POSTER PRESENTATION SCHEDULE

JANUARY 14th
5:00 – 8:00 PM
Boxwood and Dogwood Rooms

1. **Modeling Sea Level Rise Impacts Using the Sea Level Affecting Marshes Model (SLAMM) in North Carolina Coastal Regions**
   Robert Mickler and David Welch, Alion Science and Technology

2. **Sea Level Rise Anomaly along the Eastern Seaboard in the of Summer 2009**
   William Sweet, National Oceanographic & Atmospheric Administration

3. **Analyzing Shoreline Change in the New River Estuary, NC**
   Cowart, L., Currin, C., Fonseca, M., Malhotra, A., NOAA, NOS, Center for Coastal Fisheries and Habitat Research

4. **Controlling the Marsh Edge: Wave Energy, Sediment Accretion and Vegetation Dynamics in Fringing *Spartina* Marshes**
   Currin, C., Delano, P. D., Greene, M., NOAA, NOS, Center for Coastal Fisheries and Habitat Research

5. **Interpreting Sea Level Rise Maps**
   N. Kettle, S. Chhotray, K. Dow, and J. Whitehead

6. **An Analysis of the Impacts of Sea Level Rise on Four Coastal Communities and Recommendations to Modify the NFIP and Building Codes**
   Adam J. Reeder, PBS&J

7. **Ecological Effects of Rising Sea Level on Shorezone Wetlands: Neuse River Estuary, North Carolina.**
   David M. Kunz and Mark M. Brinson, Department of Biology, East Carolina University

8. **An Ongoing Field Experiment to Test if Zonation of Tidal Marsh Vegetation is in Synchrony with Hydrologic Conditions Developed during Rising Sea Level**
   John Haywood, Mark Brinson, and Robert Christian, Department of Biology, East Carolina University; Linda Blum, Department of Environmental Science, University of Virginia

9. **Geovisualization to Communicate Sea Level Rise**
   Thomas R. Allen, RENCI@ECU Engagement Center; and Department of Geography, East Carolina University

10. **Perceptions of Sea Level Rise among Adult Residents of North Carolina's Outer Banks Region**
    Robert T. Perry, Albemarle Ecological Field Site, UNC-Chapel Hill

11. **Evaluating Potential Impacts of Sea Level Rise on Water Level and Flooding in Northeastern North Carolina**
    Tom Shay, Brian Blanton, Rick Luettich, Dave Mallinson, Steve Culver, Stan Riggs

12. **Using a coupled geologic and hydrodynamic modeling approach to understand the response of a coastal system to sea-level rise and geomorphic change**
    David Mallinson, Stephen Culver, Stanley Riggs, Brian Blanton, Richard Luettich

1. Modeling Sea Level Rise Impacts Using the Sea Level Affecting Marshes Model (SLAMM) in North Carolina Coastal Regions

Robert Mickler and David Welch
Alion Science and Technology

This sea level rise (SLR) project shows impacts from a range of model scenarios in selected areas along the North Carolina coast: the Dare County Peninsula, the New River Estuary, and the Cape Fear Estuary. There is considerable uncertainty regarding the consequences of sea level rise in coastal regions. The International Panel on Climate Change's (IPCC) review of research indicates that oceans will rise 0.1 m to 0.7 m above current levels by 2100 if trends in carbon dioxide emissions continue to increase. Recent research indicates that sea levels may rise 1.4 m over current levels by 2100. Varied estimates of atmospheric warming, polar glacial melting, and other phenomena contribute to this wide range of SLR.

