**CREST SYMPOSIUM**
**Monday, June 30 – Wednesday, July 2, 2003**
**Student Union Center**
**Nicholls State University**
**Thibodaux, Louisiana**

***PROGRAM***

**Monday, June 30, 2003**

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| 09:00 – 16:00 | Bayou Lafourche Tour<br>Departure point:<br>Office of Barataria-Terrebonne National Estuary Program<br>Nicholls State University Campus<br>320 Audubon Drive (across the street and parking lot from Student Union Center)<br>Thibodaux, LA |
| 18:00 – 19:30 | Registration and Kick-off reception |

**Tuesday, July 1, 2003**

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| 08:00 – 12:00 | Registration |

Session 1 Chair: **Denise Reed** *(University of New Orleans*)
*Theme: The Need for Science and Technology in Coastal Restoration*

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| 08:30 – 09:00 | Introductory remarks – **Marilyn Kilgen** *(Nicholls State University)*<br>Welcome – **Alice Pecoraro** *(Nicholls State University)* and **Denise Reed** |
| 09:00 – 09:30 | Information and knowledge are the touchstone: not science – **Margaret Davidson** (*NOAA CSC*) |
| 09:30 – 10:00 | Restoring the Mississippi River basin with 10 million hectares of wetlands – **William Mitsch** (*Ohio State University*) |
| 10:00 – 10:15 | Break |
| 10:15 – 10:45 | Science for integrated, sustainable and adaptive ecosystem restoration: Chesapeake Bay and coastal Louisiana – **Donald Boesch** (*University of Maryland*) |
| 10:45 – 12:00 | Panel discussion<br>Panel: Margaret Davidson, Donald Boesch, Bill Nuttle (*Eco-hydrology, Canada*), David Kennedy (*NOAA ORR*), Ed Theriot *(US Army Corps of Engineers)*, John Roussel (*LA Dept. Wildlife and Fisheries*) |

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| 12:00 – 13:30 | Lunch break<br>Keynote Speaker: **Richard Condrey** *(Louisiana State University)*<br>Bison on the beach, parakeets in the cypress; Louisiana's historical ecology |

Session 2 Chair: **Lawrence Rozas** *(NOAA NMFS)*
*Theme: Achieving Restoration Goals for Fish and Wildlife Resources*

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| 13:30 – 14:20 | Predicting and monitoring the response of animals to wetland ecosystem restoration: lessons from the Everglades – **Dale Gawlik** (*S. Florida WMD*) |
| 14:20 – 14:45 | Using river diversions to restore estuaries: potential effects on fisheries populations – **Wim Kimmerer** (*San Francisco State University*) |
| 14:45 – 15:10 | The ecological role of oysters in wetland dominated estuaries – **Charles Peterson** (*University of North Carolina*) |
| 15:10 – 15:30 | Break |
| 15:30 – 15:55 | A cost:fishery benefit analysis of wetland restoration in Galveston Bay, TX – **Thomas Minello** (*NOAA Fisheries*) |
| 15:55 – 17:00 | Panel discussion<br>Panel: Greg Linscombe *(LA Dept. of Wildlife and Fisheries)*, Virginia Burkett (*USGS*), Charles Simenstad, Charles Peterson, Thomas Minello, Dale Gawlik, Wim Kimmerer |
| 17:00 – 20:00 | Poster session |
| 17:00 – 20:00 | Reception |

**Wednesday, July 2, 2003**

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| 08:00 – 12:00 | Registration |

Session 3 Chair: **Robert Twilley** *(University of Louisiana, Lafayette)*
*Theme: Achieving Restoration Goals for Water Quality*

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| 08:30 – 09:15 | Assessing and managing nutrient-enhanced eutrophication in estuarine and coastal waters influenced by human and climatic perturbations – **Hans Paerl** (*University of North Carolina)* |
| 09:15 – 09:40 | Nutrients, climate and hypoxia: predicting water quality trends in the next 50 years – **Dubravko Justic** *(Louisiana State University)* |
| 09:40 – 10:05 | A comprehensive conceptual model of wetland loss in the Mississippi Delta – **John Day** *(Louisiana State University)* |
| 10:05 – 10:30 | Break |
| 10:30 – 10:55 | Potential water-quality impacts of Mississippi River diversions in coastal restoration – **Charles Demas** *(U.S.G.S., Lafayette)* |
| 10:55 – 12:00 | Panel discussion<br>Panel: John Day, Dubravko Justic, William Mitsch, Bill Nuttle (*Eco-hydrology, Canada*), Hans Paerl, Charles Demas, Jane Watson *(EPA)* |
| 12:00– 13:30 | Lunch break |

# AGENDA

Session 4 Chair: **Mark Ford** *(McNeese State University)*
*Theme: Achieving Restoration Goals for Coastal Wetlands and Vegetation*

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| 13:30 – 14:20 | **Charles Simenstad** (*University of Washington*) |
| 14:20 – 14:45 | Establishing vegetation-based performance criteria for coastal marsh creation and restoration – **Christopher Craft** *(Indiana University)* |
| 14:45 – 15:10 | Incorporating disturbance dynamics and flood pulsing into restoration projects – **Beth Middleton** (*USGS, Lafayette*) |
| 15:10 –15:30 | Break |
| 15:30 –15:55 | Modeling for evaluation, monitoring and assessment of large-scale wetland restoration projects: the Everglades example – **Fred Sklar** (*S. Florida WMD*) |
| 15:55 –17:00 | Panel discussion<br>Panel: Beth Middleton, Christopher Craft, Gene Turner (*Louisiana State University)*, Fred Sklar |
| 17:00 | Symposium closes |

# AGENDA

## SCIENCE FOR INTEGRATED, SUSTAINABLE AND ADAPTIVE ECOSYSTEM RESTORATION: CHESAPEAKE BAY AND COASTAL LOUISIANA

*Donald F. Boesch [boesch@ca.umces.edu]*
*University of Maryland Center for Environmental Science*

Modern environmental management, including ecosystem restoration, espouses integrated approaches, sustainable solutions, and adaptive management. The integration required is challenging and multi-dimensional—extending among resources and user groups, across environmental media, over space and time scales, and among stakeholders, managers and scientists. As we seek to fix problems that have resulted from past activities yielding unsustainable results, we often have only the vaguest of notions of the sustainability of achievable alternatives in a world changing around us. What is it we are trying to restore or, at least, rehabilitate? Because of this uncertainty and because of the opportunity to learn from what we do, we are embracing adaptive management as a structured way to improve outcomes.

