of the wave and vegetation

interactions in the coastal wetlands. An accurate prediction of waves in inundated wetlands is of importance for Louisiana coastal protection and restoration.