Annual Report for Period: 12/2006 - 11/2007 **Submitted on:** 10/01/2007
Principal Investigator: McGlathery, Karen . **Award ID:** 0621014
Organization: University of Virginia
Title:
Long-Term Drivers, State Change and Disturbance on the Virginia Coast Reserve: LTER V

Project Participants

Senior Personnel

Name: McGlathery, Karen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wiberg, Patricia
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Porter, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Anderson, Iris
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Virginia Institute of Marine Sciences

Name: Bachmann, Charles
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, Naval Research Laboratory

Name: Berg, Peter
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Blum, Linda
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Brinson, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI - Subcontract to East Carolina University

Name: Christian, Robert
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI - Subcontract to East Carolina University

Name: D'Odorico, Paolo
Worked for more than 160 Hours: No
Contribution to Project:

Co-PI, University of Virginia

Name: Day, Frank
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Old Dominion University

Name: Dueser, Raymond
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Utah State University

Name: Erwin, Russell
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia and U.S. Geological Survey, Biological Resources Division.

Name: Fagherazzi, Sergio
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Boston University

Name: Fuentes, Jose
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Galloway, James
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Macko, Stephen
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Mills, Aaron
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Moncrief, Nancy
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, Virginia Museum of Natural History, collaborates with Co-PI Dueser

Name: Oertel, George
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Old Dominion University

Name: Reyes, Enrique
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to East Carolina University

Name: Scanlon, Todd

Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Shugart, Herman
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Smith, David
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Young, Donald
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI, Subcontract to Virginia Commonwealth University

Name: Zieman, Joseph
Worked for more than 160 Hours: No
Contribution to Project:
Co-PI, University of Virginia

Name: Schwarzschild, Arthur
Worked for more than 160 Hours: Yes
Contribution to Project:
Research Site Manager

Name: Long, Bridget
Worked for more than 160 Hours: Yes
Contribution to Project:
2007: worked with PI's Blum and Christian on a marsh productivity database.

Post-doc

Graduate Student

Name: Battistelli, Joseph
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisors: PI's Mills & Blum

Name: Bissett, Spencer
Worked for more than 160 Hours: Yes
Contribution to Project:
Advisor: PI Young

Name: Blecha, Staci
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student. Advisor: Day

Name: Brantley, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:

Ph.D student. Advisor: Young

Name: Casciano, Gina
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student, Advisor: Blum

Name: Cole, Luke
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student, Advisor: McGlathery

Name: Conroy, Patrick
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student, Advisor: D. Smith

Name: Egge, Noah
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D Student, Advisor: Macko

Name: Fennell, Jeremy
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student. Advisor: Young

Name: Flewelling, Samuel
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student, Advisor: Mills

Name: Harbeson, Stephanie
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D Student. Advisor: Macko

Name: Hardison, Amber
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. Student. Advisor: Anderson

Name: Haywood, John
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student, Advisor: Brinson

Name: Hume, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisors: McGlathery & Berg

Name: Kathilankal, James
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Fuentes

Name: Koopmans, Dirk

Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Berg

Name: Kunz, David
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisor:Brinson

Name: Lawson, Sarah
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student, Advisor: McGlathery & Wiberg

Name: Marsh, Amanda
Worked for more than 160 Hours: Yes
Contribution to Project:
Advisor: Christian. M.S. Thesis 2007: Effects on a salt marsh ecosystem following a brown marsh event

Name: McMillan, Brett
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Day

Name: Michaels, Rachel
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Zieman

Name: Mozdzer, Thomas
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Zieman

Name: Naumann, Julie
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Young

Name: O'Connell, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Shugart

Name: Poleto, Juliette
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisor: Anderson

Name: Reynolds, Laura
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisor: McGlathery

Name: Richardson, David
Worked for more than 160 Hours: No
Contribution to Project:

M.S. student. Advisor: Shugart

Name: Robertson, Travis
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisors: Wiberg, McGlathery & Blum

Name: Sahu, Parameswar
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Scanlon

Name: Vick, Jackie
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisor: Young

Name: Voss, Christine
Worked for more than 160 Hours: No
Contribution to Project:
M.S. student. Advisor: Christian

Name: Weinmann, Richard
Worked for more than 160 Hours: Yes
Contribution to Project:
Ph.D student. Advisor: Shugart

Name: Shafer, Justin
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student. Advisor: Day

Name: Du, Xizhen
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student, Advisor: Fagherazzi

Name: Shiflett, Sheri
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student Advisor: Young

Name: Mcleod, George
Worked for more than 160 Hours: No
Contribution to Project:
2007 worked on Gargathy Inlet survey. Advisor: Oertel. Funded off non-LTER source.

Name: Gomez, Loreto
Worked for more than 160 Hours: No
Contribution to Project:
2007 worked on Gargathy Inlet survey. Advisor: Oertel. Funded off non-LTER source.

Undergraduate Student

Name: Curtis, Ben
Worked for more than 160 Hours: No
Contribution to Project:

2007 worked with PI Zieman and graduate student Thomas Mozdzer on island plant studies.

Name: Hippert, Rachel
Worked for more than 160 Hours: Yes
Contribution to Project:
2007 worked with PI McGlathery on lagoon studies.

Technician, Programmer

Name: Overman, Kathleen
Worked for more than 160 Hours: Yes
Contribution to Project:
Technician, Laboratory Manager

Name: Boyd, David
Worked for more than 160 Hours: Yes
Contribution to Project:
Technician

Name: Buck, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Fauber, Donna
Worked for more than 160 Hours: Yes
Contribution to Project:
Fiscal Technician

Other Participant

Research Experience for Undergraduates

Name: Richards, Joshua
Worked for more than 160 Hours: Yes
Contribution to Project:
Worked with graduate student Andrew Hume and PI McGlathery on lagoon dynamics project during 2007.

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: No Info

Name: Smith, Chris
Worked for more than 160 Hours: Yes
Contribution to Project:
2007 Worked with Iris Anderson on lagoon nitrogen studies.

Years of schooling completed: Junior
Home Institution: Same as Research Site
Home Institution if Other: Virginia Institute of Marine Sciences/ William & Mary
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2007
REU Funding: REU supplement

Organizational Partners

USGS Biological Resources Division

Co-PI R. Michael Erwin is supported by USGS/BRD.

Department of Navy Naval Research Laboratory

Co-PI Charles Bachmann is supported by, and works at, NRL.

The Nature Conservancy

The Virginia Coast Reserve of the Virginia Chapter of The Nature Conservancy provides access to study sites and field research facilities. They are frequent collaborators on research projects.

NOAA National Environmental Satellite Data Information Service

NOAA installed an operates a Climate Reference Network station at our laboratory in Oyster, VA. The resulting data provides a valuable adjunct to LTER meteorological data.

Coastal Zone Management - Virginia

In 2007 a monthly public seminar series on environmental issues and research activities at the VCR-LTER was established with support by the Coastal Zone Management and Seaside Heritage Program of the Commonwealth of Virginia.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

See attached PDF file

Findings: (See PDF version submitted by PI at the end of the report)

See attached PDF file

Training and Development:

We have engaged in training at all levels of education. At the graduate level we have a large number of students who participate in the research conducted at the VCR/LTER. A smaller number of undergraduate student REUs participate in research, while a larger number of undergraduates experience the LTER site through class field trips. In the K-12 area we are engaged in taking hands on science into the classroom in the area of field measurements using state-of-the-art equipment. This involves classroom teaching on the part of VCR scientists, field demonstrations and WWW-based communications.

Graduate Training

The VCR/LTER project helped support research activities by thirty-five graduate students at six universities. Since Nov. 2006, four masters and one Ph.D student have completed their graduate degree.

Undergraduate Training

During 2007, two REU students were supported: Chris Smith worked with Iris Anderson on nitrogen processing in the lagoon system and Josh Richards worked with graduate student Andrew Hume and PI Peter Berg. Additional undergraduate research assistance (either volunteers or supported by VCR/LTER core funds) were: Ben Curtis worked with PI Zieman on a project related to the spread of Phragmites and Rachel Hippert worked with PI McGlathery on seagrass and lagoon studies. Bridget Long, a University of Virginia, Department of Environmental Sciences undergraduate student, was supported by the core VCR LTER grant to work with Blum and Christian on the project's marsh grass productivity monitoring database. Bridget completed processing of summer 2006 samples and was instrumental in facilitating sample collection during August 2007.

Schoolyard LTER

During the 2007, the VCR-LTER program continued to support science education on the Virginia Eastern Shore through continued support of water quality monitoring projects and assistance in the development of a new Ecology class at Northampton High School. Science staff from field station presented guest lectures on a variety of environmental topics to Earth Science, Ecology, Environment Science and Marine Biology classes at Northampton High School.

In July 2007 a 10-day, teacher training and curriculum development workshop for the High School science faculty of both Northampton and Accomack Counties was conducted by VCR/LTER researchers at the new Anhueser Busch Coastal Research Center. VCR-LTER researchers presented lectures, led field trips, and moderated discussion groups. The participating high-school teachers developed new lectures and classroom activities based on the topics covered in the lectures and targeted towards specific 'Standards Of Learning' (SOL) objectives.

During 2007 a new Research Experience for High School Students (REHS) program modeled on the REU program was initiated, pairing 4 highly motivated and qualified high school students with graduate students conducting field research at the VCR/LTER. The students will be presenting the results of their research projects to high school science classes, civic organizations and at the annual VCR-LTER All Scientist Meeting in January 2008.

Outreach Activities:

Schoolyard LTER

During the past year the VCR-LTER program continued to support science education on the Virginia Eastern Shore through support of Water Quality Monitoring Projects and assistance in the development of a new Ecology class at Northampton High School. LTER Science staff presented guest lectures on a variety of environmental topics to Earth Science, Ecology, Environment Science and Marine Biology classes at Northampton High School. In July a 10-day, teacher training and curriculum development workshop for the High School science faculty of both Northampton and Accomack Counties was conducted at the new Anheuser-Busch Coastal Research Center. Principal Investigators and associated scientists from the VCR-LTER presented lectures, led field trips, and moderated discussion groups. The participating teachers developed new lectures and classroom activities based on the topics covered in the lectures. The new activities were targeted towards specific Standards Of Learning (SOL) objectives mandated by the Commonwealth of Virginia.

Additionally, a new Research Experience for High School Students (REHS) program modeled on the REU program was initiated with supplemental funding from NSF, pairing 4 highly motivated and qualified high school students with graduate students conducting field research at the VCR. At the end of the summer, these H.S. students prepared a summary presentation of their work which they will present to high school science classes, civic organizations, and at the annual VCR-LTER All Scientist Meeting to be held in January 2008.

Outreach to undergraduate students

In Spring 2007, the VCR/LTER hosted a group of wildlife-oriented undergraduate students from the University of Virginia. Site Manager Art Schwarzschild and PI Michael Erwin introduced the students to the various monitoring activities of the LTER site, research in the lagoons, and on the barrier islands. They visited Cobb Island and were given a short introduction to barrier island geology, avian ecology, and invertebrate biology. PI Erwin also took the group to the Eastern Shore of Virginia National Wildlife Refuge to give them a more complete assessment of the role of the eastern shore in the annual life histories of a large number of migratory waterbirds along the Atlantic Flyway.

Public Outreach

During 2007, a monthly public seminar series on environmental issues and research activities presented by VCR/LTER researchers was established, with support by agrant from the Virginia Coastal Zone Management and Seaside Heritage Program. Initial steps were taken to establish and hire a science education coordinator position at the Anheuser-Busch Coastal Research Center to interface with the VCR LTER scientists and the local education community on the Eastern Shore of Virginia. This position should be filled during the upcoming year.

International Collaboration

In the spring of 2007 the VCR/LTER hosted an extended visit by Dr. Chau Chin Lin of the Taiwan Ecological Research Network (TERN) to work on information management. During his stay Dr. Lin reviewed U.S. LTER efforts aimed a promoting use of controlled vocabularies for documenting data and worked on developing expertise with scientific workflow systems, particularly Kepler. Along with Chau-Chin Lin, VCR/LTER Information Manager John Porter made an invited presentation to the Coastal Environmental Sensing Networks workshop at the University of Massachusetts, Boston in April 2007. In the summer of 2007, John Porter helped organize, and participated in, an information management workshop for the East Asia Pacific International Long-Term Ecological Research Network. The workshop was held in Shanping Taiwan and included information managers from Taiwan, China, Malaysia, Thailand and Australia. The workshop focused on the use of Ecological Metadata Lanaguage and the Kepler scientific workflow system. A follow-up workshop will be held in Seoul South Korea in October 2007.

Bob Christian and Iris Anderson traveled to Italy, worked with Italian scientists at the University of Parma on constructing and analyzing networks of N cycling from coastal lagoons, and developed ideas for future collaborations. Furthermore, they attended the 2007 Congress of the Italian Society of Ecology in Ancona, Italy. There they conferred with Italian scientists about the newly instituted Italian LTER and promoted cooperative arrangements. Christian gave a plenary talk on 'Viewing the World as networks of Networks.'

Outreach through the WWW

The VCR/LTER WWW site (http://www.VCRLTER.virginia.edu) is widely used. Since the start of the current VCR/LTER grant cycle in November 2006 through August 31, 2007, we have provided 1.01 terabytes of information to over 203,000 distinct hosts via the web server. Each day, we average over 30,000 requests for information ('hits') resulting in over 3.4 GB of downloads. A complete web statistics report is available at: http://www.vcrlter.virginia.edu/analog/Nov2006toSep2007/ .
LTER network outreach and service

Christian in cooperation with Robert Waide, Caleb Hickman, James Brunt and Jeffery Johnson met for a workshop to assess the collaboration among LTER network sites through network analysis of cross-site publications. Their initial efforts have demonstrated a strong trend to increased coherence of the LTER network over the past 25 years. It appears that the synthesis efforts of the late 1990's have had a positive effect in this regard.