I argue here that the process of science and the community of scientists must better address the challenges posed in seeking integrated, sustainable and adaptive approaches to restoration of large coastal ecosystems. I use as examples the experience and current state of the practice in the two great American ecosystems in which I have had the privilege of spending nearly my entire life: the Chesapeake Bay and coastal Louisiana. In my view, scientists should focus on developing new kinds of knowledge that: connects actions, environments and resources; strengthens predictions about the future based on understanding of past trajectories and present processes; and inter-relates stove-piped objectives (e.g. wetland loss and hypoxia). Further, scientists need to contribute to the definition of achievable restoration objectives in terms, for example, of ecosystem services and resilience. Scientists must also both insist on and participate in rigorous adaptive assessment cycles and make sure that the resulting learning is institutionalized. Are you ready?

## RESTORING THE OYSTER'S ROLE IN PROVIDING ECOSYSTEM SERVICES

*Charles H. Peterson [cepeters@unc.edu]*
*University of North Carolina*

Throughout much of the east coast and some of the Gulf, oysters and the reefs they construct have undergone dramatic declines over the past century. The consequent loss to oyster fisheries represents the most widely recognized impact of this decline. However, there is growing appreciation of the importance of the role of oysters and their biogenic reef habitat as providers of eocsystem services. The most important of such ecosystem services is provision of biogenic habitat that promotes production of fish and shellfish. One estimate of the value of oyster reefs to fish, crab, and shrimp production suggests that for each acre of restored oyster reef in the southeast an augmented 2.6 kg of fish are produced annually. Oysters also (1) reduce turbidity through water filtration, thereby enhancing submerged aquatic vegetation habitat; (2) induce denitrification, thereby counteracting some effects of eutrophication; (3) enhance biodiversity by providing hard substrate for epibiotic colonization; (4) sequester carbon, thereby reducing greenhouse gas concentrations; and (5) act as a living, growing breakwater to protect salt marsh shoreline from erosion and promote sediment deposition in the marsh, perhaps keeping up with sealevel rise. Oyster reef restoration has accordingly evolved from a put-and-take habitat intended for oyster fishery enhancement to reef sanctuaries intended to be self-sustaining biogenic habitat. The history of success in restoration is mixed, but many negative reports use criteria based on oyster fisheries rather than ones based on ecosystem services. In the subtidal estuary, building tall reefs has great benefits in enhancing oyster growth, reducing sedimentation, limiting oyster disease, and limiting oyster exposure to bottom-water hypoxia. Future research should develop integrated restoration plans by hydrographic water basin so as to insure adequate spawning stock biomass of oysters to produce repeated larval settlement, to consider physical rentention mechanisms that can enhance settlement and allow successsful establishment of disease-resistant strains, and to direct oyster reef restoration into basins where vegetated upland and coastal marsh buffers are present to provide landscape-scale enhancement of function.

## A COST : FISHERY-BENEFIT ANALYSIS OF WETLAND RESTORATION IN GALVESTON BAY, TEXAS

*Thomas J. Minello[1] [tom.minello@noaa.gov], Philip Caldwell, Lawrence P. Rozas*
*[1]National Marine Fisheries Service, Southeast Fisheries Science Center, Galveston Laboratory*

Salt marshes in the northern Gulf of Mexico are valuable nursery habitats for fishery species such as penaeid shrimps and blue crabs. Extensive marsh loss has led to numerous restoration projects in the region, but little design information has been available for optimizing fishery productivity from these created wetlands. We have sampled the small-scale (1-10 m) spatial distributions of shrimps and blue crabs in marsh systems and developed models to estimate populations of these juvenile fishery species in natural and created marshes of different land-water configurations. These models focus on the vegetation-water interface, and the amount of edge in salt marshes is an important characteristic determining population size. By comparing these standing crop estimates with standardized project costs, we can compare the construction cost versus the projected fishery benefit for different restoration projects. A mechanistic simulation model also has been developed to explain the ecological relationships regulating brown shrimp production in marsh systems. By combining such production models with our spatially-oriented standing crop models, we can estimate expected production for different marsh creation projects and explain why maximizing marsh edge is important for production of these decapod crustaceans. Terracing and the formation of small marsh islands are two restoration techniques that produce a large amount of marsh edge and should provide productive habitats for penaeid shrimps and blue crabs.

