Addressing Eastern Shore and Chesapeake Bay Environmental Issues and Economic Development: University Research and Education

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Abstract

The Chesapeake Bay/ Eastern Shore region has experienced dramatic changes and challenges environmentally. This has created rich research opportunities for the region's universities committed to improving environmental quality. Six university programs that focus on the environmental concerns of the region are described -- including their facilities and examples of their research contributions and STEM education and outreach. Also discussed are the recent history of the regional ecosystem and the socio-economics of the area's communities. In addition to contributing to environmental quality, the university programs can be leveraged toward science and technology-based economic development on a regional scale through a strategy for a regional innovation cluster. This would foster a knowledge-based workforce, university-industry collaborations, technology transfer, entrepreneurship, and business development.

Introduction: Critical Environmental Conditions

The Delmarva Peninsula's "Eastern Shore" region is bounded on the west by the Chesapeake Bay and on the southeast by the Atlantic Ocean. Both the bay and coastal ecosystem are national environmental treasures.

There are notable activities underway at each of six universities on the Eastern Shore. These research programs are contributing to the quality of the local environment on the shore. They are also contributing indirectly to the region's economic development. Their efforts can be better harnessed and targeted toward the common goal of creating a concerted strategy for an environmental science and technology-based regional innovation cluster.

The Dynamic Seaward Side

The Atlantic Ocean side of the Eastern shore offers one of the few remaining undeveloped areas along the Atlantic seaboard available for the

study of coastal barrier ecosystems. It has a long expanse of pristine beaches and large coastal wilderness areas. The Nature Conservancy created the Virginia Coast Reserve in the 1970s to protect a chain of 14 barrier islands. The preserve comprises some 40,000 acres and extends about 70 miles along the lower Atlantic shore of the Delmarva Peninsula. It has also been designated by the United Nations as an International Man and Biosphere Reserve. The northern end of the preserve features the Chincoteague National Wildlife Refuge and the southern end features the Eastern Shore National Wildlife Refuge.

Proceeding north to south, the larger of the barrier islands are: Chincoteague, Assateague, Wallops, Assawoman, Hog, Wreck, and Smith.[1] Assateague Island is actually a system of barrier islands about 27 miles long and averaging a half-mile wide. The islands are separated from one another by deep inlets. The islands are bounded on the east by the ocean and on the west by the coastal bays that separate them from land.

These barrier islands experience dramatic rates of shoreline change. As they migrate toward land in response to the rising sea level, the change can be as much as 40 feet in a single year. Wreck Island, for example, has lost 300 yards on its northern end in recent years. In addition to long-term climate change, critical natural events such as storms also cause change. Until a major hurricane in 1933, some of the barrier islands were populated with pine forests and small villages, and several islands had a few hundred inhabitants, structures, and Coast Guard stations. The hurricane eroded and submerged the woodland and dunes. Both the hurricane and disease wiped out the underwater seagrass decades ago. Because seagrass serves as a nursery for wildlife like shellfish, the shellfish subsequently disappeared as well.

The barrier islands are now largely sandy environments that help to buffer the Eastern Shore communities from storms. The island ecosystem also features lagoons, tidal marshes, and mainland watersheds. On the side of the islands facing land, there are broad shallow bays and extensive salt marshes adjacent to forested uplands. The seagrass in the lagoons acts as a seaside filter for pollutants and excess watershed nutrients.

[1]Other islands are: Metompkin, Cedar, Paramore, Cobb, Ship Shoal, Myrtle, and Mockhorn. Many, but not all, of the islands that serve as environmental research sites are owned by The Nature Conservancy. Chincoteague and Wallops Islands, for example, are not part of the Reserve.

Research Opportunities

The barrier island ecosystem shelters more than 250 species of raptors, shorebirds, and songbirds and is one of the most important migratory bird stopover habitats on Earth.[2] Several of the islands feature complex and heterogeneous landscapes where walking just a few yards can introduce major differences in habitat. All of these factors make the ocean side an ideal place to study wildlife and the natural processes of landscape change. It has been called a "high-speed landscape" because changes that might take decades elsewhere can be observed in a few years. Short-term disturbances – such as storms and species invasions – interact with slower more progressive environmental changes to produce the region's geographic and biological dynamics.