Journal Publications

Defina, A., Carniello, L., Fagherazzi, S., and D'Alpaos, L., "Self organization of shallow basins in tidal flats and salt marshes", J. Geophys. Res., p. F03001, vol. 112, (2007). Published, doi:10.1029/2006JF000550

Fagherazzi, S., C. Palermo, M. C. Rulli, L. Carniello, and A. Defina, "Wind waves in shallow microtidal basins and the dynamic equilibrium of tidal flats", J. Geophys. Res., p. F02024, vol. 112, (2007). Published, doi:10.1029/2006JF000572

Berg, P., H. Roy, and P. L. Wiberg., "Eddy correlation flux measurements - the sediment surface area that contributes to the flux", Limnology and Oceanography, p. 1672, vol. 52, (2007). Published,

Naumann, J. C., and D. R. Young, "Relationship between community structure and seed bank to describe successional dynamics of an Atlantic Coast maritime forest", Journal of the Torrey Botanical Society, p. 89, vol. 134, (2007). Published,

Christian, RR; DiGiacomo, PM; Malone, TC; Talaue-McManus, L, "Opportunities and challenges of establishing coastal observing systems", ESTUARIES AND COASTS, p. 871, vol. 29, (2006). Published,

Heyel, SM; Day, FP, "Long-term residual effects of nitrogen addition on a barrier island dune ecosystem", JOURNAL OF THE TORREY BOTANICAL SOCIETY, p. 297, vol. 133, (2006). Published,

Brantley, S. T., and D. R. Young, "Leaf-area index and light attenuation in rapidly expanding shrub thickets", Ecology, p. 525, vol. 88, (2007). Published,

Young, D. R., J. H. Porter, C. M. Bachmann, G. Shao, R. A. Fusina, J. H. Bowles, D. Korwan, and T. F. Donato, "Cross-scale patterns in shrub thicket dynamics in the Virginia barrier", Ecosystems, p. , vol. , (2008). Accepted,

Naumann, J. C., D. R. Young, and J. E. Anderson, "Linking leaf chlorophyll fluorescence properties to physiological responses for detection of salt and drought stress in coastal plant species", Physiologia Plantarum, p. , vol. , (2008). Accepted,

Jiménez, J. E., M. R. Conover, R. D. Dueser, and T. A. Messmer, "Influence of habitat patch characteristics on the success of upland duck nests.", Human-Wildlife Conflicts, p. 244, vol. 1, (2007). Published,

Rodriguez-Iturbe, I., P. D'Odorico, F. Laio. L. Ridolfi, and S. Tamea, "Challenges in wetland ecohydrology: interactions of water table and unsaturated zone with climate, soil, and vegetation", Water Resour Res., p. W09301, vol. 43, (2007). Published, doi:10.1029/2007WR006073

Bachmann, CM; Ainsworth, TL; Fusina, RA, "Improved manifold coordinate representations of large-scale hyperspectral scenes", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, p. 2786, vol. 44, (2006). Published, 10.1109/TGRS.2006.88180

Crusius, J., P. Berg, D. J. Koopmans, L. Erban, "Eddy correlation measurements of submarine groundwater discharge", Marine Chemistry, p. , vol. , (2007). Accepted,

Gu, C., G.M. Hornberger, A.L. Mills, J.S. Herman, and S.A. Flewelling, "Nitrate removal in streambed sediments: effects of flow and biogeochemical kinetics", Water Resources Research, p. , vol. , (2007). Accepted,

Fenster, M.S. and Hayden, B.P., "Ecotone displacement trends on a highly dynamic barrier island: Hog Island, Virginia", Estuaries and Coasts, p. , vol. , (2008). Accepted,

Books or Other One-time Publications

Amie Aguiar, "Social and physical influences on wading bird foraging patch selection", (2007). Thesis, Published
Bibliography: M.S. Thesis, University of Virginia

Amanda C. Marsh, "Effects on a salt marsh ecosystem following a brown marsh event", (2007). Thesis, Published
Bibliography: M.S. Thesis. East Carolina University

Porter, J. H., "From the Barrier Island to the Database: Evolution of wireless sensor networks on the Virginia Coast Reserve", (2007). , Published
Collection: Conference on Coastal Environmental Sensor Networks, Boston, MA, USA,
Bibliography: Center for Coastal Environmental Sensor Networks, University of Massachusetts, Boston.

Amanda Lynn Floyd, "Effects of Inundation Regime and Plant Community on Soil Bacterial Communities in an Eastern Shore, VA Salt Marsh.", (2007). Thesis, Published
Bibliography: M.S. Thesis, University of Virginia. May 2007.

Fennell, J. D., "Phragmites australis patch characteristics in relation to watershed landcover patterns on the Eastern Shore of Virginia", (2007). Thesis, Published
Bibliography: MS thesis Virginia Commonwealth University Richmond, Virginia

Young, D. R., "Estimating aboveground net primary production in shrub-dominated systems", (2006). Book, Published
Editor(s): T. J. Fahey and A. K. Knapp
Collection: Principles and standards for measuring primary production
Bibliography: Oxford University Press New York

Vick, J., "Corticular photosynthetic dynamics for a coastal evergreen shrub: Myrica cerifera", (2007). Thesis, Published
Bibliography: MS thesis Virginia Commonwealth University Richmond, Virginia

Chuanhui Gu, "Hydrological control on nitrate delivery through the groundwater-surface water interface", (2006). Thesis, Published
Bibliography: Ph.D Thesis. University of Virginia, Charlottesville, VA.

Franklin, R. B., and A. L. Mills, "Distribution of microbes and microbial communities", (2007). Book, Published
Bibliography: Springer, Dordrecht

Ogram, A., S. Bridgham, R. Corstanje, H. Drake, K. Küsel, A. Mills, S. Newman, K. Portier, and R. Wetzel, "Linkages between microbial diversity and biogeochemical processes across scales", (2006). Book, Published
Editor(s): R. Bobbink, Beltman, B., Verhoeven, J.T.A., Whigham, D.F.
Collection: Wetlands as a Natural Resource. Volume 2: Wetlands: functioning, biodiversity, conservation, and restoration.
Bibliography: Springer

Franklin, R. B., and A. L. Mills, "Spatial distribution of microbes and microbial communities", (2007). Book, Published
Editor(s): R. B. Franklin and A. L. Mills
Collection: Distribution of microbes and microbial communities in space
Bibliography: Springer, Dordrecht.

Franklin, R. B., and A. L. Mills, "Quantitative analysis of microbial distributions", (2007). Book, Published
Editor(s): R. B. Franklin and A. L. Mills
Collection: Distribution of microbes and microbial communities in space
Bibliography: Springer, Dordrecht.

McGlathery, K. J., "Nitrogen cycling in seagrass meadows", (2008). Book, Accepted
Editor(s): Capone, D., E. Carpenter, D. Bronk, and M. Mulholland
Collection: Nitrogen Cycling in the Marine Environment
Bibliography: in press

Web/Internet Site

URL(s):

http://www.vcrlter.virginia.edu

Description:

This is the main web site for the VCR/LTER project and serves as the "file cabinet" for all aspects of the project. The web site provides access to data, interactive maps, images, bibliographic listings and full-text of student theses and dissertations.

Other Specific Products

Product Type:

Data or databases

Product Description:

The VCR/LTER publishes over 100 datasets using standard Ecological Metadata Language metadata.

Sharing Information:

Data is made available to all researchers online. Researchers fill out a data license indicating their agreement with LTER policies on proper acknowledgment and are immediately granted access to the requested data.

Contributions

Contributions within Discipline:

We have continued to contribute to the understanding of coastal systems through our efforts in studying the effects of sea level rise (which involves developing detailed understandings of the processes that effect accretion in marshes - both physical and biotic, and encroachment into uplands), coastal eutrophication, seagrass restoration, controls on plant production, determinants of faunal biogeography in an island system, and prediction of future state change.

WATERSHEDS AND LAGOONS

Coastal eutrophication has been recognized as an increasing problem in areas such as the East and Gulf coasts of the U.S. Symptoms of eutrophication include blooms of phytoplankton, which when they decompose may reduce available oxygen in the water; blooms of harmful algae that are toxic to fish, shellfish, and occasionally humans; blooms of macroalgae that cause die-backs of sea grasses which are vital to maintaining populations of many fish and crabs. Eutrophication generally results from export of excess nutrients from land, in particular nitrogen. Sources of nitrogen include agriculture, septic tanks, waste water treatment plants, industry, and atmospheric deposition of nitrogen derived from automobiles, power plants, and other industrial sources. Nitrogen from these sources is most often transported to coastal waters in shallow groundwater and in surface water runoff.

Coastal lagoons are common features of the land margin, especially along the East and Gulf coasts. We have hypothesized that these lagoons play an important role in retarding and transforming nitrogen during transport from land to the sea. Our study of the Virginia Coast Reserve lagoonal system has been designed to: (1) measure groundwater sources of nutrients to the lagoon; (2) measure rates of biological processes that remove or transform nitrogen in the waters and sediments of the lagoon; (3) compare rates of nitrogen cycling processes to physical transport across and out of the lagoon in order to determine whether the nitrogen remains in the lagoon for a sufficient length of time to allow biological processing to occur. The biological studies described in this report are being performed jointly by Iris Anderson, VIMS, and Karen McGlathery, University of Virginia.

Our preliminary results support our hypotheses that: (1) nitrogen entering the lagoon is rapidly removed by both benthic macro- and microalgae. The bloom of macroalgae that results in early summer crashes during mid-summer, releasing much of the nitrogen as dissolved inorganic and organic nitrogen. The sediments act to rapidly remove the nitrogen released to the water column by a combination of mechanisms including immobilization by benthic microalgae and coupled nitrification - denitrification. We are currently attempting to determine how the nitrogen released during decomposition of the macroalgal bloom is partitioned between the various potential consumptive mechanisms.

Our conclusions regarding the importance of macroalgae in influencing the dynamics of nutrient movements within the lagoon helps to explain the role of the lagoon as an active mediator between mainland nutrient sources (e.g., agricultural fields) and the coastal ocean. The recent discovery that the dominant macroalga in the lagoon is an exotic (rather than its native congener), will be important to understanding long-term changes in the lagoon's characteristics.

Shallow bays in the VCR and elsewhere along the US Atlantic coast experienced a dramatic state change in the 1930's when a single storm decimated seagrass populations already decimated by disease. Until recently, VCR lagoons persisted in an alternate, algal-dominated state. Recent field work and modeling showed that high turbidity events in the VCR were episodic and wind driven and we estimated that average light availability over 65-87% of the lagoon bottom is suitable for seagrass recolonization (Lawson et al., 2007). Beginning last fall, in collaboration with Robert Orth from the Virginia Institute of Marine Science, we began to restore seagrass in a 509 acre 'set aside' we have obtained from the Virginia Marine Resources Commission in our primary lagoon study site, Hog Island Bay. This restoration builds on our 10-year database on patterns and process in Hog Island Bay in the absence of seagrass, and gives us the opportunity to determine experimentally the ecosystem-level effects of a rapid state change back to the original seagrass-vegetated state.

The seagrass restoration project contributes to important theoretical and applied problems related to coastal ecosystems. On a more theoretical level, it directly addresses questions related to ways in which biotic feedbacks modify the response to of the systems to external drivers by maintaining a stable state or facilitating a change to another state. In the lagoons, the biotic feedbacks that influence the success of seagrass establishment and growth include the vegetation effects on reducing sediment resuspension and the potential facilitation of seedling establishment by benthic fauna. In addition, a state change from algae to seagrass will have system-wide impacts because these benthic primary producers play key roles in determining rates and patterns of primary production and nutrient cycling and in trophic interactions. Variations in the rates and dominance of these processes as primary producer communities change, will ultimately determine the fate and retention of watershed nutrients as they pass through the lagoon 'filter' to the open ocean. As the community shifts to seagrass dominance, we expect the retention time of watershed N in the lagoon to increase.

On a more applied level, the experimental approach we are taking to establishing and monitoring the seagrass plots in Hog Island Bay, a relatively pristine system, will provide important baseline information for restoration projects undertaken in more highly impacted systems. To put our results on the new seagrass beds in context, we have established a chronosequence by augmenting the Hog Island Bay meadows with those recently seeded (1-7 yr old) using the same technique in South and Spider Crab Bays, just south of Hog Island Bay, and a natural meadow in South Bay, which is at least 10 years old. We have begun measurements of productivity, nutrient cycling, algal density/diversity, faunal densities/diversity, flow conditions and sediment resuspension in the new seagrass beds; a subset of these measurements are being made at sites along the seagrass chronosequence. In addition, we are quantifying macroalgae epiphytes, benthic microalgae, benthic invertebrates and fish through the seagrass recolonization period to assess changes in faunal abundance and diversity.

Surface Elevation Tables (SETs) are used at numerous VCR/LTER research sites to quantify subtle changes in sedimentation that ultimately will determine the fate of marshes in the face of sea level rise. These baseline measurements at different marshes are then used in association with process-based studies focusing on the processes such as transport of material through tidal flooding, burial of organic matter and its decomposition, marsh plant production (both above and below ground), bioturbation by crabs and even herbivory by insects to develop models aimed at predicting changes in marshes over the coming decades. Our preliminary results indicate that the rate of acretion are position dependent, with the upper marsh receiving less input. Results in the lagoon marshes suggest that sea-level rise may be exceeding the ability of the marshes to keep up, but that some unvegetated pool/tidal flat areas are vegetating, a somewhat unexpected result.

Recent work on microbial communities in the marshes and tidal creeks at the VCR (as well as 9 other coastal systems as part of a cross-site comparison study) contribute to our understanding of what abiotic and biotic factors determine microbial community structure and the scales over which microbial communities vary. Linking information about variation in microbial community structure and microbially controlled processes (e.g., nitrogen-fixation), will allow prediction of how critical ecosystem processes will be affected by disturbance. (Blum)

BARRIER ISLANDS

The results of this work to date have increased our understanding of dynamic vegetation changes and their causes in coastal barrier island ecosystems. New cross site and cross species analyses are linking meteorological and climatological drivers to plant production. This analysis is revealing complex patterns showing that all species and sites do not respond similarly to meteorological drivers.