## PHYSICAL, BIOLOGICAL, AND MANAGEMENT RESPONSES TO VARIABLE FRESHWATER FLOW AND DIVERSIONS IN THE SAN FRANCISCO ESTUARY

*Wim Kimmerer [kimmerer@sfsu.edu]*
*San Francisco State University*

Freshwater flow is the principal cause of physical variability in estuaries, and a focus of conflict in estuaries in regions of high human demand for freshwater. Variation in freshwater flow can have many effects: for example, increasing flow can inundate flood plains, increase loading and advective transport of materials and organisms, dilute or mobilize contaminants, compress the estuarine salinity field and density gradient, increase stratification, and decrease residence time for water while increasing it for some particles and biota. There is no general theory about the effect of freshwater flow on estuarine fishes, and physical factors such as salinity and turbidity can be as important as effects arising through flow-based trophic stimulation of the foodweb. In the San Francisco Estuary, freshwater flow is highly variable, and has been altered by shifts in seasonal patterns of river flow and increases in diversions from the basin. Abundance or survival of several estuarine-dependent fish and shrimp species increases with freshwater outflow. Although the mechanisms underlying these relationships are largely unknown, I show that they almost certainly arise through changes in physical habitat conditions, rather than through a stimulus at the base of the foodweb. Several flow-based management actions were established in the mid-1990's, including a salinity standard based on these flow effects, as well as reductions in diversion pumping during critical periods for listed species of fish. The effectiveness of these actions has not been established. Their high cost, however, suggests a need for analysis of population-level effects of these actions to justify continuing them.

## ASSESSING AND MANAGING NUTRIENT-ENHANCED EUTROPHICATION IN ESTUARINE AND COASTAL WATERS: INTERACTIVE EFFECTS OF HUMAN AND CLIMATIC PERTURBATIONS

*Hans W. Paerl [hpaerl@email.unc.edu]*
*University of North Carolina at Chapel Hill, Institute of Marine Sciences*

Estuaries are among the most productive, resourceful, and dynamic aquatic ecosystems on Earth. Their productive nature is linked to fact that they process much of the world's riverine and coastal watershed discharge. These watersheds support more than 75% of the human population and are sites of large increases in nutrient loading associated with urban and agricultural expansion. Increased nutrient loading has led to accelerated primary production, or eutrophication, symptoms of which include increased algal bloom activity (including harmful taxa), accumulation of organic matter, and excessive oxygen consumption (hypoxia and anoxia). While nutrient-enhanced eutrophication is a "driver" of hypoxia and anoxia, physical-chemical alterations due to climatic events, such as stormwater discharge, flooding, droughts, stagnancy, and elevated temperatures are also involved. The complex interactions of anthropogenic and climatic factors determine the magnitude, duration and aerial extent of productivity, algal booms, hypoxia and anoxia. Using the eutrophic Neuse River Estuary (NRE), North Carolina, USA as a case study, the physical-chemical mechanisms controlling algal bloom and hypoxia dynamics were examined. Because primary production in the NRE and many other estuaries is nitrogen (N) limited, emphasis has been placed on reducing N inputs. Both the amounts and chemical forms of N play roles in determining the composition and extent of phytoplankton blooms that supply the bulk of the organic carbon fueling hypoxia. Bloom organisms that are readily grazed represent minimal C flux to the sediments, while toxic or inedible blooms promote sedimentary C flux and hence may exacerbate hypoxia potential. From a watershed perspective, nutrient (including dissolved and particulate forms) input reductions are the main options for reducing eutrophication. Being able to distinguish the individual and cumulative effects of physical, chemical and biotic controls of phytoplankton productivity and composition is key to understanding, predicting, and ultimately managing eutrophication. Long-term monitoring, experimental assessments and modeling of eutrophication dynamics over appropriate spatial and temporal scales is essential for developing realistic, ecologically sound, and cost-effective nutrient management strategies for estuarine and coastal ecosystems contemporaneously impacted by both anthropogenic and climatic perturbations.

## NUTRIENTS, CLIMATE AND HYPOXIA: PREDICTING WATER QUALITY TRENDS IN THE NEXT 50 YEARS

*Dubravko Justic [djusti1@lsu.edu]*
*Coastal Ecology Institute and Department of Oceanography and Coastal Sciences, Louisiana State University*

It is generally believed that coastal eutrophication is controlled primarily by the magnitude of anthropogenic nutrient loading and that this cause-effect relationship provides a common explanation for the global eutrophication of the second half of the 20$^{th}$ century. Nevertheless, superimposed on this long-term eutrophication trend we find strong climatic signals, and there is also a compelling paleoevidence suggesting that climate variability has greatly influenced coastal and estuarine ecosystems in the past. Because of large uncertainties in the climate system, and also at different levels of biological control, it is difficult to predict future eutrophication trends. Model simulations for Gulf of Mexico hypoxic zone, for example, suggested a number of possible outcomes, ranging from a 58% decrease to a 63% increase in the frequency of hypoxia. Also, a comparison of the northern Gulf of Mexico and the Hudson River estuary revealed that the increased riverine freshwater inflow which increases eutrophication in the northern Gulf of Mexico, has the opposite effect on eutrophication in the Hudson River estuary. Thus, the degree to which coastal eutrophication will be affected by future climate variability will likely vary from one system to another, depending on geographical location, morphology, anthropogenic stressors, and the current eutrophication status.

## INCORPORATING DISTURBANCE DYNAMICS AND FLOOD PULSING INTO RESTORATION PROJECTS

*Middleton, Beth A. [beth_middleton@usgs.gov]*
*U.S.G.S., National Wetlands Research Center*

In the past decade, wetland restoration has incorporated natural hydrologic and disturbance regimes in a few flood pulsed riverine wetlands, tidally pulsed salt marshes and mangrove swamps, as well as northern peatlands and sedges meadow. To be self-sustaining, restoration sites should be able to withstand flood pulsing and natural disturbance since these are driving functions in the succession of natural communities. Furthermore, species are often dependent on flood pulsing and natural disturbance, to the extent that without it, natural regeneration rarely occurs. This is especially true in the regeneration dynamics of species in baldcypress swamps, where the early life history of dominant species is dependent on flood pulsing. Seeds are short-lived and only disperse in the water, but will only germinate and establish in drawndown conditions, a fact that belies their adaptation and dependence on flood pulsing. Other natural disturbances including fire, grazing and wind throw also can be important in the regeneration of wetland species, and are linked to the maintenance of biodiversity. Worldwide, landscapes have been reengineered to prevent natural disturbances for the purpose of agricultural, urban and navigational development. To successfully restore wetlands, restorationists need to find creative ways to address the requirements of species regarding natural disturbance and seasonal hydrologic flux within a highly modified landscape.