The modeling platform used for this research, Sea Level Affecting Marshes Model (SLAMM), traces land cover change to 2100 over multiple time steps using a range of estimates of SLR. Model calculations include inundation, erosion, overwash, and saturation on a cell by cell basis by employing a digital elevation model (DEM), slope layer, and National Wetland Inventory (NWI) cover classes. User inputs include tidal regime, sea level rise trend, shoreline erosion, and marsh accretion rates. As sea level rises, SLAMM models vegetation transitions between 23 explicit land cover classes based on National Wetland Inventory (NWI) land cover designations. Model outputs include land cover statistics and GIS-based maps. Upland and wetland losses to estuarine waters and open ocean exceed 90% in vulnerable parts of the Albemarle-Pamlico estuary. Less vulnerable estuaries such as the Cape Fear lose a much smaller proportion of land by 2100. Contrasting geologic settings help to explain differences in model simulation results. Impacts from sea level rise will be more pronounced in lower elevation regions common in northern North Carolina.

Better knowledge of wetland functioning will provide more accurate ranges of land cover change over the next century. Little is known regarding how different ecosystems will respond to higher water levels and changing climatic conditions in North Carolina's coastal wetlands. Increased plant growth rates due to higher temperatures or nutrient influx may slow land inundation. On the other hand, salt water intrusion may hasten sea level rise impacts by decreasing marsh productivity. This research, therefore, presents a range of modeling scenarios in order to inform efforts developing policy and adaptive strategies for North Carolina's coastal communities.

2. Sea Level Rise Anomaly along the Eastern Seaboard in the of Summer 2009

William Sweet, National Oceanographic & Atmospheric Administration

NOAA tide stations recorded higher than normal sea levels (SL) along the U.S. East Coast in June and July 2009. Near-peak levels in the latter half of June coincided with a *perigean-spring* tide that added to the observed SL anomaly, produced minor coastal flooding, and caught the attention of coastal communities because of the lack of coastal storms. In terms of annual SL heights, the event was not very abnormal. The SL was anomalous because of the unexpected timing and geographic scope of the 'residual' values, which are unaccounted for within the predictions of the earth-moon-sun tides and the mean seasonal SL cycles. The June 2009 mean residual values were elevated from Florida to Maine and the most extreme to occur over the entire East Coast during a summer period as far back as 1980.

There are two mechanisms responsible for high SL residuals. The first are northeasterly (NE) winds, which had a moderate component in June 2009 between Cape Hatteras, NC and the Gulf of Maine that caused coastal SL to rise. The other mechanism was a reduced transport of the Florida Current (FC), a component of the Gulf Stream System measured in the Florida Straits. When transport is low, the eastward-rising cross-current slope relaxes and raises coastal SL. The SL event is unique in that the NE winds were not at a multi-year high or the FC transport at its low. But the coupled forcing created abnormally high SL residuals that were highest between North Carolina and New Jersey in the region of greatest overlap of the two forces.

3. Analyzing Shoreline Change in the New River Estuary, NC

Cowart, L., Currin, C*., Fonseca, M., Malhotra, A.
NOAA, NOS, Center for Coastal Fisheries and Habitat Research

One potential consequence of sea level rise is an increase in erosion rates of the estuarine shoreline. Shoreline erosion is a concern not only for the cost of lost infrastructure, but also for the potential loss and degradation of coastal habitats and the ecosystem services they provide. We examined shoreline erosion rates and shoreline composition along the estuarine shoreline of Marine Corps Base Camp Lejeune, located in Jacksonville, NC. Shoreline change was calculated using Geographic Information Systems (GIS) software and aerial photography from multiple time periods, including 1956, 1989, and 2004. Over this period, the average erosion rate for the New River Estuary shoreline was -0.28 m yr^{-1} , and 10% of the shoreline exhibited an erosion rate >1 m yr^{-1}. Additionally, the wave exposure of the shoreline was determined, using a Wave Exposure Model (WEMo), and the shoreline was characterized in the field using Geographic Positioning System equipment and GIS software. The shoreline-change rates, wave exposure, and shoreline characterization data were statistically analyzed to further understand the relationship between the shoreline change that has occurred, shoreline composition, and the processes acting on the shoreline. These results will be incorporated into a Shoreline Management Plan for Marine Corps Base Camp Lejeune.