To date, one of our most significant contributions has been to demonstrate that biotic interactions are very important in the coastal environment of the VCR, which we often define as being dominated by physical parameters. Most importantly PI Donald Young, demonstrated the importance of the presence for a soil actinomycete, Frankia, for the successful establishment of Myrica cerifera. Myrica usually is usually the first woody species to establish in these environments. Once established, Myrica rapidly forms extensive thickets in coastal environments. These thickets are excellent indicators of island stability and may be precursors to the establishment of maritime forest.

Twenty years of research in shrub thicket ecology has provided excellent background and experience for studying the potential for invasive species in coastal environments. This is especially true for the weedy grass, Phragmites australis. Populations of Phragmites are establishing and rapidly expanding throughout the VCR as well as in coastal environments of the mid-Atlantic region. Phragmites often establishes in habitats similar to those of shrub thickets. The detailed understanding of the ecology of P. australis with respect to nutrient uptake and competitive relationships provide a basis for predictions regarding its ultimate distribution.

Studies of island-dwelling organisms, such as those underway at VCR, have long played an important role in testing ecological and evolutionary theory about patterns and processes related to distribution and abundance of species and genetic variation within and among natural populations. The Virginia coast is a highly dynamic, frequently disturbed landscape, and the Virginia barrier islands are the only undeveloped barrier system on the Eastern seaboard. As such, this system affords a unique opportunity to study phenomena associated with island systems, including fragmentation of habitats and populations, local extinction, dispersal, and colonization, which are also important issues in conservation biology. The relative isolation of the islands also provides an excellent opportunity for assessing the roles of paracitism and disease in overall vertebrate population dynamics.

The role of mammals and predation on the large waterbird community has been chronicled, and continues to show annual changes. Managing foxes and raccoons at selected barrier islands has dramatically enhanced the reproductive success of a number of species of ground-nesting waterbirds, including the federally threatened piping plover. Nonetheless, fewer colonies (but larger) of nesting terns (4 species) and black skimmers have consolidated onto fewer islands over the past decade compared to the distribution pattern in the 1970-80s.

SYSTEM-WIDE INTEGRATION

One of the questions we have begun to address in the last year is what the composition and structure of the VCR landscape patterns will be in the future and what processes will drive ecological states changes in those landscapes. We are using two types of models to synthesize our long-term monitoring and experiments and shorter-term process studies to address the causes and consequences of state change on the VCR landscape. The goal of this modeling effort is to be able to predict the non-linear and threshold responses of the VCR ecosystems to long-term environmental change and short-term disturbance events.

Landscape modeling: Previous VCR efforts focused on developing various conceptual and mathematical models of limited parts of the landscape and demonstrated a need to integrate the diverse spatial and temporal information into a regional model for the VCR ecosystem. In response, we have begun developing a mechanistic, process-based ecological basin model to understand the coupling between hydrologic and geomorphic free surface changes and the ecological responses of state change on scales that vary from local to the entire coastal reserve. The

model integrates physical and ecological processes over a grid of landscape cells. Each cell contains a unit ecosystem model that represents a certain habitat type and incorporates location-specific algorithms to quantify fluxes of materials between cells. Hydrodynamic, soil, and plant productivity modules are dynamically coupled via a unit ecosystem model (Reyes et al. 2000, 2004). The model also contains a habitat-switching module that tracks habitat characteristics for each land parcel within the model boundary, such that long-term processes and ecological responses can be examined.

Network modeling: Ecological network analysis is an effective tool for evaluating both
the biogeochemical and trophic consequences of state We have used ecological network analysis at the VCR to evaluate nitrogen cycling within mainland marshes (Thomas and Christian 2001) and the lagoon (Voss et al. 2005) and also the food web structure of salt marsh ponds (Dame 2005). We are expanding this effort to include states across the entire VCR landscape to provide assessments of nitrogen cycling relative to the contributions of biomass storage, recycling, physical and biotic exchanges. In addition, co-PI Bob Christian has furthered the use of network analysis within the ecological community via publications and workshops sponsored by NSF biocomplexity and the LTER network. Several groups within and beyond the LTER network have begun using the tools.

Contributions to Other Disciplines:

The studies conducted by the VCR/LTER are inherently interdisciplinary or multidisciplinary. Our studies are being performed by an interdisciplinary team of ecologists, hydrologists, biologists, and physical oceanographers. When such collaborations take place, it is not unusual that each each group of scientists will gain greater insight into problems that may not be recognized within their own discipline.

Additionally, our workshops on network analysis have exposed a broad group of scientists to the field or network ecology. Social scientists have also used network analysis, and one of our accomplishements has been to bring awareness of the different approaches to the broader group. (Christian)

Research on ecological information management has included computer scientists. The challenges posed by ecological data provide opportunities for innovation in computer science. Our work with development of wireless sensor networks, and processing of the massive data flows they can generate, contributes to better defining the cyberinfrastructure challenges that will confront us in coming decades. During 2006-2007 the VCR Information Manager participated in the Cyberinfrastructure-Core group and we hosted a modeling workshop that focused on the cyberinfrastructure needs of advanced ecological modleling. (Porter)

Connections between storminess at the Virginia Coast Reserve LTER and variations at the El Nino frequency have proved negative. In addition, General Circulation Models (The Hadley Model) indicate no chang

Contributions to Human Resource Development:

As can be seen from the number of graduate and undergraduate students listed on our participant list, this project provides abundant opportunities for training. Moreover, the inter- and multi-disciplinary nature of the research teaches the students how to operate in a collaborative environment.

Our SLTER program, and related activities, have helped introduce scientific concepts to K-12 students. Additionally, an intensive 10-day workshop in July 2007 helped high school science teachers from counties on the Eastern Shore of Virginia in curriculum development activities.

Contributions to Resources for Research and Education:

Our WWW site (http://www.vcrlter.virginia.edu) provides access to a wide variety of information in text, graphical and video forms. Data are frequently downloaded for use by classes and researchers at institutions not associated with the VCR/LTER. Since the inception of VCR/LTER V in Nov. 2006, the web site has distributed 1.0 terabytes of information to over 203,000 different client computers. The site averaged over 30,000 requests per day û over a twofold increase since 2006. A detailed summary can be found at: http://www.vcrlter.virginia.edu/analog/Nov2006toSep2007/. To a large degree this increase was driven by increases in search engines indexing the web site, indicating that the site should be relatively easy to locate via Google and other search engines.

Contributions of VCR/LTER towards providing data can be more directly assessed by examining formal data download requests. Since 1 Nov. 2006, there have been 107 formal requests for data. 75% of the requests were for research purposes, with educational requests making up the remaining 25%. Requests by researchers from 'outside' the VCR/LTER research community accounted for 53% of all requests. These outside requests included numerous researchers from outside the US, including one or more requests from researchers in Italy, Australia, Canada, China, France, South Africa, and Spain.

Through our Schoolyard LTER supplement, we have been able to provide equipment such as global positioning system, taxonomic guides and

water chemistry analysis kits and equipment to the Northampton Co. VA Public Schools. This program now extends from grades K-12 through the Northampton Co. elementary, middle and high schools.

Work that we are currently doing at the VCR is of much interest to the Department of Environmental Quality of the State of Virginia, and in particular to the Water Conservation Districts located on the Eastern Shore. The major source of nitrogen to VCR coastal lagoons is agriculture. Proper management of agricultural activities and fertilization practices requires an improved understanding of nitrogen losses to the coastal lagoons via groundwater and surface water runoff.

During 2007 high school students monitored water quality at 21 sites on a bi-weekly basis. They also did quarterly testing of soil characteristics at the same sites.

Contributions Beyond Science and Engineering:

How have results from your project contributed to the public welfare beyond science and engineering (e.g., by inspiring commercialized technology or informing regulatory policy)?

We have engaged in studies designed aid the conservation of avian fauna and better understanding of the extent and change in exotic plant species in the coastal zone in conjunction with The Nature Conservancy. (Erwin, Moncrief, Porter, Hayden, Blum, Young)

Knowledge of the relationship between land use, nutrient contamination of groundwater, groundwater export of nutrients to coastal lagoons, and the fate of nutrients within lagoons will be of benefit to state and federal agencies charged with managing coastal resources. This knowledge will be especially important given the ongoing return of seagrasses to large areas of the coastal bays, from which they have been absent for over 70 years.(Anderson, McGlathery)

Linking information about variation in microbial and fungal community structure and fungal and microbially controlled processes (e.g., nitrogen-fixation, decomposition), will allow prediction of how critical ecosystem processes will be affected by disturbances due to human activities in the coastal zone. (Blum)

Activities with the UN programs on observing global change along coastal ecosystems have significance for broad aspects of public welfare and environmental protection. One of the greatest potential contributions from PI Christian's work at the VCR LTER are to the global observing systems and the ability to detect and assess global change in coastal ecosystems. The Coastal Module of GTOS is being developed to complement the Coastal GOOS program and highlights terrestrial, wetland, freshwater, and transitional ecosystems. Further and importantly it explicitly includes socio-economic components of global change in the coastal zone. This is the first significant introduction of the human dimension into the global observing systems. (Christian)

Finally, in the summer of 2007 a monthly public seminar series on environmental issues and research activities at the VCR/LTER was established with support from the Coastal Zone Management and Seaside Heritage Program of the Commonwealth of Virginia. During the seminars, VCR/LTER researchers provide information on their research to the general public.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: $ 0.00

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

The goal of the Virginia Coast Reserve (VCR) LTER program is to understand and predict long-term ecological change in the context of slow, progressive changes in climate, land use, and sea level, and short-term disturbance events such as storms in coastal barrier systems. Our central hypothesis is that ecosystem dynamics and pattern on the landscape are controlled by the interaction between the vertical positions of the land, sea, and groundwater free surfaces, and the fluxes of organisms and materials across the landscape.

As a long-term research program, we have a number of continuing activities that constitute the core of our long-term monitoring. These include:

- *Water Quality Transects* – Two transects across the lagoon system provide information on the physical characteristics, nitrogen, phosphorus, particulate and chlorophyll levels.

- *Meteorological Stations* – Meteorological stations at Phillips Creek Marsh, Hog Island and Oyster VA provide temperature, precipitation, wind and light level-data.

- *Tide Stations* – Tide stations at Redbank, Oyster and Hog Island provide data on tide levels.

- *Sediment Elevation Tables* – These stations provide detailed measurements on marsh accretion and erosion.

- *Atmospheric Chemistry* – A precipitation chemistry station in Oyster Virginia monitors deposition of nitrogen.

- *End-of-year Biomass survey* – Samples are collected from a variety of salt marshes during the fall of each year. These samples are then sorted, dried and weighed.

- *Island biomass and vegetation cover* – Monitoring of shrub and herbaceous vegetation is done on a terrestrial chronosequence of sites on Hog Island.

- *Ground water levels* – Ten stations on Hog Island and five stations in Phillips Creek Marsh provide information on ground water levels.

- *Creek flows* - Water levels and nutrient concentrations are monitored for creeks draining mainland watersheds and feeding into VCR lagoons to determine nutrient loading related to watershed land use.

- *Semi-annual small mammal population surveys* – Hog Island small mammal populations are monitored in the fall and spring on three transects on Hog Island.

- *Fish and invertebrate sampling in seagrass beds* – Nets are used to sample fauna associated with seagrass beds and adjacent bare sediments to evaluate the consequences of large-scale seagrass restoration on faunal communities.

- *Photographic records* – Landscape changes and unusual events are monitored using web

cameras that monitor over 150 locations on a daily basis.

Additionally, since November 2006 we have engaged in a number of new initiatives that we detail below.

Watersheds and Lagoons

We have made significant progress in our large-scale experiment to restore the 'foundation' species, the seagrass (*Zostera marina*), to the coastal lagoons and to study the ecosystem-level consequences of its return after more than 75 years. In the fall 2006, Karen McGlathery and students worked with colleague Robert Orth from the Virginia Institute of Marine Sciences (VIMS), to broadcast approximately 1.5 million seagrass seeds in the 509-acre 'set-aside' in Hog Island Bay designated for seagrass restoration by the Virginia Marine Resources Commission. The seeds were broadcast in a full factorial design with 2 seed densities (50,000 and 100,000 per acre) and 2 plot sizes (0.5 and 1.0 acre), with 7 replicates per treatment. In the spring 2007, we returned to the site with our VIMS colleagues to quantify seedling recruitment in the sites. Between 7 and 12% of the seeds germinated, which is typical of a 'good' crop using the hand-broadcasting technique. We also found large patches of seagrass that had recruited naturally into the set-aside, and believe them to be 2-3 years old. In July 2007, McGlathery and a team of 10 graduate, undergraduate and high school students conducted the first synoptic survey of the newly-vegetated plots and compared these with adjacent unvegetated areas. (UVA news release: http://www.virginia.edu/uvatoday/newsRelease.php?id=2467). These surveys will be conducted annually as part of our long-term experiment. Seagrass measures included: density, canopy height, above- and below-ground biomass, growth, epiphyte biomass, and tissue carbon and nitrogen contents. Sediment measures included: benthic chlorophyll, organic content, porosity, grain size, carbon and nitrogen contents. McGlathery, Jay Zieman and graduate student Laura Reynolds are also working with colleague Michelle Waycott who is visiting UVA on sabbatical from Australia to address the genetic basis of seagrass restoration success in the region.