The Delicate Chesapeake Bay

Directly surrounded by the states of Maryland and Virginia, the Chesapeake Bay is the largest estuary in the United States. It is approximately 200 miles long and 30 miles wide at its widest point, south of the mouth of the Potomac River. At its narrowest point, the bay is 2.8 miles wide. The shoreline extends more than 11,000 miles. The bay's watershed land-to-water ratio of 14:1 is the largest ratio of any coastal water body in the world. The bay is a drainage basin for the District of Columbia and parts of six states. The watershed states are: New York, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia. More than 150 rivers and streams drain into the bay from these states. Figure 1 shows a map of the bay and its watershed states.

The bay ecosystem consists of the bay itself, its tidal rivers and streams, and all the plant and animal life it supports. The bay is mostly known for its seafood production, especially crabs, clams, and oysters. The bay's salinity is ideal for oysters, so the bay has long been considered one of the world's most productive oyster growing areas.

Challenges and Opportunities

Today, the Chesapeake Bay is experiencing rainwater-carried runoff from the watershed states, over-harvesting of marine life, invasion by foreign species, and dwindling seagrass. The pollution comes from excess nutrients in over-enriched agricultural fertilizer treatments and farm animal manure. The pollutants also include toxic runoff from metropolitan

[2]For this reason, The Nature Conservancy partners with NASA to perform migratory bird studies using state-of-the-art NPOL Doppler radar.

areas, including lawn fertilizers, septic systems, car exhaust, and similar type sources. These nutrients and pollutants fuel the growth of algae in the water. When algae die, they decompose in a process that depletes the water of oxygen which all aquatic species need to survive. Algae also block sunlight that healthy underwater bay grasses need to grow. In the 1970s, the bay was discovered to contain one of the planet's first identified marine "dead zones." The water in dead zones is so depleted of oxygen that it's unable to support marine life.

Figure 1. Chesapeake Bay watershed (courtesy Chesapeake Bay Foundation)

In the last 50 years, the bay's oyster population has been devastated by these problems. In the 1950s and '60s, diseases overtook those oysters that had not already been over-harvested since the 1800s.

The depletion of oysters has had an especially harmful effect on the bay's water quality because oysters serve as natural water filters. A single healthy oyster can filter 50 gallons of bay water a day!

Many organizations are now focused on restoring the bay's long-term health, especially the six university programs discussed here.

Eastern Shore Socio-Economics

The communities of the Eastern Shore are located in two offshore Virginia counties separated from the mainland and nine counties of Maryland's shoreline east of the Chesapeake Bay.[3] The region is east and southeast of the Washington, DC metro area, and is accessible from the Washington area by driving via the Chesapeake Bay Bridge.

The region is comprised of rural coastal communities that are culturally unique due to their marine heritage and natural resources. Many of these communities have ongoing concerns for the economic viability and social well-being of their year-round residents. In addition to the up-and-down fortunes of the commercial fishing and shellfish industries, there are concerns about maintaining the production of agricultural and livestock farms, particularly chicken farms which are major employers in the region, as there are estimated to be more than 9,800 poultry industry jobs on the Eastern Shore.[4] At the same time, these communities are concerned about the environmental integrity of the region, including the groundwater resources that supply fresh water to residents and industries.

Agencies and organizations in the region are working to expand eco-tourism and promote the region's maritime cultural heritage. There is a popular annual birding festival and an annual benefit festival based on the wild horses of Assateague Island.[5] Economic indicators show that the dollar flow from these events to local businesses has increased over recent decades, although the impact is mostly seasonal.

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[3]The offshore Virginia counties are: Northampton and Accomack. The Maryland counties can be subdivided into Lower Shore, Mid Shore, and Upper Shore. The Lower Shore counties are Somerset, Wicomico, and Worcester. The Mid Shore counties are Caroline, Dorchester, and Talbot. The Upper Shore counties are Cecil, Kent, and Queen Anne's. When these Maryland and Virginia counties are combined with counties in Delaware, the entire geographic region comprises the Delmarva Peninsula.

[4]Delmarva Poultry Industry, Inc. provides these data on Delaware, Maryland, and Virginia separately, and these statistics are based on Maryland and Virginia only.