**MODELING FOR EVALUATION, MONITORING AND ASSESSMENT OF LARGE-SCALE WETLAND RESTORATION PROJECTS: THE EVERGLADES EXAMPLE**

*Sklar, Fred H. [fred.sklar@sfwmd.gov]*
*South Florida Water Mgmt. District, Everglades Division*

The Water Resource Development Act (the Act) of 2000 approved the Comprehensive Everglades Restoration Plan (CERP) as "a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem…". The Act was the culmination of 100 years of Everglades degradation and at least, 10 years of litigation. The science that was the basis for the Act was good but mostly hydrologic. The biological and ecological performance measures, used to evaluate alternative plans, were mostly qualitative. We now find ourselves having to conduct scientific "catch-up" to make sure that plans are sound and likely to succeed. Other restoration efforts can learn from the Everglades example by making 1) conceptual, 2) evaluation, and 3) assessment models an integral part of an adaptive management approach.

Conceptual models are at the very heart of CERP. Based upon a risk-management approach to problem identification, these models identify the stressors and attributes that need to be monitored, modeled and assessed. Conceptual models for the Everglades divide the landscape into regions such as ridge and slough or Florida Bay. These models make CERP focus on hypotheses in relation to specific restoration objectives and designs. They also justify and explain the use of Performance Measures. Once Performance Measures are in place, the emphasis shifts to evaluation and assessment models.

Types of evaluation and assessment models used for Everglades restoration include habitat suitability indices (HSI), transition probability models, gradient models, and distributional mosaic models. A HSI is based upon GIS layers that describe areas considered optimum for a restoration objective. Transitional probability models are based upon an analysis of the statistical patchiness and adjacency of cells over time, in association with some spatial feature such as a levee. Gradient models use a spreadsheet approach to distribute some restoration objective downstream of some spatial feature. A distributional mosaic model is a complex gradient model that distributes thousands of rules and/or thermodynamic equations across the landscape to govern energy and material flows.

These models, going from simple HSI's to the more complex mosaic models, represent a progression and maturation of a science-based, decision-making process. Early in the restoration process (i.e., feasibility) there are often many hypotheses and uncertainties. As a result, agencies tend to rely on "best professional judgements," HSI's and statistical approaches to present "draft" plans to a legislative body. In the planning phase of the restoration process there is more emphasis on scenario testing. This requires more complex gradient models and an estimate of the direct effects of some wetland alteration on a particular restoration goal. In the design and implementation phases, the cost of restoration becomes a big concern and the uncertainties make agencies very worried about "success." As a result, mosaic models become more mechanistic and complex as they attempt to capture cause-and-effect relationships. In the end, it is an adaptive management framework that allows a science-based restoration program to test hypotheses, reduce uncertainties and evolve towards success.

## HEIGHT MATTERS

*Juliana Blackwell [Juliana.Blackwell@noaa.gov], Nancy Doyle*
*NOAA National Geodetic Survey*

In Louisiana and surrounding Gulf Coast states, the land is subsiding, or sinking. Without knowing the extent of subsidence in coastal areas, land managers cannot accurately evaluate and plan for the resulting continual loss of land and the threat it brings to coastal communities. The NOAA National Geodetic Survey, working with the Louisiana Spatial Reference Center and other partners, is currently analyzing the elevations in Louisiana. As part of the Height Modernization effort in Louisiana, a survey of Louisiana's Highway 1 from Raceland to Grand Isle was performed in October 2002 to determine accurate elevations of this critical hurricane evacuation route. A second survey from Belle Chasse to Venice was performed in June 2003.

## EFFECT OF DAVIS POND FRESHWATER DIVERSION PROJECT ON WATER QUALITY AND MICROBIAL ECOLOGY OF BARATARIA BAY

*Raj Boopathy [Biol-rrb@nicholls.edu]*
*Nicholls State University*

Louisiana is losing coastal wetlands at the rate of 25 to 35 square miles per year, the highest rate in North America. There is an urgent national need to address this national issue. One method of addressing the coastal land loss is through the Federal-State sponsored action of diverting Mississippi river freshwater and sediments into the estuaries. This will help to reduce high salinities from moving inland from the Gulf of Mexico and stressing freshwater wetlands, while also helping to reduce natural and human-induced marsh soil subsidence. Such a freshwater diversion has been constructed at the head of the Barataria basin at Davis Pond and it is operational since July of 2002. The operation of Davis Pond is expected to save an estimated 33,000 acres of marsh from coastal land loss in the next 50 years. The change brought about the freshwater diversion will affect the aquatic ecosystem in many ways from micro-flora to invertebrate and vertebrate organisms. We studied the water quality and diversity of microbial communities at five different locations in the wetland. We observed a shift in microbial populations especially enteric bacteria as the salinity level changed gradually. We will report total monthly microbial counts in study sites along with variation in microbial communities and population dynamics.