4. Controlling the Marsh Edge: Wave Energy, Sediment Accretion and Vegetation Dynamics in Fringing *Spartina* Marshes

Currin, C*., Delano, P. D., Greene, M.
NOAA, NOS, Center for Coastal Fisheries and Habitat Research

The response of salt marshes to sea level rise will be a key determining factor in how NC estuaries appear fifty to one hundred years from now. Will the marshes keep up, or drown, or migrate inland? How will this response vary from the northern, microtidal lagoons to the southern riverine systems? In particular, what will happen to the salt marshes which often occupy a relatively narrow space between the estuary and developed uplands? Fringing salt marshes dominated by *Spartina alterniflora* occur throughout the estuarine ecosystem in southeastern North Carolina. Often bordered by tidal flats and seagrass beds, they lack the levee formation typical of tidal creek marshes, and receive significant wave energy compared to interior marshes. In an effort to identify the factors controlling vegetation, sediment accretion and erosion rates in fringing salt marshes, we deployed Sediment Elevation Tables at the upper and lower edges of *Spartina alterniflora* marshes at 6 sites in Carteret County.

We measured elevation change, accretion rate as measured by marker horizons, and plant and sediment characteristics from 2004 to Spring 2008. We obtained fine-scale (2 cm) Digital Elevation Models of the sites, and calculated Relative Wave Exposure with a model incorporating fetch, wind data, and bathymetry. The lower edge of fringing salt marshes was accreting sediment but losing elevation at a rate ranging from -2 to -40 mm/year, suggesting compaction or other subsurface processes are important. This loss in elevation was not accompanied by a change in marsh vegetation distribution during the study period, and we found tall *Spartina* thriving at elevations 30 cm below MSL. The upper edge of the *Spartina alterniflora* marsh was accreting sediment at a rate similar to observed increases in surface elevation, with rates ranging between 1 and 4 mm/year. Intertidal oyster reefs reduce erosion of the lower marsh surface, and offshore breakwaters increase marsh sediment accretion rates significantly, although increased erosion may occur along adjacent shorelines.

5. Interpreting Sea Level Rise Maps

N. Kettle, S. Chhotray, K. Dow, and J. Whitehead.

Sea level rise maps are often used to communicate potential risks associated with climate change. There are many issues that complicate the interpretation of these maps that are not always apparent to non-experts or conveyed clearly by maps makers. In addition, there are numerous assumptions that compromise the accuracy of the final maps. These challenges complicate the use of sea level rise maps for decision making. It is critical to communicate assumptions, scenarios, and choices underlying the assessment process and provide guidance on how to interpret sea level rise maps.

This poster presentation addresses both of these challenges. The presentation begins by identifying and describing the major assumptions and choices within the development of sea level rise maps, which includes estimating rates of change and selecting data. Several examples associated with shoreline change, human response, and coastal elevations are discussed to illustrate how sources of error and uncertainty compromise the accuracy of the assessment process. A checklist is provided as a means of summarizing key issues and challenges in interpreting sea level rise maps. This checklist addresses issues relating to the sea level rise scenarios, tide levels, and sensitivity of elevation models. By addressing the challenges in creating and interpreting sea level rise maps, we assist concerned citizens in evaluating these products.

6. An analysis of the impacts of sea-level rise on Four Coastal Communities and Recommendations to modify the NFIP and building codes

Adam J. Reeder, PE
Project Manager, PBS&J

The study will evaluate the impacts of sea-level rises on 4 coastal communities in North and South Carolina. A Benefit-Cost Analysis (BCA) of several newly constructed houses in the coastal high hazard flood zones were compared, the analysis consisted of houses built to the current minimum NFIP compliance and were evaluated against houses constructed with freeboard of 1 to 4 feet. The study will look at the current risks faced by the example structures and then evaluate the increased risks associated with those structures when they are impacted by sea-level rise. Recommendations will be made on ways to modify the existing NFIP and code requirements for constructing residential structures at or above the BFE and provide the reader assistance in determining minimum freeboard requirements for hazard prone areas.