The 1 acre, 100,000 seed treatment plots in Hog Island Bay are also part of our chronosequence of seagrass sites, which also includes older (5-6 years) sites in South Bay, and mature (>10 years) references sites (Fisherman's Island, Nassawadox). At these sites, McGlathery and graduate student Luke Cole will be measuring a suite of nitrogen cycling processes to understand the role of seagrass in retaining and/or transforming watershed nitrogen as it passes through the coastal lagoons to the open ocean. Dave Smith and graduate student Patrick Conroy are using the chronosequence sites to address the effects of seagrasses on the diversity and abundance of both fish and vertebrate fauna. Sediment cores and seagrass are being collected for invertebrates along with special collecting "sponges", and a large pocket seine is being used to sample the fish at each site.

Steve Macko and graduate student Stephanie Harbeson are using stable isotopes to track the exchange of energy from seagrass primary production to consumers as seagrass habitats are restored. Approximately 1000 samples from South Bay restored *Zostera marina* plots were collected from the summer of 2004 to the summer of 2006. The samples consisted of primary producers through higher trophic level fish. Carbon, nitrogen, and sulfur bulk isotopic values

($\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$, respectively) of primary producers verify that *Z. marina*, epiphytes and macroalgae are isotopically distinct, thus allowing for source differentiation. Bulk isotope analyses of South Bay consumers indicate a diminished signal coming from seagrasses. There are no species feeding solely on *Z. marina*. However, a mixture of food sources that includes a small proportion of seagrass is possible if the primary producers are considered all together. Combinations of primary producers with a range of proportions are seen to contribute a portion of a number of consumer diets.

Peter Berg and his student Andrew Hume applied the new non-intrusive eddy correlation technique to study oxygen exchange of the restored seagrass meadows in a South Bay. A suite of physical parameters such as horizontal velocity, wave action, light, turbidity and temperature, were measured parallel with the eddy-correlation measurements. Our results represent the first detailed data on temporal dynamics of oxygen exchange for eelgrass meadows in true *in situ* light and hydrodynamic conditions. This is important because conventional methods for measuring oxygen exchange have serious limitations in their ability to mimic the true *in situ* conditions. The combined data allowed us to pinpoint the major controls of the oxygen exchange dynamics to estimate eelgrass community metabolism and its response to changes in environment variables.

Iris Anderson and her student, Juliette Poleto along with her colleague Mark Brush, modified an existing watershed model to determine current base flow N loads to Gargathy Bay. The work was done in collaboration with the Accomack County Department of Planning. The N load model was run under various land use scenarios, including increased residential and agricultural development and population increase. Results of the modeling indicate that current base flow N loads to Gargathy bay are estimated to be about 30,000 kg N y-1. Additionally, the model indicates that N loads could significantly increase with intensified poultry production and increased residential development with minimum lots sizes of 1/4 acre and 1/2 acre. Accomack County is using these data to guide updates to their comprehensive plan. Poleto is currently applying the N load model to the Burton's Bay watershed, within the VCR. She is also in the process of evaluating the responses of four coastal bays to nutrient loads; they include Gargathy, Burton's, Hog Island, and Isle of Wight bays. System metabolism is measured monthly using both the open water and component techniques, along with water and sediment characteristics. In addition, Poleto is applying the sewage plume mapping technique seasonally to identify the sources of N to the various coastal bays.

Under separate funding from NSF, Aaron Mills, Janet Herman, and George Hornberger examined the role of stream sediments in the removal of nitrate from groundwater discharging into the stream under base flow conditions. Although most of the effort was concentrated on one stream, Cobb Mill Creek at the Anheuser-Busch Coastal Research Center, occasional sampling of 17 additional streams was conducted to determine to what extent observations from Cobb Mill Creek could be extrapolated to the rest of Northampton and Accomack County streams. Those measurements also facilitate an effort to determine the annual loading of nitrate from the coastal streams to the seaside lagoons. Furthermore, a combined field sampling, laboratory simulation, and modeling exercise examined the effect of transport time on the removal of nitrate in the sediments, and additional work investigated the effect of transient storm events on discharge and on nitrate flux to the streams. This work will continue in the next year.

Mills and co-workers are currently placing stream recorders in 3 previously ungauged streams to provide continuous discharge measurements to improve understanding of delivery of freshwater and of nutrients (especially nitrate) to the seaside lagoons. The streams are located in each of the three experimental watersheds, i.e., Tommy's Ditch in the Smith Island lagoon, Phillips Creek in Hog Island Bay, and Bundick's Creek in Metompkin Bay.

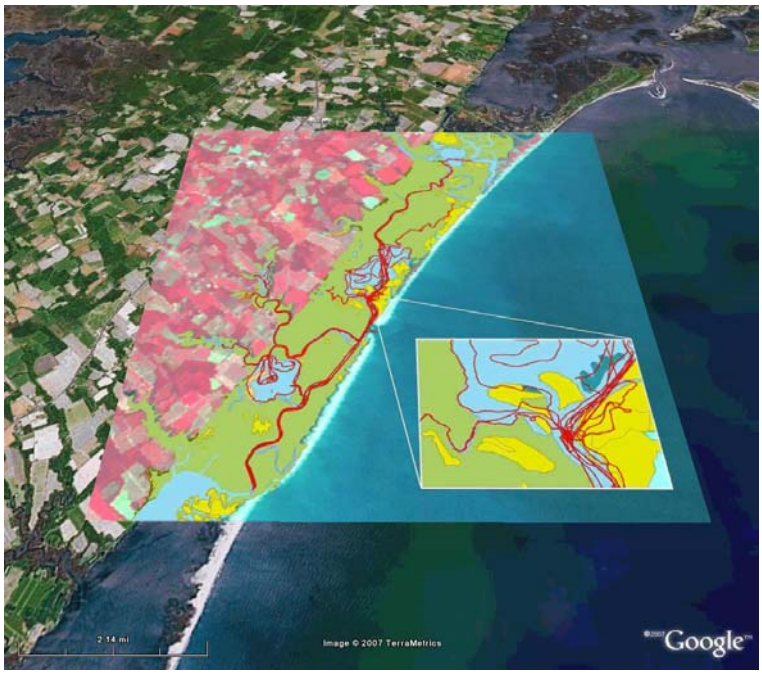
With funding from NSF Ecosystems Program, Iris Anderson, her student Amber Hardison and colleagues Elizabeth Canuel, Craig Tobias, and Joe Vallino, conducted multiple mesocosm experiments to investigate the role of benthic primary producers in uptake, retention, and recycling of carbon and nitrogen in shallow coastal lagoons. Hog Island Bay, Virginia, considered a more pristine lagoon along the Delmarva Peninsula was contrasted with Isle of Wight Bay, Maryland, which represents a more eutrophied lagoon. Stable isotopes were used to trace carbon and nitrogen flow through primary producer, dissolved, faunal, and bacterial pools using bulk and compound specific stable isotope analyses. Hardison visited the Netherlands Institute of Ecology to learn a newly developed method for the analysis of carbon and nitrogen isotopic enrichment in hydrolysable amino acids from Drs. Bart Veuger and Jack Middelburg. The differential uptake of carbon and nitrogen into specific amino acids allows the partitioning of bulk sediment microbial uptake into heterotrophic and autotrophic components, which lends a great deal of insight into the specific organisms cycling carbon and nitrogen within the sediments. Results of the experiments suggest so far that carbon and nitrogen are retained within the sediments primarily by the autotrophic and heterotrophic microbial populations. This benthic microbial role may be diminished in the presence of large benthic macroalgal populations, but macroalgae often play a temporary role as a nutrient sink. Following the die-off of a macroalgal bloom, which is often a symptom of eutrophication, macroalgal carbon and nitrogen are rapidly taken up by the sediment bacterial population, transferred to the benthic microalgal pool, and retained within the sediments for a period of at least two weeks. Additional experiments are planned to quantify the long-term retention of nutrients within the sediments.

In September 2007, Travis Robertson (graduate student working with Linda Blum, Karen McGlathery, and Patricia Wiberg) began collaborative work with Linda Zettler (Woods Hole Oceanographic Institution) on the spatial and environmental factors associated with structure and functioning of microbial communities in coastal bays. This is a new initiative building on previous work by Linda Blum's students at the VCR. Linda Zettler will examine microbial community richness across LTER sites including the VCR, while Robertson will provide information about the similarity and functioning of communities, environmental conditions, and spatial distribution of communities relative to community richness within the VCR LTER.

As part of our effort to develop a hydrodynamic model for Hog Island Bay and other lagoons in the VCR, Sergio Fagherazzi and Patricia Wiberg have been exploring the often complex role of wind on lagoon-bottom shear stresses, sediment resuspension and morphologic evolution. Our initial simulations using the Venice hydrodynamic model to explore the effect of wind direction on lagoon circulation brought two issues to light. One is the correlation between wind and water level. Unless the hydrodynamic model is embedded in a much larger model of the Atlantic Ocean, the effect of wind on water level must be imposed. This has led us to compile and analyze historical wind, atmospheric pressure, predicted tide and measured tide data. These compiled data files will be added to the VCR-LTER data catalog. The other is the high

variability in fetch, an important factor controlling wave height, as a function of wind direction and tidal elevation. The fetch is very large when winds blow along the axis of the Delmarva Peninsula and water level is high. However, for low water levels or for winds blowing across the lagoon, fetch is much smaller. Wind waves are also sensitive to water depth, and water depth is affected by wind speed and direction. As a result, there is the potential for strong winds from particular directions to lead to disproportionately large wave conditions, wave-generated bottom stresses, sediment resuspension, and marsh erosion.

George Oertel and his students have made contributions toward understanding the processes of tidal exchange in the VCR lagoons. They previously collected 16,000 depth data points for Hog Island Bay and used these to build a bathymetric model of the lagoon. They have now extended this work to Gargathy Bay, which is a small coastal lagoon (2,000 ha) in the northern part of the VCR. It is a "marsh-choked" system with numerous tidal channels and shallow bays. Their intent is to compare the flushing characteristics of this system to the larger open-water system of Hog Bay. Initially, a level line was surveyed from USGS benchmark "Sutton" to a piling at Gargathy Landing. An NAVD 88 vertical datum at the piling was established as a temporary benchmark (TBM) for referencing all lagoonal surveys. From this reference benchmark, thirteen additional TBM's were established at convenient locations throughout the network of tidal channels between Wallops Island and Metompkin Bay. These TBM's were used to normalize survey data collected during fluctuating water levels of the tides. In 2007, Mcleod and Gomez (students of G. Oertel) surveyed the Magothy lagoon system using a high-resolution echosounder (Innerspace Digital Fathometer, Model 448) and a Trimble™ 4000 SE Gobal Positioning System using WSG 84 datum. Surveys were made from TBM's, until all navigable waterways in the Gargathy lagoon were covered. About 186 line kilometers of echosounding data were collected from the survey area. Survey lines were opened and closed on the closest TBM to adjust for fluctuations in tidal water levels. The tracklines produced over 24,000 echosoundings data points. These data will be used to construct the bathymetric model of the Gargathy coastal lagoon needed to do second-order spatial analyses for flushing models.



Tidal Marshes

In 2007, Linda Blum, Bob Christian and Mark Brinson continued to monitor marsh surface elevations with surface elevation tables (SETs) and root-zone SETs (R-SETs), and to measure

rates of surface accretion over a feldspar marker layer. Measurements in September 2007 extend the data set to include more than 10 years of data. Currently, we are examining the relationship between marsh elevation and accretion with marsh plant biomass, groundwater elevations, patterns of tidal flooding, and rainfall to assess the impact of an extended, extreme drought that occurred during the 2000-2002 growing seasons.

In preparation for beginning N-addition experiments as part of a new research initiative described in our most recent proposal, we identified potential experimental sites. John Haywood (ECU PhD student, Mark Brinson) has begun characterization of the sites and will begin fertilization at the start of the 2008 growing season. These experiments will allow us to determine if plant community response to increased N-levels promotes state change from high marsh to low marsh by shifting the allocation of plant production from roots to leaves.

During the past year we have continued to study an area of sudden marsh dieback that occurred in 2004 in the low marsh of Upper Phillips Creek. The event occurred on our most intensively studied mainland marsh. This has provided useful background information. We found that end of the year live biomass of nearby *Spartina alterniflora* was lower in 2004 than in previous years or 2005. Further, a significant accretion and redistribution of sediments occurred in association with Hurricane Isabel in fall 2003. This may have altered the hydrology of the marsh. Continuing work begun in 2005, we have collaborated with Elijah Ramsey and Amina Rangoonwala of the USGS National Wetlands Research Center, Lafayette, LA and with Chip Bachman, Naval Research Lab, Washington, DC on using remote sensing to study the dieback area.

Linda Blum and graduate students Amanda Floyd and Gina Casciano evaluated how bacterial and fungal communities associated with two plant communities, *Spartina patens-Distichlis spicata* and *Juncus roemerianus*, respond to the frequency of tidal flooding.

With funding from the Department of Energy NICCR program, Sergio Fagherazzi, Patricia Wiberg and Karen McGlathery are investigating rates of erosion or accretion of the marsh-tidal flat boundary and the processes that control the evolution of that boundary. The study combines modeling and field work. This summer we established 4 sites in Hog Island Bay where we will monitor marsh erosion or accretion over at least a 3-year period. Three of the sites are erosional, reflecting the dominance of erosional sites in this system. One site, located behind a protective ridge of sand and oyster rock, appears to be accretional. In each site we have surveyed in 2 shore perpendicular transects extending from ~50 m into the marsh to ~50 m into the adjacent tidal flats. We have also installed erosion pins at 6 sites along each eroding marsh edge. These sites will be revisited 4-6 times per year, with an emphasis on collecting data shortly after a large storm. Even during the 6-week period of time between our first and second trips to establish our sites, significant erosion was observed at our site on Hog Island. Plans for the next year include installing SETs to monitor vertical changes near the marsh edge and collecting data on current and wave conditions in the lagoon near our sites.