[5]This event involves herding horses and thinning the herds by auctioning foals and fillies.

Efforts to establish an incubator-style Sustainable Technology Park on the southern tip of Virginia's Eastern Shore in the early 2000s did not survive. However, an industrial base has recently been growing around the federal facilities on Wallops Island in Virginia. These include a NASA flight center, NOAA data station, and Naval systems center. Workers at Wallops include around 1,000 full-time NASA civil service employees and contractors, 100 NOAA employees, and 30 Naval personnel. The related technology industry growth includes both on-site and off-site offices for the major government contractors, along with Wallops Research Park, Mid-Atlantic Regional Spaceport (promoting Virginia's commercial space industry), and the Virginia Space Flight Academy and Marine Science Consortium – which are attractions for kids and adults. Additional entities with similar purposes exist on the Maryland side of the border, along with a "Skipjack Network" website, which showcases enterprises that can help strengthen and diversify the economy of Maryland's Eastern Shore.

University-Based Research and Education

Due to the delicate and dynamic nature of the Eastern Shore, the region has become a hotbed of studies that relate, in some way, to the environment of the region. Several universities have important research and education programs in the area. They are: University of Virginia, Virginia Tech, William and Mary, and three of the twelve institutions comprising the University System of Maryland (USM) – University of Maryland-Eastern Shore, Salisbury University, and University of Maryland Center for Environmental Science. I briefly highlight each in geographical order beginning at the southern tip of the peninsula and heading north. This is not meant to be a comprehensive inventory of all facilities, research, and education & outreach – but rather some examples of activities and assets. The appendices provide additional background on some of the programs.

University of Virginia

The University of Virginia (UVA) Anheuser-Busch Coastal Research Center (ABCRC) is located on 42 acres in the harbor at Oyster, Virginia, on the southern end of the Eastern Shore. Researchers at ABCRC are studying sea level rise, storm effects, groundwater conditions, and the populations of fish, shellfish, vegetation, birds, and mammals. The facility is located within The Nature Conservancy's Virginia Coast Reserve. The Conservancy's shore office is about 20 miles north of Oyster

near Nassawadox. Several primary research sites within the coastal preserve are located along this north-south route.

Long-Term Research and Data

ABCRC serves as the home laboratory for the National Science Foundation (NSF)-supported Long-Term Ecological Research (LTER) program at the Virginia Coast Reserve (VCR). Long-term data provide the means to assess changes in climate, sea level rise, and land cover, which have significant consequences for all populations on Earth – human, animal, plant, and microbial. LTER scientists are able to predict future environmental conditions and new patterns in land and sea levels, forecast the rate and direction of change, and distinguish long-term trends from short-term changes.

VCR/LTER scientists have studied the changes in the VCR marshes from the 1950s to the present. The scientists collect data from meteorological stations, tide gauges, water level recorders, and other monitoring equipment. They use remote sensing satellite imagery and web camera photography. Wireless networks at the research sites provide access to Global Positioning System (GPS) latitudinal and longitudinal surveys necessary for creating Geographical Information System (GIS) maps. For example, shrub thicket and land use data are combined with other environmental data such as data on shellfish reefs, and all the data are entered into a long-term database for comparison purposes.

The project's main web site[6] is referred to as its "file cabinet," where the raw data are publicly accessible via a searchable online catalog.[7] The databank includes images such as time-series photos and webcams, and interactive maps.[8] For example, a map of Hog Island from 1852 can be overlaid onto a map of the island in 2012, or whatever year the user

[6]www.vcrlter.virginia.edu

[7]For immediate access, researchers can use the data access server searchable by keywords, research areas and sites; or, they can make a formal data request by completing a data license form indicating agreement with LTER acknowledgment policies.

[8]VCR/LTER publishes more than 130 datasets using standard ecological metadata language. In addition to the VCR/LTER web site, the data are available through several collaborative efforts to make long-term ecological data available, including the National LTERnet, NASA Mercury, and National Biological Information Infrastructure data catalogs. UVA and ABCRC also participate in the EcoTrends Project, primarily funded by NSF and the Agricultural Research Service, and which coordinates research across participating state and federal agencies and institutions.

chooses. The data also include field trip videos, researcher interviews,[9] dissertations and theses, and bibliographic listings. During the current 6-year funding cycle, more than 700,000 clients – users in more than 190 different countries or international organizations – have downloaded more than 5.1 terabytes of information via the data access portal.[10] In the same time period, some 175 books and articles have also been published.