The study assumed a project useful life of approximately 50 years. This was timeframe was utilized in order determine if there is an immediate need to address the building codes and floodplain management requirements in areas subject to storm surge.

The economic analysis indicated that in many instances the increases in damages were at minimum of 20 to 30 percent above the current damages associated with hurricanes. This utilized a very minimal amount of sea-level rise. When more dramatic sea-level rise models were utilized hurricane damages in some locations experienced damages of approximately twice the current expected damages. This is due to changes in the cost of construction and variations in predicted flood elevations between the 100- and 500-year return period storms.

While many studies evaluate the economic impacts associated with sea-level rise associated with entire communities and infrastructure, this study was focused on the impacts to single-family residential structures. The study evaluates a variety of structure sizes, four different geographic locations and three different locations within each floodplain in order to assess the risk to a large number of houses. Many residents of coastal areas are familiar with the flooding damage from previous hurricanes and the study provides an alternative approach to communicate the increased risk to their homes and their communities due to sea-level rise.

7. Ecological Effects of Rising Sea Level on Shorezone Wetlands: Neuse River Estuary, North Carolina.

David M. Kunz and Mark M. Brinson.
Department of Biology, East Carolina University

Sea-level controlled wetlands in western Pamlico Sound, and specifically those in the Neuse River Estuary, NC, have been affected by sea level for hundreds of years. Their capacity to sustain themselves derives principally from accumulation of organic matter and sediments on the Pleistocene surface. These wetlands occupy the 'shorezone,' defined as the area between an eroding shoreline and the landward margin where the hydrologic influence of sea level diminishes and terrestrial hydrology dominates.

To analyze how shorezones have changed as sea level rises, we have developed a conceptual framework to substitute space for time. Along the length of the estuary, we partitioned the land into interstream divide units. GIS was used to analyze differences between units and translate them into the space-for-time framework. Four temporal stages of shorezone transgression were identified along a spatial continuum for analysis. Each represents several thousand years of landward migration: early – upstream migration, intermediate – non-migration, late – over-flat migration, and terminal – non-migration. Assuming that vertical accretion of sediments maintains the presence of shorezone wetlands, the temporal stages can be extended into the future.

From a whole-estuary perspective, shorezone wetland vegetation systematically changes according to position along the estuarine gradient. Factors affecting vegetation include
salinity, wrack deposition from storm surges, fire, shoreline erosion, and human activities. Shorezone plant communities range from brackish marsh to freshwater swamp forest. Zonation occurs at two scales: (1) within shorezones, from the shoreline to the landward margin and (2) across shorezones of the Neuse River Estuary, from west to east as the salinities increase. Plant community zonation can be explained principally by the salinity gradient, which itself is a component of the space-for-time framework.

The framework is intended to provide a better understanding of processes that have led to the current position and types of shorezones. Revealed patterns also call attention to where and how effects of rising sea level will be the greatest. For example, conversion of freshwater forest to brackish marsh is a natural progression and is expected to continue. Overland migration of shorezones will continue to convert uplands to wetlands. These rates are most rapid east of the Suffolk Scarp where slopes are lowest, but rapid rates occur locally wherever there is migration up stream floodplains. Recognition of the varied patterns throughout the length of the Neuse River Estuary, for example, should lead to a diversity of management approaches based on site-specific characteristics.