Jose Fuentes and his student James Kathilankal installed a 5-m tower with an eddy covariance system to investigate the rates of carbon flows in the salt marsh dominated by smooth cord grass (*Spartina alterniflora*). The flux tower includes various instruments to study the assimilatory

response of the ecosystem to changing environmental variables. The study is expected to provide more information on ecosystem level fluxes of carbon and energy from inter-tidal salt marshes which form the interface between terrestrial and aquatic ecosystems. The relatively large tidal amplitude, coupled with short vegetation provides a unique scenario where the canopy can be completely submerged during various periods of the day, thus providing an ideal setting for understanding the ecosystem level response to submergence. The various meteorological variables measured include, temperature, humidity wind speed and direction, soil temperature and heat flux, and radiation components. Other ancillary measurements include water temperature, water level above the marsh surface and rainfall. Instruments are controlled by data loggers which are in turn interfaced with data acquisition units. The data acquisition unit is connected to the internet so that users can view the status of the instruments on the flux tower. A surface-atmosphere coupled model was also developed to quantify the rates of carbon flows in the various compartment of the salt marsh. The model incorporates knowledge of atmospheric turbulence and diffusion, radiative transfer, and *Spartina* physiology to determine rates of carbon assimilation by the ecosystem in response to prevailing environmental drivers. One important goal of this modeling studies is to quantify the carbon assimilation response of the ecosystem due to disturbance (e.g., N'easterners and tropical storms). These studies will also provide information on the carbon net ecosystem exchange (NEE) which will be used to evaluate the ecosystem functioning in response to environmental changes such as salinity variations.

Todd Scanlon established an eddy covariance system in the Cobb Mill Creek marsh to quantify carbon dioxide, water vapor, and nitrous oxide fluxes. For the latter, a tunable diode laser trace gas analyzer (Campbell Scientific, TGA100A) has been added to obtain high-frequency measurements. Water vapor and carbon dioxide time series have been continuously collected since September 2006, while nitrous oxide measurements during this timeframe have been intermittent, due to instrument-related problems. Following a site visit by a Campbell Scientific engineer, we have been able to collect a "clean" dataset beginning on September 5, 2007 that should be able to determine if this upland marsh is a hotspot of denitrification and nitrous oxide emissions. Simultaneous with these atmospheric flux measurements, we are measuring bi-directional discharge through the culvert at the marsh outlet using an ISCO 4250 Velocity-Area flow meter. Nitrate and ammonium measurements were collected over the course of multiple tidal cycles to quantify nitrogen inputs and outputs to the marsh (Aaron Mills is working upstream of the marsh to quantify streamwater contributions). The goal of this research is to develop a nitrogen budget for the marsh and to determine the processes responsible for the observed temporal variability in nitrous oxide emissions.

Barrier Islands

Mike Fenster, with colleagues Bob Dolan, and Mauricio González have expanded our work on the geomorphology of the barrier islands. The have focused on three primary tasks: (1) acquiring baseline data capable of establishing a sediment budget and conducting a quantitative material flux analysis of the active sand prism (including sediment sources and sinks) of the Virginia barrier island (VBI) chain; (2) examining the role of both long-term wave climate and short-term storm disturbances in controlling the morphologic and shoreline changes on this mixed-energy barrier island and tidal inlet system; and (3) investigating decadal-scale (i.e., ≈ 50 yr) ecotone displacement trends and the relationship between ecotone displacement and shoreline migration

on Hog Island, Virginia. An important part of this effort was the collection of 155 barrier island foreshore sediment samples (Fisherman Island to Chincoteague Island), 75 Assateague Island foreshore sediment samples (Hooks Cove to Assateague State Park), and 135 offshore sediment samples.

A major new phase of our work has been the expansion of our core study sites to new islands in the region. Frank Day and his students are studying plant biomass on grassy dunes on Hog, Parramore and Smith Islands. On each, three grassy dunes were chosen based on their relative age, which was determined based on topographic and vegetative analysis. A random 150 m line transect was created along the ridge of each dune. Fifteen 0.25 m^2 plots were randomly located along the transect. Each plot was clipped of all aboveground vegetation. Fifteen 40 cm deep soil cores were taken to determine belowground biomass. Factors such as soil N, depth to groundwater and unique microtopographic features were also determined. Statistical analysis will evaluate biomass variability among dunes on each island, as well as among the three islands. The influence of factors such as nitrogen content and depth to fresh water will be examined.

Day's lab group also quantified plant biomass in interior marshes in interdunal swales on Smith, Parramore and Hog Island to examine the differences in biomass and root/shoot allocation and investigate factors that may affect variability in these marshes. The sites included two interior marshes on Hog Island, one marsh on South Smith Island, and on marsh on northern Parramore Island. In each marsh, fifteen 0.25 m^2 plots were randomly located. Aboveground biomass was harvested at each site. Soil cores were taken to 40 cm depth to quantify belowground biomass. Water table depth and salinity were also recorded at each plot. Total nitrogen values for roots, shoots and the soil will be determined using a Carlo Erba CN analyzer to help identify any differences among marshes. Meteorological data will be used to evaluate the influence of rainfall and storm events on marsh biomass.

Day and students also completed a four-year study of Hog Island and Parramore Island 'pimples', small, rounded dunes forming along main dune ridges of the barrier islands. There are distinct plant assemblage zones found on pimples, although most of these dunes are 10 – 20 m in diameter. The hypothesis was tested that fresh water availability was a main determinant of differences between assemblages and that pimple size and location would influence diversity and assemblage structure.

Raymond Dueser and his student Joel Martin continued a series of experiments and observations aimed at clarifying the role of predation in observed declines of beach-nesting and colonial waterbirds, and how such impacts might be minimized. They conducted experimental manipulations wherein eggs treated with estrogen were exposed to raccoon (*Procyon lotor*) predation to test whether aversive egg taste might be an effective management tool for reversing declines in rare or threatened species of beach-nesting birds on the Virginia Coast.

Don Young and his students have expanded our understanding of VCR ecological processes to the landscape level. They have established two new study sites on Metompkin Island, one additional site on south Hog to complement our work on the North end of the island, and two sites on Smith Island. Their initial focus is relating within and among island differences in seed

arrival, via birds, relative to island location on the VCR landscape and to the surrounding community composition. The focus is on woody species, primarily from fleshy-fruited species. At each of the 6 sites at least 10 avian fecal collector devices (AFCD) have been installed. Fecal matter will be collected from the AFCDs, all seeds will be extracted, washed, and identified and then related to surround vegetation. The primary collection times are fall and spring passerine migration periods. In addition, the fecal matter will be assayed for the presence of *Frankia*, an actinomycete that forms a symbiotic N fixation association with *Myrica cerifera*, the dominant woody species at the VCR. We are testing the hypothesis that passerine birds are responsible for dispersing the seeds and are the endosymbiont for this ecologically important shrub. Shrub seedlings cannot become established without the presence of *Frankia* in the soil.

To assist with efforts in scaling from local measurements to landscape level processes, Don Young's lab group also has focused on seasonal measurements of spatial variations in plant physiological parameters and associated variations in fluorescence and reflectance. At monthly intervals several hundred measurements of chlorophyll fluorescence (light adapted) and leaf reflectance were collected on Hog Island. These data are being related to glasshouse experimental studies of drought and salinity stress of *Myrica cerifera* and *Phragmites australis*. In September, SpecTIR, Corp, collected 1 m hyperspectral data from the northern half of Hog Island. The field and hyperspectral data will be analyzed to identify spatial variations in plant stress on Hog Island. These relationships will then be used with future hyperspectral data sets to assess plant stress on other islands of the VCR. The primary funding for this research effort is the Army Research Office but all data are available and applicable to the VCR LTER mission.

In a collaborative effort between the VCR/LTER and the University of Virginia Dept. of Computer Science, a "mote-based" wireless sensor network was developed to rapidly measure environmental parameters. Through a series of discussions with John Porter and Don Young, the system was developed initially to focus on light measurements. The 140-sensor system was tested on Hog Island in late summer of 2007. The sensor system was used to quantify and describe light heterogeneity within *Myrica cerifera* shrub thickets. The Virginia Commonwealth University lab, including doctoral student Steven Brantley, assisted with the sensor deployment. To assess heterogeneity the sensors were arranged in a rectangular grid, in a cross pattern, and on branches within the shrub canopy. Data were collected for an extended period with each sensor logging every second, for 24 hrs each day. The data remain to be analyzed but an empirical calibration curve between the sensors and pre-calibrated light sensors is being developed. Dr. Leo Salavo (Virginia), presented a paper describing the system at a SenSys conference in Australia in August and the presentation is to be published in the conference proceedings.

Remote imaging

In September NRL scientist and co-PI Bachman and his team conducted an airborne and in situ data collection campaign over the mainland, barrier islands and lagoons of the VCR. One aircraft was outfitted with NRL-RSD hyperspectral and thermal cameras; the second aircraft was equipped with LIDAR. The in situ data collections on the land included: soil properties (shear strength, soil moisture, density/grain size, modulus of rigidity), plant biomass, canopy light penetration in *Spartina alterniflora* marshes and barrier island shrub thickets, in situ spectral reflectance, hemispherical camera LAI in uplands. In addition land-cover DPGS surveys were

updated. In the water, in situ data were collected on optical properties (inherent and apparent), bottom reflectance, shallow water above-surface spectral measurements, and salinity/temperature profiles.

Landscape Modeling

Enrique Reyes and his students are currently developing a set of models to characterize mainland habitats of the Virginia Coast Reserve Landscape model. This initial focus on mainland habitats was to test our landscape modeling capabilities and use a systematic approach to data collection. Other habitats, like seagrasses and *M. cerifera* thickets common on the islands will be collected at a later date. There are about 30 required inputs including variables, rates and initial conditions for each of the unit models representing the habitats of the VCR basin. We have designed a set of linked databases for the process-oriented data that change among habitats (i.e., habitat-specific data). The databases are organized to match the sectors of the unit model, with a separate database for each sector such as macrophytes, hydrology, suspended sediments, etc.

The environmental information for the VCR mainland habitats and adjacent lagoons can be classified in spatially distributed and time-series records. The spatially distributed data include topographical maps and vegetation classification maps. The time-series parameters are the ones used for weather forecast, air traffic, and tidal stage monitoring. All the environmental data have been organized in a spreadsheet format that allows for easy access and formatting routines that are used by the ecological models.

Study area maps were collected from different sources. (a) The Department of Commerce (DOC), National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal Services Center (CSC) has published a series of land cover maps under the title “Virginia C-CAP zone 60” which includes images from 1996, 2001 and 2005 on Landsat TM (Thematic Mapper) imagery. This raster habitat/classified Landsat TMD information allows analysis of trends, land loss and vegetation succession. These maps were digitized and georeferenced with a GIS software (ArcGIS) that facilitates the manipulation of the data in an effective manner. (b) The Coastal Relief Gridded (NOAA) database provided the topographic and bathymetric data. Bathymetric data sources include the US National Ocean Service Hydrographic Database, the US Geological Survey (USGS), and US Army Corps of Engineers LIDAR (SHOALS). Topographic data are from the USGS 3-arc-second DEMs and Shuttle Radar Topography data (SRTM). This initial GIS dataset will be improved by other VCR concurrent efforts such as the new LIDAR set collected by Chip Bachman.

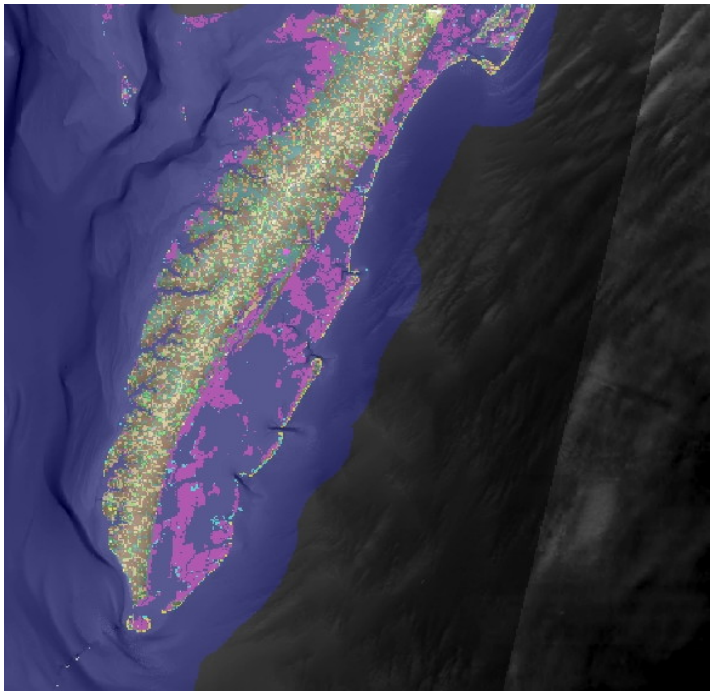


Figure 1 shows the dataset that corresponds to vegetation/habitat maps of the coastal zone for 2005 using the original NOAA classification.