LTER Education

The Schoolyard LTER (SLTER) program works extensively with high schools in Northampton County, a relatively poor Virginia county, and the impact of the program has been significant. SLTER has developed classes including a popular "Environmental Science II" course and some 200 students have performed activities similar to those performed by the professional scientists. SLTER provides the schools with water analysis kits, cameras, GPS units, computers, and taxonomic software. The students collect data to monitor water quality at a few dozen VCR sites, and enter their data into a long-term student database to identify changes. They describe their projects in multimedia presentations at semester's end.

Graduate training is considered a particularly important part of the LTER education mission, and each year about 20 students conduct research projects at the site. Some 30 master's theses and doctoral dissertations have been completed during the current funding cycle.

Virginia Tech

Virginia Tech's Eastern Shore Agricultural Research and Extension Center (ES-AREC) is located in Painter, Virginia, a mid-point between the two Virginia counties on the shore. The mission of ES-AREC is to support the sustainability of agricultural production on Virginia's Eastern Shore. The overall site is a 226-acre farm owned by Virginia Tech that includes an office complex, laboratories, equipment buildings, garages, greenhouse, cropland, graduate student housing, large freshwater pond, woodland areas, and farm manager's residence.

[9]The video presentations are also available on educational and video sharing sites such as SciVee. See http://amazon.evsc.virginia.edu/video/scivee.html.

[10]The datasets formally requested by users filling out data license forms are an important indicator of impact. These users have made 860 requests during Phase V, including 300 from researchers not associated with VCR. An additional 187 datasets were requested by automated programs.

The graduate students conduct field, greenhouse, and laboratory research. A particularly important research area is soil management since Virginia is a watershed state for the bay. A main goal of this research is to reduce soil erosion and sedimentation into the bay, tributaries, and ocean. The Center accomplishes this through applied research, demonstrations, and education on conservation-oriented best management practices and on cover crops which are planted to keep nutrients from leaching. For better nutrient management, the Center is also testing innovative fertilizer sources that promote more efficient use and decrease environmental losses from runoff, as well as alternative application practices for fertilizers and fumigants.

Economic Impact

Each year, the ES-AREC staff and researchers grow about 30 rotational crops of regional importance for their studies (Table 1). They also evaluate alternative crops with potential economic significance.

Table 1. Crops grown for research at Virginia Tech's Eastern Shore Agricultural Research & Extension Center (ES-AREC)

ES-AREC research crops				
Alfalfa	Cotton	Lettuce	Soybeans	Tomatoes
Barley	Cucumbers	Lima beans	Spinach	Watermelon
Broccoli	Dry beans	Peppers	Squash	Wheat
Cabbage	Edamame	Potatoes	Sunflowers	Zucchini
Cantaloupe	Eggplant	Pumpkin	Sweet corn	
Collards	Field corn	Snap beans	Switchgrass	

For its potato crops, the center is researching nitrogen sources, application methods, russet potato production rates in Virginia, and tuber disease management. Virginia Tech oversees a weekly report called the Virginia Potato Disease Advisory[11] that advises potato growers on the likelihood of potato disease development. Based on the ES-AREC research, the Advisory makes recommendations for regional farmers on fungicides to address potato diseases. In 2010, Eastern Shore potato

[11]The advisory operates under the direction of Steve Rideout, Associate Professor of Plant Pathology, Physiology, and Weed Sciences at ES-AREC.

growers saved $300,000 by using recommendations from the Advisory to reduce fungicide applications.

Other research projects have direct applications to the industry and economy of the Eastern Shore, as well. For example, the chicken industry is a huge sector of the economy on the Eastern Shore where economic activity estimated to be in excess of $2.3 billion.[12] Consequently ES-AREC is testing organic fertilizer sources such as poultry litter for its environmental impact.

William and Mary

The College of William and Mary's Virginia Institute of Marine Science (VIMS) has its main complex near Williamsburg, Virginia, where the campus is located on the mainland side of the Chesapeake Bay. VIMS, chartered in 1940, hosts the William and Mary graduate school in marine science at this site – Gloucester Point on the York River.