8. An ongoing field experiment to test if zonation of tidal marsh vegetation is in synchrony with hydrologic conditions developed during rising sea level

John Haywood[1], Mark Brinson[1], Linda Blum[2], and Robert Christian[1]
Affiliation: 1. Department of Biology, East Carolina University; 2. Department of Environmental Science, University of Virginia

In August 2008 we initiated an ongoing field experiment at Upper Phillips Creek, near Nassawadox, Virginia. The goal of this experiment is to determine whether the vegetation of a coastal marsh is in synchrony with hydrologic conditions that have developed with rising sea-level. The hypothesis tested is that plant community structure will persist in existing zones of vegetation in the face of sea-level rise unless disturbance provides opportunity for species change under more frequent tidal inundation. The five treatments in our experimental design are replicated four times in three plant community types and are comprised of control, fertilization, clipping alone, and simulated wrack disturbance with and without fertilization in 3m x 3m plots. Wrack simulation, the result of clipping and covering with dark plastic from August 2008 to March 2009 is considered an analogue for wrack disturbance, and fertilization is used as a stress-relief subsidy in zones where species composition may be out of phase with current inundation patterns.

This study addresses a core question guiding long term ecological research at the Virginia Coast Reserve LTER, an area with one of the fastest rates of relative sea level rise on the Atlantic Coast of the United States: How do short term disturbances interact with long term drivers to alter ecosystem dynamics and ultimately lead to state change? The three plant community types being examined include a spring-tidal zone where *Spartina alterniflora* is dominant, a flood-tidal zone where a *S. patens-Distichlis spicata* mix is dominant, and an intermediate transition zone where the two communities are mixed. This work builds on previous findings at the Upper Phillips Creek across marsh zones including observations of high resistance to augmented inundation by *S. patens* and *D. spicata*, high vulnerability of *Juncus roemerianus* to wrack disturbance, and a die-off in the low marsh interior in 2004 that is undergoing recovery. Environmental variables measured in 2009 include periodic growing season measurements of salinity and water level in the root zone of each plot. Response variables sampled in 2009 and currently being analyzed include peak above ground standing stock biomass, vegetation cover, below ground macro-organic matter, plant tissue nutrient concentrations, and pore water nutrients and sulfide.

Preliminary results suggest response to treatments differs between plant community types, and context within the marsh as determined by soil properties and inundation and drainage conditions. Preliminary observations of the response to wrack simulation treatments indicate slow recovery in the zone where *S. alterniflora* is a dominant monoculture; while the proportion of *S. alterniflora* standing stock and cover increased greatly in both fertilized and unfertilized transition areas. In the communities dominated by *S. patens* and *D. spicata* the return of vegetative cover in wrack simulation plots has been enhanced by fertilization.

9. Geovisualization and Cybercartography for Sea-Level Rise

Dr. Thomas R. Allen
Department of Geography, East Carolina University

Geovisualization and cybercartography offer potential to analyze and communicate impacts of sea-level rise. Geovisualization can assist scientific insight and representation of data and model uncertainty. Cybercartography offers organization, presentation, and communication methods using interactive, multi-sensory, and dynamic modes for decision-makers and the public. Published research, grey literature, and online mass media are reviewed and classified for their development of geovisual and cybercartographic techniques. Few maturely developed examples of geovisual analysis and cybercartography have emerged for sea-level rise. Limitations, impediments, and emerging opportunities are identified. Geovisual techniques may include map animation and interactive display of hydrodynamic and ecosystem model simulations, infrastructure, and receptor systems. Cybercartographic products may include online atlases and distributed geospatial data, immersive webmaps, and digital globes. Heretofore, these approaches have primarily used coarse resolution models and topographic data or “bath tub” inundation models. Given uncertainty in sea-level rise rates and magnitudes, geovisualization and cybercartograpy nonetheless offer assistance to scientific inference and risk awareness.