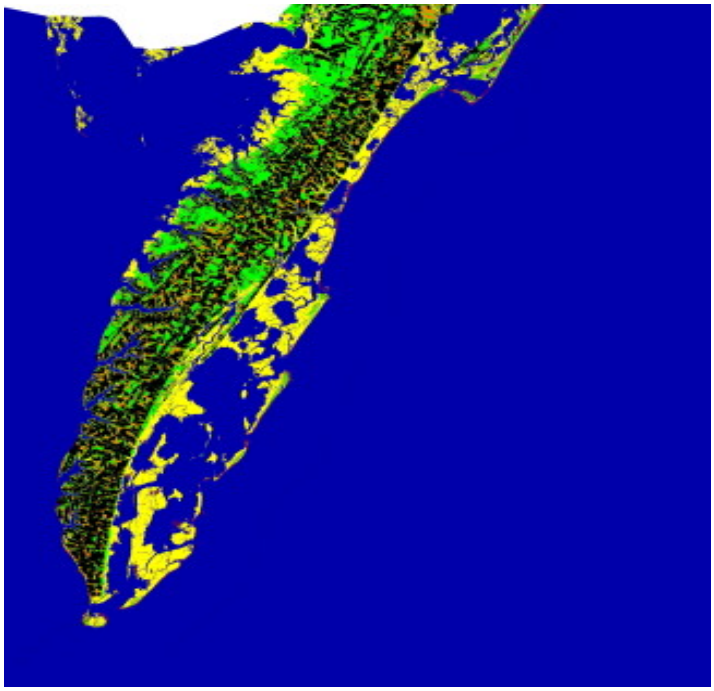


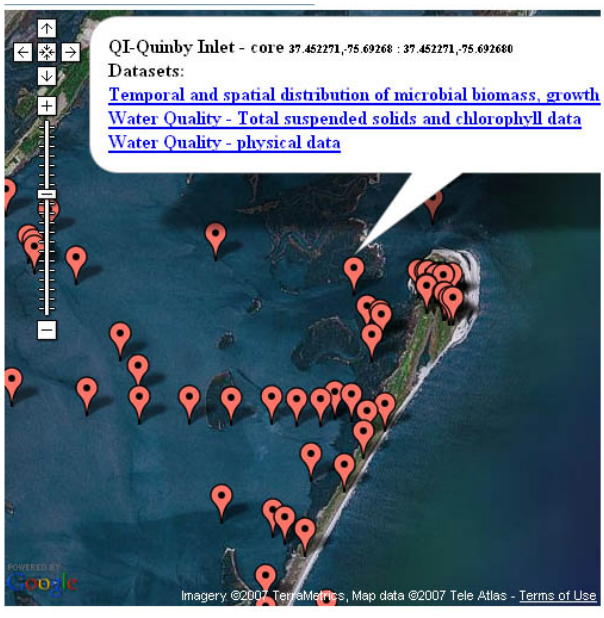
Figure 2 shows the VCR Landscape model reclassification to modeled habitats.

The original area covers approximately 344473 km^2. The principal data sets that were used for

developing the landscape model are the habitat classification analyses for the years 1996, 2001 and 2005 developed at the CSC – NOAA. An explanation of the compilation and classification methodology is provided in the Coastal Change Analysis Program (http://www.csc.noaa.gov/crs/lca/ccap.html) and on Divins, D.L., and D. Metzger, NGDC Coastal Relief Model, July 2007, http://www.ngdc.noaa.gov/mgg/coastal/coastal.html . This digital data set was then transferred into rasterized data to be used for habitat reclassification and model manipulation. We then developed unit models that consist of 30 different environmental inputs, including variables, rates and initial conditions. Each unit model was designed in modular fashion. Ecological processes are separated into sectors such as macrophytes, hydrology, dissolved inorganic nitrogen, etc. Three ecological models for marshes (low, medium and high salinity influence) were designed to examine the consequences of the present conditions and potential hydrological changes such as sea level rise. The unit model structure is divided into different submodels. Fundamental processes such as sediment and macrophyte dynamics, hydrology, etc., are divided into 11 "sectors". Each sector may include above- and below-sediment dynamics. Within each sector may be one or more modules, which are defined here as a set of interactions that define the dynamics of one state variable. The sectors provide a large degree of modularity in that the model may be run either with or without the dynamics of that sector. When a group of variables and linkages in the model has been enclosed by a sector it can be isolated from the remainder of the model and run either separately or with any combination of other sectors. For instance, the macrophyte sector could be duplicated (and/or modified) to provide increased vegetation interactions (such as in the case of the *Spartina* and *Juncus* community).

Information Management

During 2007, we improved the VCR/LTER local data catalog by changing a long list into a matrix format that can be sorted by a variety of criteria, including core area and popularity. We also did some major work on our database of locations (for datasets, species observations etc.), dealing with a large number of locations that were named and described, but had no coordinates. To avoid such problems in the future a new interface for identifying locations was developed. It uses the Google Maps API v.2 (following testing to make sure that the georeferencing was sufficiently accurate in our area) so that a user can use the standard Google Maps controls to zoom and pan the map, then click on a location to record its coordinates into our location data table. Coupled with that new facility is an interactive map (again using the Google API) that plots all locations for VCR/LTER datasets. Clicking on a location pulls up a list of all the datasets associated with that location.



We have also worked on enhancing data systems for important datasets. Traditionally these have been handled using user-designed spreadsheets. However, in some cases these were inconsistent in format and highly variable in the degree of quality control and assurance. For our water quality dataset we have developed an operational system that incorporates spreadsheet forms (including both data and "flags"), a PERL ingestion program that resolves relational issues that the spreadsheet handles poorly, a MySQL database, R-scripts that conduct standard Quality Assurance (QA) analyses, and data editing capabilities using phpMyAdmin and an ODBC-linked Access database. A web page provides a central location for uploading spreadsheets, running QA analyses and for data editing.

Our wireless network on the shore continues to expand. We had to do a major rebuild on one of the nodes when in August 2006 it experienced a direct lighting strike so intense that most connections were welded together. However, that gave us a chance to experiment with improved power systems that now permit 24/7 operation. The new well network uses the network backbone to provide near real-time data on water levels.

Network and International Activities

Collaborations with Taiwanese researchers associated with the Taiwan Ecological Research Network (TERN) and the Taiwan Forestry Research Institute (TFRI) continued. Taiwanese researchers Chi-Wen Hsaio and Dr. Chau-Chin Lin each spent 2-3 months visiting the VCR/LTER to collaborate on projects related to LTER information management. Mr. Hsaio worked on development of web-based system for quality assurance based on the Ecological Metadata Language (EML) standard implemented by all LTER sites. The system uses the EML metadata to read in the data, checks for data type and range, and provides users with opportunities to correct or discard bad values. The system was subsequently used to perform quality assurance checks on over 200 datasets generated by TERN researchers. Dr. Lin focused on learning to use the KEPLER system developed by the SEEK project to generate scientific workflows. His knowledge of the system was then used as the centerpoint for an East-Asia Pacific International LTER workshop in Shanping Taiwan during June 2007. Researchers from Taiwan, mainland China, Thailand, Malaysia and Australia spent three days learning how to use KEPLER and related tools.

Bob Christian and Iris Anderson went to Italy, worked with Italian scientists at the University of Parma on constructing and analyzing networks of N cycling from coastal lagoons, and developed ideas for future collaborations. Furthermore, they attended the 2007 Congress of the Italian Society of Ecology in Ancona, Italy. There they conferred with Italian scientists about the newly instituted Italian LTER and promoted cooperative arrangements. Bob Christian gave a plenary talk on "Viewing the World as networks of Networks."

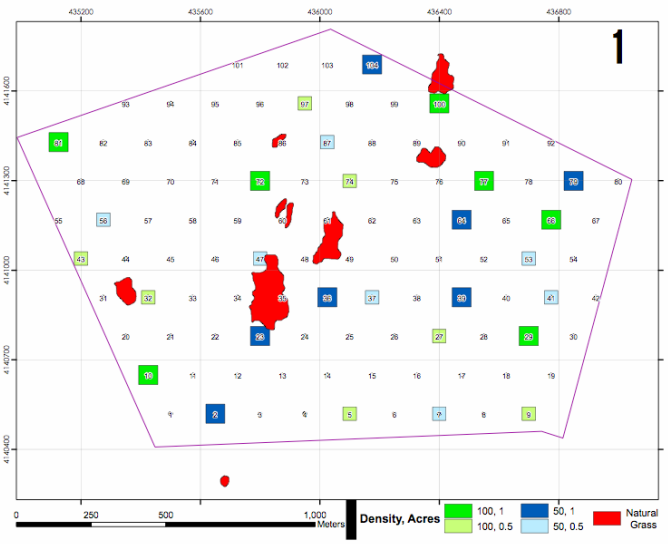
Bob Christian in cooperation with Robert Waide, Caleb Hickman, James Brunt and Jeffery Johnson met for a workshop to assess the collaboration among LTER network sites through network analysis of cross-site publications. Their initial efforts have demonstrated a strong trend to increased coherence of the LTER network over the past 25 years. It appears that the synthesis efforts of the late 1990's have had a positive effect in this regard.

FINDINGS

Watersheds and Lagoons

Seagrass restoration

Our Spring 2007 reconnaissance of the seagrass restoration site with our VIMS colleagues showed that all seeded 0.5 and 1.0 acre plots had seeds that had germinated and had seedlings growing. Preliminary estimates were recruitment rates of 7 – 12% which is typical of a 'successful' year using this hand-broadcast technique. Our more detailed survey in July 2007 of all plots showed average shoot densities of 16 – 28 shots per m^2, with 2-6x more shoots in the 100,000 seeds per acre plots than in the 50,000 seeds per acre plots. In the 'natural' plots, which we believe to have colonized at least 2 years ago based on aerial photography, shoot densities were 148 – 448 shoot per m^2. We are encouraged by the results thus far, that we had good recruitment and that seedlings survived well during the first growing season. We plan to replicate this experiment at the same site in Fall 2007, adding 1.5 million seeds in 28 new plots, again with 50,000 and 100,000 seeds per m^2 and plot sizes of 0.5 and 1.0 acres. Figure 2 below shows the location of the original plots, their densities and the natural patches.



Interestingly, our VIMS colleagues report that the seagrass bed in South Bay, which has developed from restoration efforts since 1997, has not only expanded well south of the original plots, but the area inside of our original 'set aside' area has also become denser, and the area is now one large, dense, continuous bed (Fig. 2, courtesy of Robert Orth).

Over the last year, we have done many eddy correlation deployments over a range of natural flow and light conditions over sandy sediments vegetated by 5-6 year old seagrass beds in South Bay, and over adjacent 'bare' sediments containing benthic microalgae. One example from the seagrass site is shown in Fig. 3. Through most of the 13-hour deployment clear linear trends in the cumulative flux (Fig. 3c) indicate a statistically sound eddy flux signal. From time 5 hour to 6.5 hour the current is too low to produce a signal which makes good flux estimates impossible. Note the clear effect of seagrass photosynthesis (Fig. 3d).

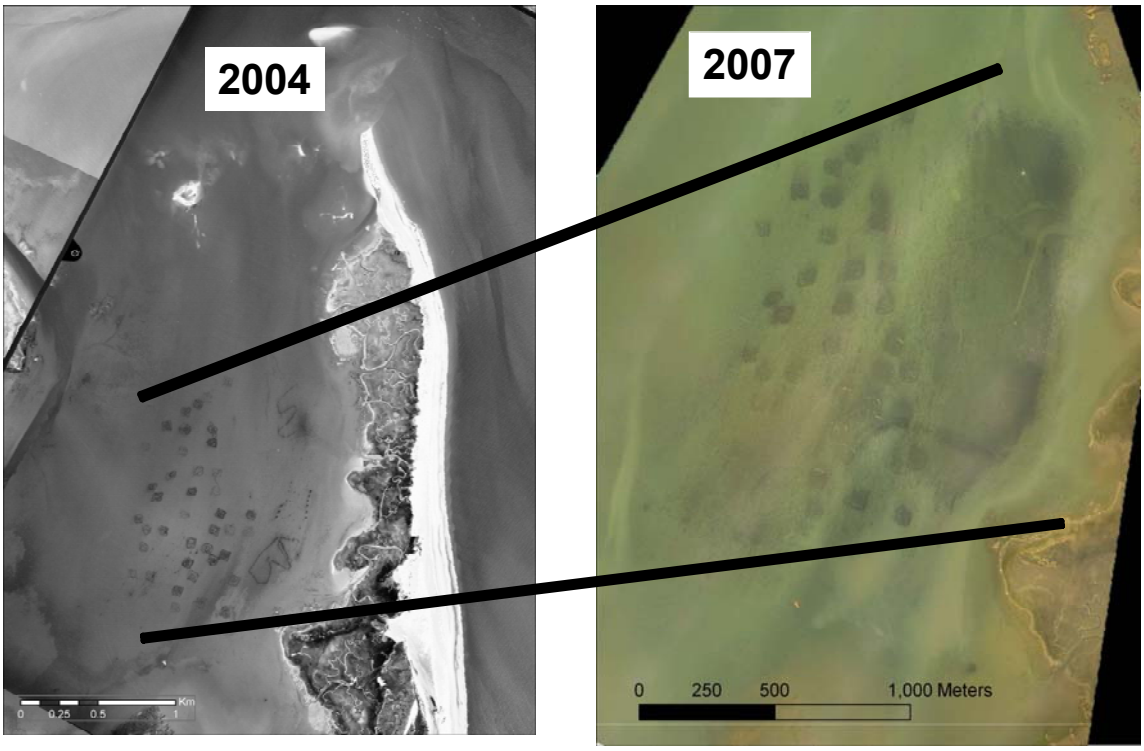


Figure 2: Seagrass restoration area. Dark squares and lines in 2004 represent plots where seagrass seeds were added.