## USE OF POST-HARVEST SUGARCANE RESIDUE IN COASTAL RECLAMATION: A PRELIMINARY STUDY

*Raj Boopathy [Email: Biol-rrb@nicholls.edu]*
*Nicholls State University*

Louisiana is losing coastal wetlands at the rate of 64.8–90.7 $km^2$ per year (25–35 square miles per year), the highest rate in North America. Between 1956 and 1990, some 3460 square kilometers of coastal wetlands reverted to open water. Effective wetland restoration efforts in coastal Louisiana should not only be long lasting but also economically efficient. There are a variety of wetland creation, rehabilitation, and restoration methods possible in coastal Louisiana whose scale varies widely. One such method of addressing the coastal land loss problem is to restore the coast by providing various support material for the re-growth of marshes in the wetland. This can be done by using the post-harvest sugarcane residue, which is currently burned by the sugarcane farmers every year. The sugarcane residue is a renewable resource, which is generated every year at the rate of 3 to 10 tons per acre. If this residue could be used to reclaim the coastal land loss, it not only can be used for this purpose, but also one of the sources of air pollution (sugarcane burning) problem can be solved in the state. This study will look into all possible organic ways of addressing the coastal land loss problem.

## NEKTON USE OF RESTORED HABITAT AT SABINE NWR, LOUISIANA

*[1]Christina Bush [cbush4@lsu.edu] [2]J. Andrew Nyman, [1] Megan K. La Peyre[1]*
*[1]U.S.G.S. Louisiana Fish and Wildlife Cooperative Research Unit, School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA 70803*
*[2]School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA 70803*

Marsh terracing and coconut fiber mats are two restoration techniques currently being implemented at Sabine National Wildlife Refuge. We tested two hypotheses related to these restoration techniques: (1) marsh terracing increases nekton use, and (2) coconut matted marsh edges increase nekton use. We sampled nekton along: (1) natural marsh edge (< 1 m from marsh – water interface), (2) coconut matted marsh edge, (3) terrace edge, and (4) open water (50 m from marsh – water interface for all 3 edge types). Using a collapsible throw trap with 3 mm mesh and a 3 x 2 m straight seine, 180 nekton samples were collected at four sampling dates from winter 2001 to fall 2002. Nekton density, biomass, and diversity were lower in open water habitats associated with natural marsh and terraces than at natural marsh edge, terrace edge, or coconut matted sites ($p < 0.0001$). Coconut matted and natural marsh edges had significantly higher numbers of some benthic dwelling species (e.g. blue crab *Callinectes sapidus*, white shrimp *Litopaenaus setiferous*, naked goby *Gobiosoma bosc*, clown goby *Microgobius gulosus*, Gulf pipefish *Syngnathus scovelli*) than terrace marsh edges ($p < 0.0004$), potentially due to differences in substrate caused by construction of the terraces. Researchers have suggested that decreased benthic habitat quality at dredged material marshes is related to an impaired infaunal community and differences in sediment texture. At Sabine NWR, terracing and coconut matting increased nekton use by 4.5 times above that in open water habitat by enhancing and increasing marsh edge relative to open water. The value of terrace and coconut matted marsh habitat for individual species may vary depending on their niche requirements. Future research on terrace success at providing nekton habitat should address nekton growth rates and correlate nekton composition to the infaunal community.

## THE CREST PROGRAM; A NEW COASTAL RESEARCH INITIATIVE IN LOUISIANA AND MISSISSIPPI

*P.Chapman[1] [pchapman@lsu.edu], D.J. Reed[2]*
*[1] CREST Office, Louisiana State University, [2] University of New Orleans*

The southern portions of Louisiana and Mississippi are at grave risk from coastal erosion and habitat loss, caused both by physical factors and changes in water quality. Eleven universities within these two states and NOAA therefore have created a cooperative program for Coastal Restoration and Enhancement through Science and Technology (CREST) to help policymakers, planners and coastal resource managers use the latest science and best technologies to ensure sustainable and productive coastal habitats and communities. In this way, advances in science and technology can be integrated directly into restoration programs to ensure that coastal habitat restoration is implemented cost-effectively and successfully sustains coastal resources.

University partners are working closely with federal and state agencies and other interested groups to ensure information developed is available to all involved in ongoing and future coastal habitat restoration efforts. By cooperating in this way, it is hoped to improve the local knowledge base for coastal habitat restoration, to train the next generation of researchers, and to gain economically through the shared use of resources. Activities will include both large-scale, e.g., the effect of river diversions on nutrient and sediment distributions and the resulting biology of the receiving waters, and small-scale activities, e.g., the use of bagasse and post-harvest sugarcane residue in wetland restoration. Coordinating activities through CREST will provide a cost-effective way to continue the vital work of protecting the coastal zone along the northern Gulf of Mexico.

## IMPACT OF MISSISSIPPI RIVER FRESHWATER DIVERSION ON COASTAL MARSH STABILITY

*R.D. DeLaune[1] [Rdelaune@aol.com], A. Jugsujinda [1], C.W. Peterson [2],W.H. Patrick, Jr. [1]*
*[1] Wetland Biogeochemistry Institute; [2] Coastal Ecology Institute School of the Coast and Environment, Louisiana State University*

To counteract extensive wetland loss resulting from subsidence and saltwater intrusion a series of diversion projects have been implemented to introduce freshwater and sediment from the Mississippi River into Louisiana coastal wetlands. To keep pace with increases in water level due to subsidence Louisiana coastal marshes vertically accrete through the accumulation of both organic matter and mineral sediment. The impact of Mississippi River freshwater diversion on enhancing vertical marsh accretion (mineral and organic matter) and plant biomass production (the source of organic matter) was examined. Using $^{137}$Cs dating and artificial marker horizons increases in rate of vertical marsh accretion were measured at marsh sites in Breton Sound estuary which has been receiving freshwater from the Mississippi River (Caernarvon diversion) since 1991. Accumulation of mineral sediment organic matter and nutrients in the marsh soil profile increased at marsh sites impacted by freshwater and sediment input. Greenhouse studies using marsh soil-plant cores showed an increase in plant biomass production as a result of nutrient addition and lowering of salinity. Results demonstrated that freshwater diversion would enhance both plant biomass production and marsh accretion.