10. Perceptions of Sea Level Rise among Adult Residents of North Carolina’s Outer Banks Region

Robert T. Perry
Albemarle Ecological Field Site
UNC-Chapel Hill

Despite the vast body of research on the subject of sea level rise, little is known about how the public perceives the phenomenon. The lack of research on this topic leaves policy makers unsure about what, if anything, they should do to address sea level rise. This study examined the perceptions of people residing in the Outer Banks region of North Carolina regarding sea-level rise through the use of a convenience sample method. A survey designed to gauge whether respondents thought sea level rise was occurring, how they felt sea level rise might impact them, what responses, if any, should be taken to address sea level rise, and how informed they felt on the topic was distributed by hand and through a local newspaper. A total of 240 respondents completed surveys and, of those, 232 were included in the study’s analysis. Descriptive statistics of the respondent’s an swers were then compiled for interpretation. From these comparisons, it appears that level of education, above all other factors, plays the greatest role in determining how informed respondents felt on the subject of sea level rise, as well as how concerned they were about the issue. In general, those with higher levels of education seemed to feel more informed on the subject of sea level rise and considered it something that needed to be addressed. Considering the study’s data, the single greatest recommendation to policy makers is that there should be more comprehensive outreach and education of the public on the topic of rising sea levels and their likely impact on the Outer Banks region.

11. Evaluating Potential Impacts of Sea Level Rise on Water Level and Flooding in Northeastern North Carolina

Tom Shay[1], Brian Blanton[2], Rick Luettich[1], Dave Mallinson[3], Steve Culver[3], Stan Riggs[3]

[1]University of North Carolina at Chapel Hill, Marine Sciences Program
[2]Renaissance Computing Institute
[3]East Carolina University, Department of Geology

Sea level rise during the 21st century has a significant potential for altering circulation, water level and flooding in North Carolina's estuarine and coastal areas. Due to their minimal elevation above present day sea level, much of the North Carolina Outer Banks and the lands surrounding the Albemarle and Pamlico Sounds are particularly vulnerable to inundation and erosion. A comprehensive evaluation of the most likely future conditions in these areas is extremely complex since it will depend on the rate of sea level rise, the influence of climate change on severe storms, the natural response of the barrier islands and estuarine shorelines, and man's commitment to sustaining preferred coastal configurations (e.g., via shoreline hardening, beach nourishment, breach repair, etc).

Our poster provides an initial evaluation of estuarine and coastal changes in northeastern North Carolina during the 21st century for several potential future scenarios including elevated sea level and two configurations of the Outer Banks (current conditions and large scale collapse). For each scenario, the coastal circulation and storm surge model ADCIRC is used to compute resulting modifications to the basic tidal circulation and elevations. In addition a coupled version of ADCIRC and the coastal wave model SWAN is used to compute the storm surge, inundation and wave conditions had Hurricane Isabel occurred under each scenario. The results provide insight into potential future conditions in this region of North Carolina.

Depending on the availability of a suitable video display system at RENCI, we hope to have several animations of model results to complement the poster.

12. Using a coupled geologic and hydrodynamic modeling approach to understand the response of a coastal system to sea-level rise and geomorphic change

David Mallinson[1], Stephen Culver[1], Stanley Riggs[1], Brian Blanton[2], Richard Luettich[3]
[1]East Carolina University, Department of Geology
[2]Renaissance Computing Institute
[3]University of North Carolina at Chapel Hill, Marine Sciences Program

We are using coastal geologic data to produce paleobathymetric/geomorphic models as input to a hydrodynamic model (ADCIRC) to understand variations in tides and sediment transport which may result from storm impacts and sea-level rise. The approach is based upon geologic observations of late Pleistocene and Holocene facies within and surrounding the Albemarle-Pamlico Estuarine System (APES) and the associated Outer Banks of North Carolina. Based upon existing geologic data, we understand that major coastal reorganization occurred in the past, and will occur in the future, and is accompanied by rapid transitions in the tidal regime and sediment transport processes in response to sea-level rise and degree of barrier island continuity.

To understand the process-response, we are developing paleobathymetric, paleoenvironmental and geomorphic models of the APES system at specific time slices based upon core data, seismic data, and age-depth models. These data are used to model tidal effects (amplitude changes and energy dissipation) with ADCIRC (see complementary poster: Shay et al). Model outputs are being compared to sedimentological and paleoenvironmental data to determine the degree of correspondence of the model with observations, robustness of the method, and to identify discrepancies. These data will facilitate an understanding of the past coastal system process response, and the potential for future changes.