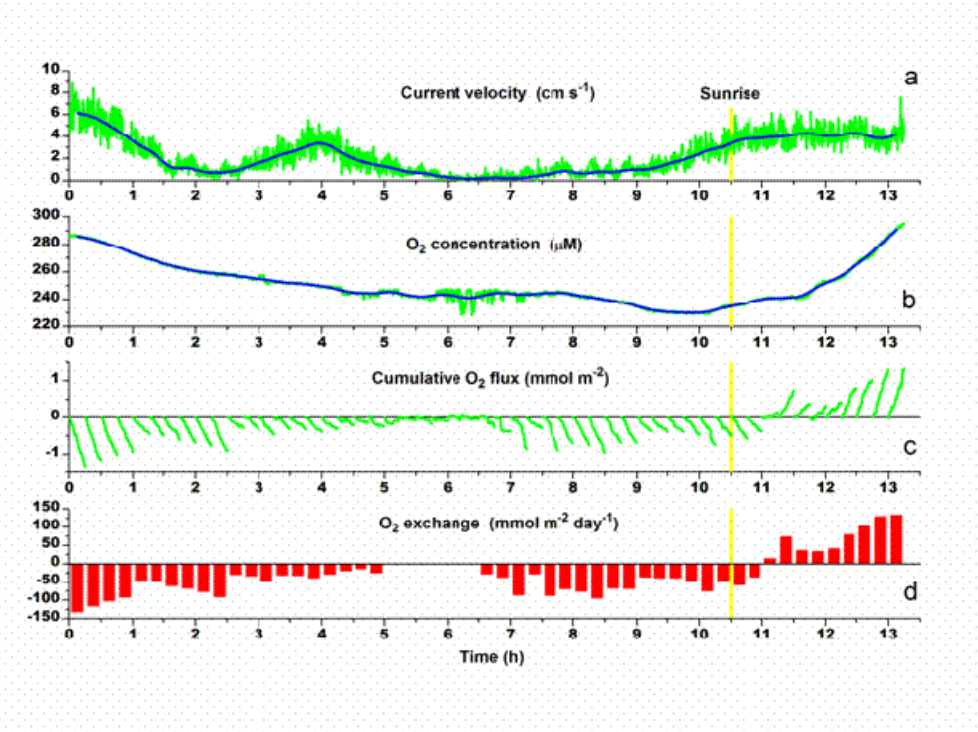


Fig. 3: Typical eddy correlation measurements and their interpretation over a seagrass bed for a 13 hour period. (a) Current velocity – blue line represents the mean. (b) Oxygen concentration – blue line represents the mean. (c) Cumulative fluxes. (d) Derived fluxes.

Several researchers have predicted that sediment-water exchange of permeable sediments is highly dynamic and strongly affected by variables such as current velocity. For example, it has been predicted that oxygen uptake increases markedly with increasing current velocity due to an increase in sediment flushing. Intuitively this makes sense, but the effect has never been shown experimentally before, simply because standard flux methods are not applicable for permeable sediments. However, we see that trend in many of our data. For example, the night-time fraction of the data shown in Fig. 3, measured over permeable sediment, clearly exhibits this behavior (Fig. 4). The sediment-water oxygen uptake increases several fold, when current velocity is varying from 1 to 6 cm s^{-1} (Fig. 4b).

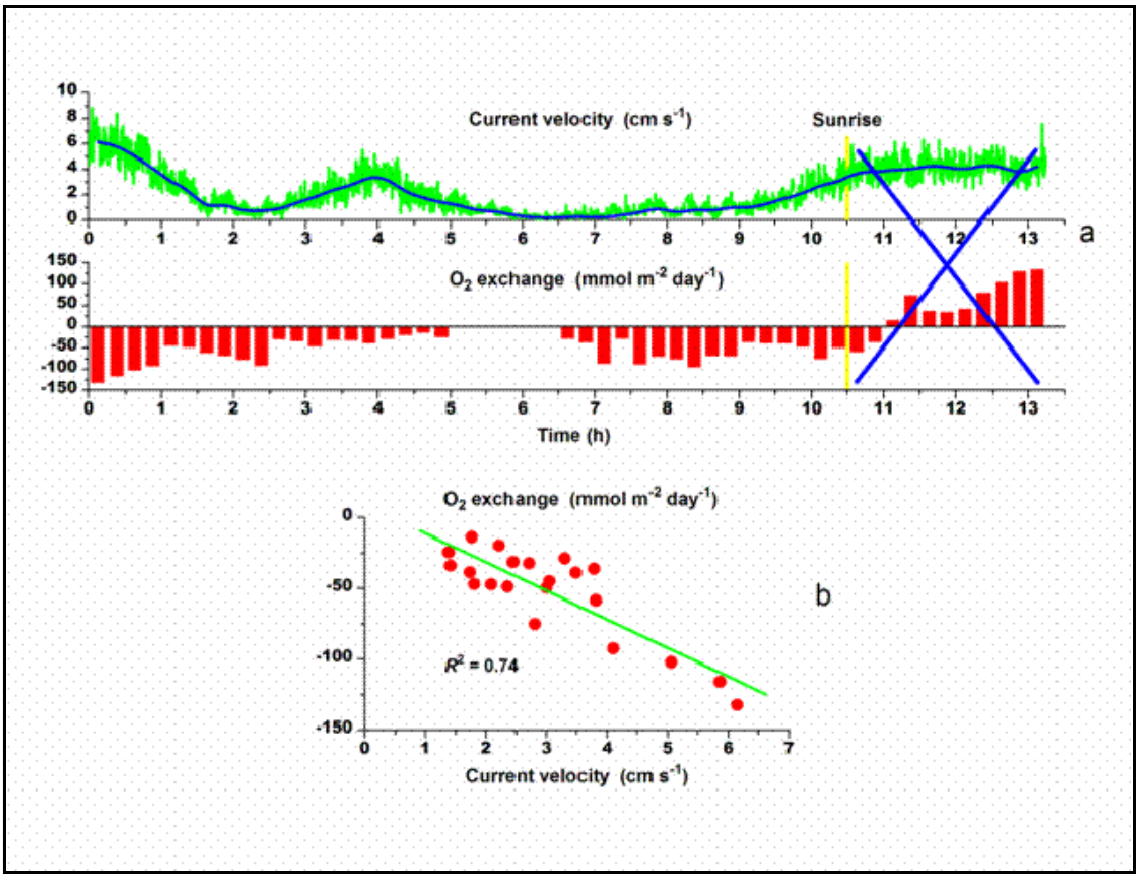


Fig. 4: (a) Night-time current velocity and sediment-water oxygen uptake. (b) Night-time fluxes plotted as a function of current velocity showing a clear trend.

In the restored seagrass meadows, isotope differences were found between tissues of fish compared to those captured from algae sites. Atlantic silversides, silver perch, bay anchovies, and spot collected in late summer in seagrass plots have distinct $d^{13}C$ and $d^{34}S$ isotope values compared to individuals of the same species collected in algae plots. The carbon isotopic values of fish collected in algae sites were consistently more depleted relative to fish collected in seagrass sites for all four species and are likely indicative of distinctly different dietary carbon sources to organisms at these sites. With the exception of the bay anchovy, the sulfur isotope values of the fish were also depleted in algae sites relative to seagrass plots. Several explanations may account for the diminished contribution from seagrasses to the higher trophic levels of the food web. First, it is likely that seagrasses may be a small but necessary component of consumer diets. Second, tissue isotope compositions turnover slowly, especially for larger animals, fish captured within the plots may have migrated there recently, and insufficient time may have passed for the seagrass signal to show up in bulk tissue samples. Third, a number of fish species may only rely on seagrass primary production for specific time periods owing to changes in feeding strategies over the course of a season or over a lifetime. Fourth, seagrass may enter the food chain through the detrital pathway, and the signal may be altered by bacterial reworking of the tissues. Some of the data suggest changes in diet preferences with age. A linear correlation was found between bulk tissue $d^{13}C$ and fish length for several species during the sampling period. The phenomenon was recorded for Atlantic silversides and spot captured in

algae sites, as well as pinfish and pigfish captured in seagrass plots. The larger, presumably older silversides and spot are isotopically depleted relative to smaller, more juvenile fish while the reverse is true for pinfish and pigfish. The isotope distinctions between monthly samples are most clear among the algae sites, although it was also noted in seagrass plots.

We also measured the transfer of primary producer fatty acids to primary consumers and higher level consumers. Fatty acid profiles and relative concentrations of individual fatty acids in macrophytes differ among the species, allowing for source differentiation. The fatty acid composition of the tissues of macrophytes can be compared to that of local consumers in an evaluation of the ultimate sources of dietary fatty acids. Particular attention is being focused on the biomarker fatty acids found in eelgrass as well as other primary producers. The dietary importance of eelgrass to consumers in barren sediment sites is suggested to be negligible, resulting in fatty acid profiles differing from organisms captured at the two sites dominated by the macrophyte and seagrass primary producers.

Hydrodynamics and sediment transport

Measurements and modeling of flows in Hog Island Bay (e.g., Lawson et al., 2007) show that sediment resuspension from the lagoon bottom is strongly controlled by wind, owing to its influence on currents, water level and waves. This work has also shown that sediment resuspension is the primary control on light availability at the lagoon bottom, a critical variable for sea grass and other benthic primary producers.

We also have analyzed the response of the VCR lagoons to wind events and estimated how the related distribution of bottom shear stresses is influenced by the distribution of channels, salt marshes, and tidal flats. In order to study the distribution of bottom shear stresses produced by wind waves, we first analyzed the distribution of fetch and water depth (Fig. 5). These two parameters, together with wind speed, were then used to determine the wave height in each basin location through equations commonly used in the literature. The main difference in wave height occurs when the salt marshes are submerged. Under this scenario, neglecting the influence of vegetation on wave attenuation, the potential for erosion is the highest. The direction of the wind is critical when the entire basin is below water. In this case the maximum wave heights and erosion potential occur for winds directed along the axis of the peninsula (NNE-SSW). When the marshes become emergent the highest fetches are in the N-S direction, even though the difference between different wind directions is less pronounced. The distribution of water depth in the basin slightly increases the bottom shear stresses for winds that blow from the North, since the southern part is in average shallower. For water elevations below the marsh platform a decrease in water depth and related fetch does not significantly change the wave height. Higher shear stresses develop at the bottom as water depth decreases. For low water elevations the decrease in submerged area (and therefore locations affected by wind waves) is compensated by an increase in average bottom shear stresses, so that the potential bottom erosion is similar for elevations between 0.0 and -0.6m for a given wind speed.

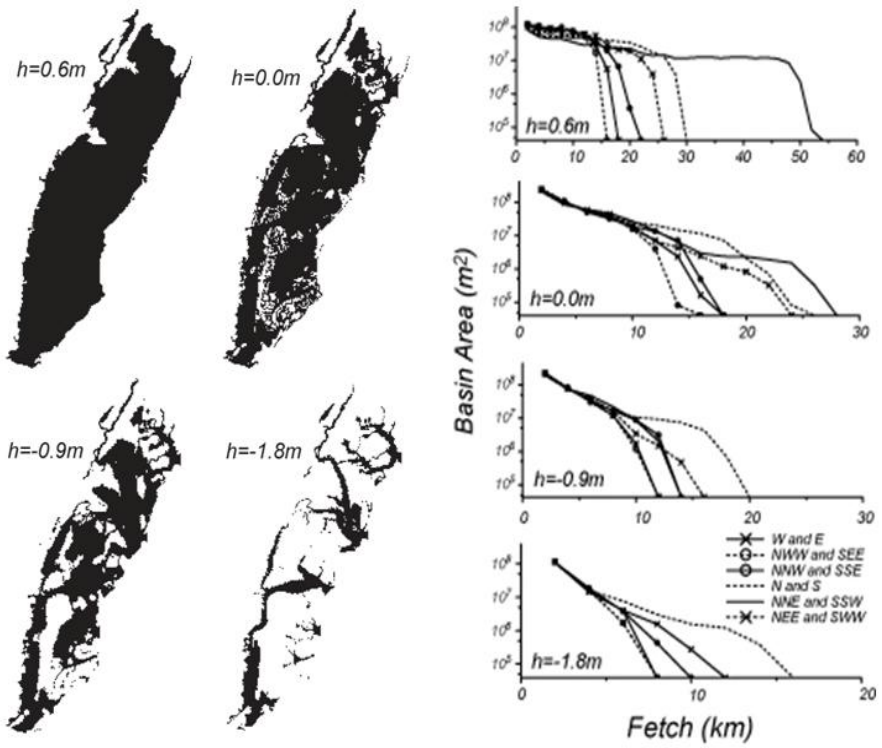


Fig. 5. The maps (left) show the change in fetch length as a function of water depth in the lagoons along the Eastern Shore of Virginia. The dependence of fetch on basin area and wind direction is shown in the plots on the right. High water levels when winds are from the NNW-SSE result in dramatically larger fetch lengths than other wind directions or water depths.

Watersheds and groundwater nutrient fluxes

The effect of retention time on redox sequences along the hydrological flow path of groundwater discharging through low-relief coastal stream sediments and the subsequent impact on the fate of NO_3^- carried in the groundwater was examined by carrying out column experiments on two intact cores. Rates of denitrification were determined for the organic-rich streambed sediments, and a macroscopic, multi-species, reactive transport model based on multiple Monod kinetics was developed to interpret and extend the experimental results. Regionalized sensitivity analysis and parameter estimation were used to determine a set of parameters that best describe the experimental data for one column.