## LABORATORY REARING OF ALLIGATOR GAR LARVAE FROM EGGS COLLECTED IN A LOUISIANA BRACKISH-WATER MARSH

*Allyse M. Ferrara[1] [biol-amf@nicholls.edu], Quenton C. Fontenot[1], Randy C. Landry[2]*
*[1]Nicholls State University; [2] T. Baker Smith and Son, Inc.*

Adult alligator gar *Atractosteus spatula* are commonly found in saline and fresh waters throughout most of southern Louisiana and were previously believed to spawn only in fresh water. On 25 April 2003, adult alligator gar were observed spawning in a brackish-water marsh near Montegut, Louisiana (salinity = 7.0 ppt; temperature = 25.0°C). Several thousand alligator gar eggs were observed attached to *Spartina patens*. A sample of *S. patens* and attached eggs was collected, transported to Nicholls State University, and transferred to two heated (25° C) and aerated 39 L glass aquaria. One aquarium was maintained at 7 ppt salinity (through day 6 post-hatch) and the other aquarium was maintained at 0 ppt salinity. Larvae began to hatch within 72 hr of egg collection and immediately attached to *S. patens* or sides of the aquaria. Prior to these observations no published records of alligator gar spawning in brackish waters were available. Although spawning and juvenile habitat requirements of alligator gar are poorly understood, these observations provide evidence that potential spawning and juvenile habitats of alligator gar must be expanded to include brackish water areas.

## A COMPARISON OF TWO TECHNIQUES ESTIMATING BELOW GROUND BIOMASS IN SALT MARSHES RESTORED USING DEDICATED DREDGED MATERIALS

*Ford, M.A. [mford@mail.mcneese.edu], K.R. Edwards, B.J. Hoffpauir, K.P. Mills*
*McNeese State University*

Very little has been published on underground plant processes in marshes restored using dedicated dredged material. Two different methods, a root zone tissue volume technique and an in-growth root primary production technique, both of which were parts of different, larger projects, were used to obtain below ground biomass data from restored salt marshes. These sites range in age from 3 to 20 years. We compared the biomass data from both methods to determine if there were similarities between the two techniques. The root zone tissue volume sampling was a single event at the end of the growing season, whereas the below ground biomass production sampling took place quarterly. When the production sample data were added together, both the biomass values and site ranking pattern were very similar to the root zone tissue volume dry biomass data. Below ground biomass levels were highest in the reference site, at 0.025 $cm^3$ for both techniques. The oldest created site (1984) had the second highest values, estimated at 0.014 and 0.007 $cm^3$ by the tissue volume and production techniques, respectively. This was followed by the 1993 (0.014 and 0.0105 $cm^3$ and 1996 (0.005 and 0.006 $cm^3$ sites, with the lowest values (0.003 and 0.006 $cm^3$ being found at the newest (1999) site. Below ground biomass estimates were similar when using these two techniques, although the data are still preliminary. However, based on these data, it is apparent that, even after 20 years since site creation, below ground biomass in the restored marshes is still significantly different from that of a neighboring natural reference marsh.

## CASE STUDIES OF WETLANDS RESTORATION AND PROTECTION IN TEXAS

*Daniel J. Heilman [dheilman@shinermoseley.com], T. Neil McLellan*
*Shiner Moseley and Associates, Inc.*

Many complex variables must be considered and carefully assessed when developing approaches for restoring and protecting coastal wetlands. Typical projects in these ecologically fragile areas must overcome difficult site conditions, including soft foundation soils and shallow water, and, as is often the case in Texas bays and estuaries, strong surge and currents from deep-draft vessels that travel between our major ports and the gulf. In addition, limited project funding combined with a desire to restore or protect a large area often presents a challenge. Our firm has designed numerous wetlands restoration and protection projects that have been constructed in Texas over the past fifteen years. These projects have included uniform and mound placement of dredged material, terracing, and construction of finger berms for creating new wetlands, as well as constructing breakwaters and revetments using rock, geotextile tubes, and articulating concrete mats to protect both restored and existing wetlands. We have applied science, some "trial and error," a good knowledge of standard and innovative construction techniques, and a combination of engineering and biology to develop successful approaches to our projects. Some highlights include a project that augmented the growth of seagrass in Galveston Bay and construction of the largest island in Nueces Bay as a rookery site. Our poster display will present case studies of five to ten projects recently constructed in Texas. We will provide lessons learned, unexpected results, and examples of how difficult site conditions can be addressed during design and construction.

## STORM WATER DIVERSION AS A METHOD OF WETLAND RESTORATION

*Jennifer Howard [jhowa11@lsu.edu], Stephen Faulkner*
*Louisiana State University*

The Barataria-Terrebonne estuary has been eroding at a rate of up to 103.6 $km^2$ yr-1 for several decades. If the current rate of loss is not slowed by the year 2050, an additional 2,550$km^2$ of coastal wetlands will be lost. Curently, stormwater in Terrebonne Parish is pumped into canals and ultimately discharged into the Gulf of Mexico. An opportunity exists in the Barataria-Terrebonne estuary to use this stormwater for wetland restoration. This project examines the feasibility of stormwater diversions as a large-scale wetland restoration method. The approach of this project is 1.) to compare the soil N and P chemistry and sedimentation rates for different wetlands that have historically received stormwater input, 2.) to gather baseline water and soil chemistry of a degraded marsh prior to receiving stormwater, and 3.) to investigate the seed banks of the marsh to determine if a viable seed source exists. To examine the distribution of seeds, composite cores were taken in both the vegetated and mudflat areas of the degraded marsh. The cores were then placed into sterilized sand filled basins. Deionized water was added to the seed banks every two days until germination was complete. After 99 days, a total of 370 stems were counted in the seed banks from the vegetated areas and a total of 2 stems were counted in the seed banks from the mudflat. These results suggest that management techniques, such as replanting, will be necessary for establishment of vegetation in the mudflat areas.