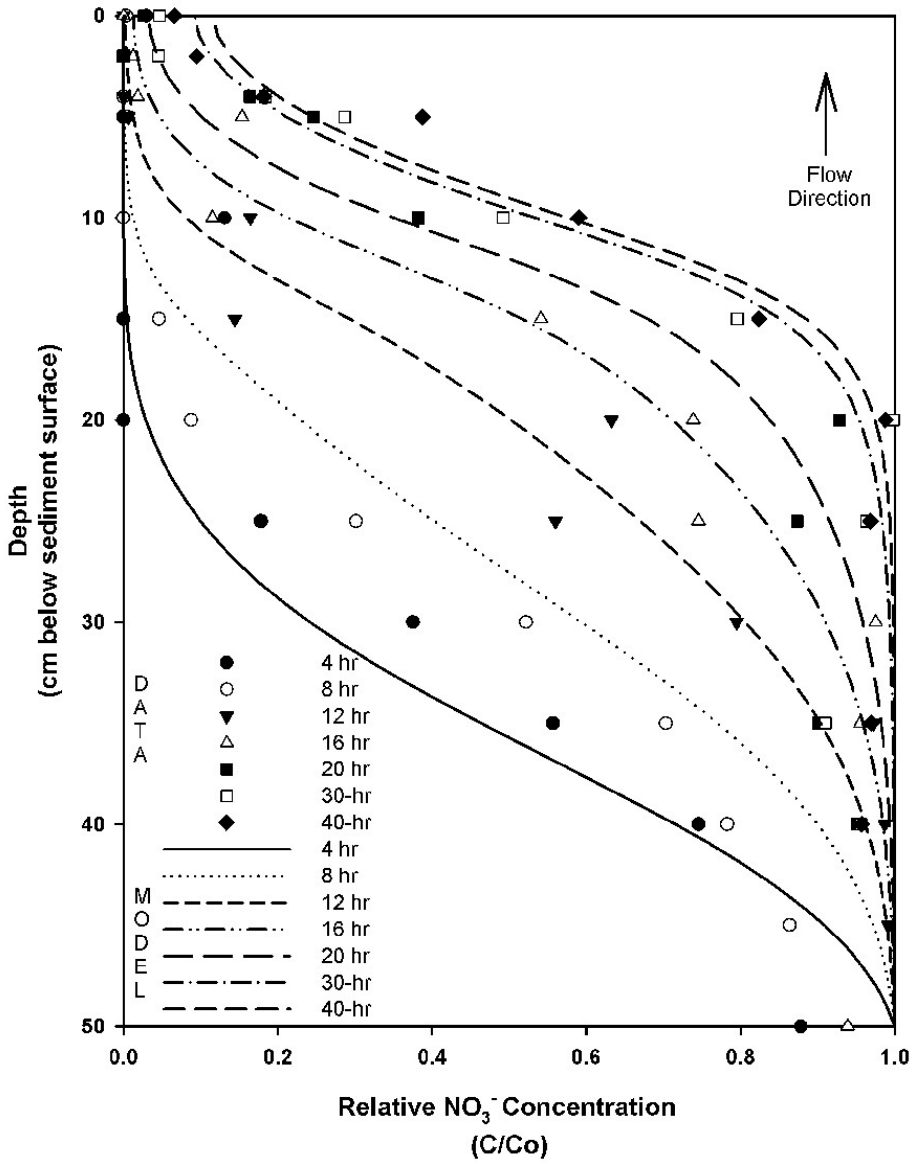


Fig. 6. Comparison of model results with experimental data collected from a time-course study of nitrate migration through an intact core collected from the sediments of Cobb Mill Creek. Data from Gu et al, (2007).

The calibrated model successfully replicated the spatial profiles of nitrate under both steady and transient conditions in the second column operated under different conditions (Fig. 6). Furthermore, when the flow velocity in the column was changed, the amount of nitrate breaking through the column changed and the model was also able to capture the change in the breakthrough characteristics of the column (Fig. 7).

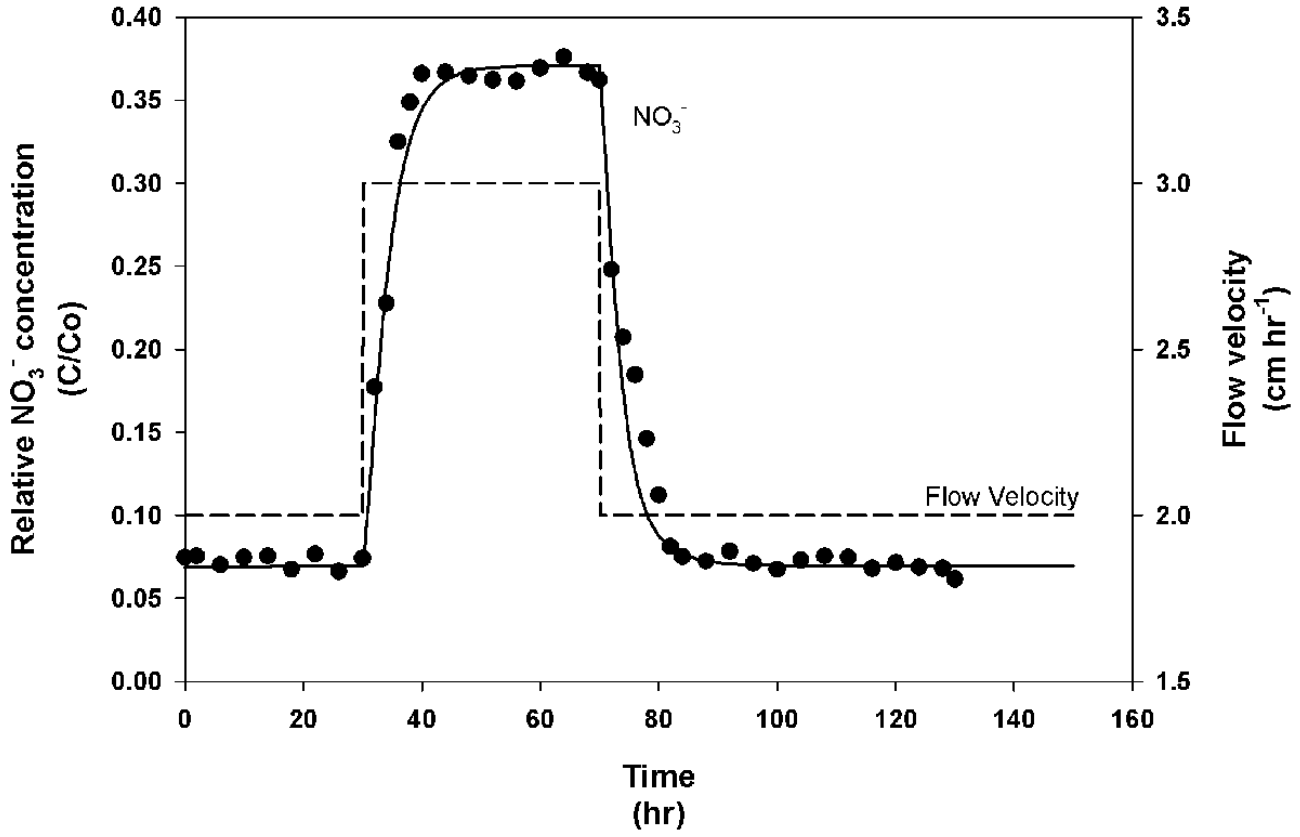


Fig. 7. Effect of flow velocity on nitrate removal in an intact sediment column and comparison of model results with experimental data.

A dimensionless form of the model was used to examine how coupled biogeochemical reactions and hydrological transport processes operating within the stream sediments could be understood in terms of Peclet (ratio of advection to dispersion) and Damkohler numbers (the ratio of the characteristic time of transport to the characteristic time for reaction). At the study site, the Peclet number and the Damkohler numbers for both oxygen and nitrate are high (Pe=25, Da_N=47.5, and Da_O=40). When Pe > 5, Damkohler numbers explain observed variations in nitrate removal rates; as the flow rate increases, the solute residence time in the reactive zone is shortened resulting in a lesser extent of reaction, such that more NO_3^- is delivered to the stream water.

Tidal Marshes

Sea-level rise and marsh accretion

Ten years of salt marsh surface-elevation data obtained with soil elevation table (SET) methods were used to determine if soil surfaces kept up with local sea-level rise (3.8-4.5 mm yr^{-1}) on the Delmarva Peninsula, VA. For diurnally- and springtide-flooded areas, rates of surface-elevation

change (5.8 and 4.4 mm yr^{-1}) matched or exceeded those of sea-level rise. Change well below rates of sea-level rise were observed in storm-tide-flooded areas (2.2 mm yr^{-1}) and the long-term elevation deficit would have been even greater except that soil accretion and root zone processes appeared to partially offset the deficit. A 2-year-long drought midway through the study (2000-2002 growing seasons) yielded puzzling dynamics. Pre-drought elevation changes were 6.5, 4.3, and 2.2 mm yr^{-1} but were negligible during the drought. Post-drought rates were 6.7 and 5.4 mm yr^{-1} in the springtide- and storm-tide-flooded areas, whereas post-drought and pre-drought change was similar in diurnally-flooded areas. Collectively, these results suggest that the influence of severe drought on marsh elevation is substantial in some areas of the marsh and may persist well beyond the end of the drought period. Furthermore, in storm-tide-flooded areas, the increased rate of elevation change post-drought may be sufficient to allow these areas to survive current sea-level rise.

Sudden marsh dieback

In 2004, one year post-drought, we observed the first evidence of marsh dieback in our principal mainland marsh study area. The focus of Amanda Marsh's (ECU) MS thesis (completed 2006) was this marsh dieback area (see Publications section). She tracked the dieback from 2004 through summer 2006. She found effects of the dieback on marsh elevation, snail density, pore water sulfide concentration, and of course ground cover. The areas of the marsh that were largely devoid of plants began to close in during 2006 and continued to revegetate in 2007.

Continuing work begun in 2005, we have collaborated with Elijah Ramsey and Amina Rangoonwala of the USGS National Wetlands Research Center, Lafayette, LA and with Chip Bachman, Naval Research Lab, Washington, DC. They are focused on remote sensing of coastal ecosystems. We have shown changes in the pigment content of leaves of green plants associated with their position in the dieback area.

Microbial community structure

Linda Blum and graduate students Amanda Floyd and Gina Casciano evaluated how bacterial and fungal communities associated with two plant communities, *Spartina patens-Distichlis spicata* and *Juncus roemerianus*, respond to the frequency of tidal flooding. Their work shows that fungi are active, abundant residents of salt marsh soils, even though it is generally accepted that fungal activity is limited in anaerobic wetland soils. Variations in bacterial and fungal community structure were linked to differences in soil organic matter content and elevation suggesting that understanding what factors influence microbial mineralization of soil organic matter will provide a mechanistic understanding between organic matter accumulation and marsh surface elevation.

Barrier Islands

Island vegetation structure

Our work on the island “pimples” showed that there were distinct assemblage types that segregated themselves by habitat type: marsh, shrub thicket, and dry summit. Shrub assemblages

were less diverse than either marsh or summit habitats. There was no relationship between pimple size and diversity or location. Differences in diversity and composition among pimples were as great as differences among transects within pimples. Pimple diversity and species composition were different from the main dunes. Fresh water availability was important in differentiating differences, both among transects and among species, but it was not the only factor. Nutrients, such as boron, were also important in describing variation among species. It is likely that interactions between water and other factors (e.g. the accumulation of some mineral nutrients in the marsh after they are leached from the dune summits) are the most important determinants of species abundance.

Shrub expansion

In a collaborative project with Charles Bachmann of the Naval Research Laboratory, John Porter and Don Young examined spatial and temporal variations in shrub thickets on VCR islands. To interpret broad-scale erosion and accretion patterns and the expansion and contraction of shrub thickets in response to sea level rise for a coastal barrier system, we examined the fine-scale processes of shrub recruitment and mortality within the context of the influence of ocean current and sediment transport processes on variations in island size and location. We focused on *Myrica cerifera* shrub thickets, the dominant woody community on most barrier islands along the coastline of the southeastern USA. Observations suggest that *M. cerifera*, a salt-intolerant species, is increasing in cover throughout the Virginia barrier islands, yet rising sea level in response to climate change is increasing erosion and reducing island area. Our objective was to explain this apparent paradox using pattern-process relationships across a range of scales with a focus on ocean currents and sediment transport interacting with island characteristics at intermediate scales. Multi-decadal comparisons across scales showed a complex pattern. At the scale of the entire Virginia barrier complex, modest decreases in upland area were accompanied by large increases in shrub area. Responses were more variable for individual islands, reflecting inter-island variations in erosion and accretion due to differences in sediment transport via ocean currents. Several islands underwent dramatic shrub expansion. Only for within-island responses were there similarities in the pattern of change, with a lag-phase after initial shrub colonization followed by development of linear, closed canopy thickets. Understanding the fine-scale processes of shrub seedling establishment and thicket development, in conjunction with the influence of ocean currents and sediment transport, provides a framework for interpreting island accretion and erosion patterns and subsequent effects on shrub thicket expansion or contraction across scales of time and space.

Colonial and Beach Nesting Waterbird Egg Predation

Experimental manipulations, involving treating birds eggs with estrogen to make them aversive to major egg predators, specifically raccoons (*Procyon lotor*), were conducted by Raymond Dueser and his student Joel Martin. Raccoons have a propensity to sample, and an egg aversion depends on the taste or smell of the egg, the appearance of the egg and the context in which the egg is found. So an aversion does not automatically generalize to eggs that are significantly different from the treated eggs. Taken together, these findings support the application of estrogen-induced aversive conditioning as a management tool, but also suggest that conditioned aversion is probably not a “magic bullet” for managing predation, and such field applications

may need to be relatively complex in their design and execution.

Island geomorphology

Our results indicate that, in general, the Virginia barrier islands north of Wachapreague Inlet (medium- to fine-grained sand) form a statistically significantly different subset from the islands south of Wachapreague Inlet (fine-grained sand) (Figure 1). In addition, the sediments that comprise Assateague Island (coarse- to medium-grained sand) appear to come from a homogeneous population distinctly different from the Virginia barrier islands. The fine-grained mean and small sorting values of offshore sediments indicate that the nearshore may provide a sediment source for the southern islands, but not the northern islands. The data also highlight the importance of the ebb-tidal delta at Wachapreague Inlet as a sediment sink and control on all islands to the south. Moreover, wave refraction modeling shows that storm waves and the long-term wave climate dynamically control the position of tidal inlets and sediment sink locations. In short, the sediment data, shoreline responses, and wave refraction modeling support the first order conceptual model of Fisher (1969), Swift (1969), and Halsey (1979) and the second order conceptual models of tidal inlet stability (Morton and Donaldson, 1973; others) and possibly the presence of tidal inlet retreat paths (McBride and Moslow, 1991; others).

Finally, results from the ecotone-shoreline analysis indicate that long-term trends in ecotone displacement and shoreline movement are non-linear for over three-fourths of the Hog Island coast. On average, the shoreline and vegetation line experienced reversals in 1972 and 1974, respectively. Rarely, however, did the ecotones and shorelines move in tandem or synchronously. Concavity tests indicate that most of the shoreline and ecotone most recently moved seaward and the distance between the shoreline and vegetation line has decreased over time. Evidence exists for a decennial time lag between the reversal of the shoreline and the ecotone and vice versa. The ecotone and shoreline trends apparently correspond to tidal inlet dynamics, individual storm events, and storm climate.