## REDISCOVERY OF THE LA COAST INSPIRES AND EDUCATES

*Gary J. LaFleur, Jr.[1] [biol-gjl@its.nicholls.edu], Dennis Sipiorski[1], Jessica Kastler[2]*
*[1]Nicholls State University; [2]LUMCON*

We have established a project aimed at raising the awareness of students to the beauty and fragility of the Louisiana coast through field photography. Using LUMCON as a base, students learn to shoot, develop, print, and present a gallery show consisting of images harvested from Louisiana barrier islands and surrounding wetlands. While the course has created a vehicle to introduce local art students to the magnificence of Louisiana's coast, it has also given biology students a chance to experience classical techniques of field observation and documentation in a true wilderness. The course has also created an archive of images that document factors affecting Louisiana's coast such as nutria, drought, hurricanes, and anthropogenic modifications. We conclude that even though current scientific and technical characterizations of the changing coast are becoming available, widespread public understanding of Louisiana's coastal problems remains elusive. We believe that ground level photographic expeditions as presented here can provide valuable information, education, and high impact images for expanding public awareness of the challenges facing coastal restoration efforts. This work was supported by the LUMCON University Ed program with permits granted by La Wildlife and Fisheries.

## FIRST YEAR OYSTER DISTRIBUTION IN THE BARATARIA ESTUARY AFTER THE DAVIS POND DIVERSION OPENING

*Earl Melancon [biol-em@nicholls.edu], Cassandra Addison, Ronnie Duke*
*Nicholls State University*

Five field sites were established in an up-estuary to down-estuary orientation with monthly sampling begun in May 2002. The most up-estuary site is located above the diversion's projected 5ppt isohaline in Coffee Bay. Two sites are mid-estuary that bracket the present public oyster grounds (above in Grand Bayou and below in Redfish Bay). The two remaining sites are farthest down-estuary and bracket the projected location of future public oyster grounds (above at Middle Bank Reef and below at Independence Island Reef). Salinity at Coffee Bay, Grand Bayou and Redfish Bay remained high enough for oysters to live, grow, reproduce and larvae to set. In the four-month period from mid October '02 to January '03 salinity at Coffee Bay remained mostly below 5ppt, and again in March-April '03. Highest salinity at Coffee Bay was >15ppt in May '03. Coffee Bay oyster mortality was highest by March '03 at 47%. Salinity at Grand Bayou remained in the 5-20ppt range most of the year except from November to February when salinities periodically dropped to <5ppt. Grand Bayou oyster mortality was highest by January '03 at 10%. Salinity at Redfish Bay remained higher than at Grand Bayou but closely followed the same pattern with periodic freshening below 5ppt during November to February. Redfish Bay oyster mortality was highest by February '03 at 23%. Salinity near Middle Bank Reef and Independence Island Reef was >15ppt for most of the study, with periods of salinity >25ppt; only a few isolated live oyster spat (<25mm) survived. The estuary functioned in a normal-to-dry mode for the majority of the year. The diversion opened March 26, 2002.

## SMALL MAMMAL POPULATIONS IN NATURAL AND RESTORED SALTWATER MARSHES IN SOUTHWESTERN LOUISIANA

*Mills, K.P. [kmills@mail.mcneese.edu], J.L. Houston, G.R. Haigh, G.D. Hartman,*
*McNeese State University*

We conducted a 2-year study in southwestern Louisiana involving live-trapping of small mammals in two naturally occurring and two restored saltwater marsh habitats. Species composition of the natural and restored marshes appears to have been similar. The predominant species were Oryzomys palustris (Marsh rice rat) and Mus musculus (House mouse); of these two, O. palustris was more prevalent in both marsh types. A small number of individuals of Cryptois parva (least shrew) was captured in one of the restored marshes. Individuals of M. musculus were captured more frequently in the restored marshes and the numbers of captures were positively correlated with the mean elevation of a trapline. Mortality of trapped rodents varied significantly as a function of
phase of the moon. Our data demonstrate that phase of the moon can be a critical factor to consider when planning studies that will involve live-trapping of rodents in marshes.

## DECOMPOSITION RATES IN DREDGE-FILLED CREATED AND NATURAL SALT MARSHES IN SABINE NATIONAL WILDLIFE REFUGE (SOUTHWEST LOUISIANA)

*Mills, K.P. [kmills@mail.mcneese.edu], K.R. Edwards*
*McNeese State University*

Decomposition is an important factor that needs to be studied when comparing created and naturally occurring wetlands. We are comparing decomposition rates in marshes created from dredge material to the rates in natural salt marshes in the Sabine National Wildlife Refuge (southwest Louisiana). We hypothesize that, as the created marshes age, the functions in these marshes will become similar to those in the natural marshes. Litter bags, which are made from fiberglass mesh and filled with 10g of dead Spartina alterniflora material (7g stems, 3g leaves), were placed out in the sites in August 2002. There are 5 replicate stations per site with twelve bags at each station. Two bags are collected from each station (10 per site) at 2 month intervals. Preliminary results show statistically significant differences in rate of decomposition between created sites and natural sites.

## MANAGING TO PROMOTE SEDIMENT DEPOSITION IN SUBSIDING LOUISIANA COASTAL MARSHES: THE BRADY CANAL PROJECT

*Denise J. Reed [djreed@uno.edu] [1], Nina DeLuca[2]*
*[1]Department of Geology and Geophysics, University of New Orleans; [2]Louisiana Universities Marine Consortium*

New restoration approaches have been developed to manage coastal marsh hydrology to benefit from natural cycles of freshwater and sediment input in the Mississippi Delta Plain. The Brady Canal restoration project represents one of the first attempts to manage for sediment deposition in the deltaic marshes. The project was developed to both combat wetland loss in the area and to enhance utilization of freshwater and sediments that are being introduced into the project area. The major goal of the project is to reduce adverse tidal effects on the project area, as well as to better utilize available freshwater and sediment for maintenance of the project area marshes. The success of the project in enhancing sediment deposition was assessed through both pre-and post-construction monitoring within the project area and on adjacent reference sites. Comparison of biweekly measures of sediment deposition show complex patterns and indicate the importance of seasonality in sediment availability, as well as inter-annual variations, to project performance. This project serves as a prototype for many planned actions that seek to control tidal influence while maximizing the benefits of seasonal freshwater and sediment delivery. It also represents a transition in thinking about marsh restoration in Louisiana from one based upon a defensive approach (i.e., protecting marsh soils and vegetation from physical stress) to an offensive approach (i.e., working with natural geomorphic processes to sustain marsh substrate).

## THE EFFECT OF VERTICAL STRUCTURE AND REFUGE ON OYSTER SETTLING AND RECRUITMENT

*Jenny Ruiz[1], Thomas M. Soniat[1] [biol-tms@nicholls.edu], Chris Finelli[2]*
*[1]Nicholls State University; [2]LUMCON*

It is likely that spatially-heterogeneous, refuge-rich oyster reefs should serve as a superior habitat for oysters and reef associates. Inexpensive, reproducible units to test the effects of vertical orientation and refuge on oyster recruitment and community development were constructed as concrete blocks into which shells were placed horizontally, vertically and widely-spaced, and vertically and closely spaced representing: horizontal orientation with no refuge (HNR), vertical with no refuge (VNR), and vertical with refuge (VWR). Ten units of each were placed in a racetrack flume located at LUMCON. About one million oyster larvae were introduced into the flume with a flow rate of 5 cm/s, 15 ‰ salinity, and a temperature of 23º C. After 3 days all larvae were counted and standardized to the number of larva per cm². Log transformed data showed significantly higher settlement on HNR than on either VNR or VWR. Thirty units of each type were also randomly placed along the shore at the LUMCON lab at Fourchon. After a month the models were retrieved. Using log transformed oyster densities, VNR>VWR and HNR=VNR and HNR=VWR. Likewise, for log transformed barnacle densities, VNR>VWR and HNR=VNR and HNR=VWR. Bryozoan percent cover showed HNR<VNR, HNR<VWR, and VNR=VWR.

## INFLUX OFRIVER WATER TO COASTAL LOUISIANA AND SUITABILITY FOR WETLAND RESTORATION

*Christopher M. Swarzenski [cswarzen@usgs.gov][1] , and ThomasDoyle[2]*
*[1] U.S. Geological Survey, Baton Rouge, [2] U. S. Geological Survey, Lafayette, Louisiana*

Flood control levees have effectively cut off most deltaic wetlands in south Louisiana, reducing or eliminating the freshwater and sediment supply needed for marsh nourishment and to keep pace with sea-level rise. However freshwater originating from the Mississippi River still floods wetlands adjacent to the Lower Atchafalaya River and Wax Lake Outlet. The GIWW (Gulf Intracoastal Waterway) crosses these outlets and distributes river water and suspendedsediment30 or more miles east and west. It has become the largest source of river water to many parts of coastal Louisiana. The channel functions like a freshwater diversion, but on a much larger scale in terms of volume and reach.

Many marshes south-east of the Atchafalaya River /GIWW junction have converted to open water since river water first began flowing through them, contrary to the expected marsh building. The marshes are buoyant and peat-based, with a highly organic, self-sustaining substrate. We compared substrate, pore-water and surface-water quality in the western Terrebonne marshes with marshes at Jean Lafitte National Historic Park and Preserve, which are isolated from river water inflow and have not converted to open water. Nitrate and atrazine are higher in the waterways near the river water source. N:K ratios are shifted in favor of above-ground production and inorganic nutrient and sulfide concentrations are higher in pore waters of marshes receiving large annual infusions of river water. River water diversions into peat-based marshes may have unexpected consequences.

## BIOMARKERS TO ASSESS REPRODUCTIVE HEALTH IN FISH AND WILDLIFE

*Jennifer Veazey [jenveazey@hotmail.com], Lois Nelson, Gary LaFleur, Jr.*
*Nicholls State University*

One goal of coastal restoration is to ensure that aquatic habitats are suitable to support fish and wildlife. Across the nation, endocrine disruption from water-borne contaminants has been documented as a cause of artificially induced sex-change. While effects of environmental contaminants rarely cause death, a significant rise in infertility can be detrimental to any population. To address the need to monitor reproductive health in Louisiana fish and wildlife we have begun to develop molecular tools to assay for environmentally-induced sex-change. Using primer sets as probes for female-specific products including vitellogenins, choriogenins, and estrogen receptors, we have tested RNA isolated from males that had been exposed to estradiol. We present preliminary data confirming that our female-specific biomarkers can be used as valid indicators of estrogen induction in males. Through RT-PCR assays we show the presence of female biomarkers in normal females and exposed males, in a range of species including the freshwater fishes *Fundulus chrysotus* and *Gambusia affinis*, the amphibian *Amphiuma tridactylum*, and the saltwater fish *Fundulus grandis*. This protocol can now be used to compare reproductive status of animals in non-impacted wetlands, impacted wetlands, and in wetlands that may be altered due to future restoration activities.