VIMS also operates the Eastern Shore Lab (ESL) located on five acres in the seaside fishing village of Wachapreague, Virginia, where the resident researchers specialize in coastal ecology and aquaculture. In addition to its existing hatchery, ESL opened a unique and innovative new seawater facility in June 2012 next to Wachapreague Channel. It provides access to clean seawater with salinity levels comparable to the nearby ocean and allows researchers to raise marine organisms in conditions that are protected, yet similar to those of the open ocean. The building is state-of-the-art and designed to withstand rising seawater, as the exterior power supplies and light fixtures are more than 14 feet above sea level.

Seagrass Research and Restoration

For more than 15 years, ESL has been leading a project to reintroduce submerged vegetation (seagrass) into the VCR coastal bays.[13]

[12]Delmarva Poultry Industry, Inc. provides this data on Delaware, Maryland, and Virginia separately, and these statistics are based on Maryland and Virginia only.

[13]The seagrass restoration project is a long-term collaborative effort with VCR/LTER, The Nature Conservancy, and other partners. VCR/LTER, for example, is providing data such as water depth and lagoon bathymetry (measurements) and logistical support for Nature Conservancy volunteers. The project has been funded over time through federal, state, private, and foundation grants, including: NOAA, through the American Recovery and Reinvestment Act (ARRA); several Commonwealth of Virginia programs; The Nature Conservancy; U.S. Army Corps of Engineers; and private grants from corporations and foundations such as Allied-Signal Foundation, Norfolk-Southern, and

Seagrass plays an important role keeping the coastal bays clean as it absorbs sediment in the water and transforms the bare seafloor to grassy underwater meadows providing homes for shellfish and finfish. The seagrass restoration started in 1997, when ESL scientists began spreading rice-sized eelgrass seeds in the coastal bays after hearing an anecdotal report of a successful small eelgrass patch south of Hog Island Bay. From 1999 through 2010, the programs spread 41 million eelgrass seeds across 350 acres in four coastal bays. Through natural re-seeding, these plantings have now expanded into 4,200 acres of eelgrass meadows. This effort has been described as the world's largest and most successful seagrass restoration project.[14] Long-term studies by VCR/LTER confirm the eelgrass recovery, and modeling studies show that full restoration has not even been reached yet.[15] With the success of the seagrass restoration program, ESL was also able to re-introduce to the new underwater meadows about 2.5 million juvenile bay scallops reared at the ESL hatchery.

Shellfish Data and Industry Applications

As recently as 2005, consistent economic data has not been collected in Virginia for shellfish aquaculture – as distinct from traditional shellfish and fish "landings" (onto the shore or dock). USDA has collected economic data for farm crops and livestock since the 1860s[16] and NOAA similarly maintains statistics on commercial fish and shellfish landings.[17] The NOAA data show that commercial operators are continuing to land clams and oysters from the bay in the traditional way, although at diminished rates.

With NOAA support, every year since 2005, VIMS has surveyed Virginia clam and oyster aquaculture farmers on their market sales and employment to produce an annual report on the newly-emerging

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the Keith Campbell Foundation for the Environment. It is estimated that the NOAA ARRA funding provided 55 jobs in Virginia.

[14]This success story was recently featured in a series of 9 articles in a February 2012 specially-themed issue of the journal, *Marine Ecology Progress Series*, co-edited by the head of the VIMS/ESL seagrass restoration program, Professor Robert Orth.

[15]However, they also show that, over time, the grass will likely be negatively impacted by increases in water temperature predicted by current climate change models.

[16]See http://www.nass.usda.gov/About_NASS/Timeline/The_Founding_Period.

[17]See http://www.st.nmfs.noaa.gov/st1/commercial/index.html.

aquaculture sector.[18] These annual data are useful for determining industry trends, and are particularly useful for the Eastern Shore communities where many shellfish aquaculture operations are based. In recent years, Virginia aquaculture has been steadily growing and changing as new techniques are proven. The numbers show that the state's clam aquaculture industry remains the largest in the nation, producing 450 million clams worth $26 million in 2011. Oyster growers using aquaculture techniques sold more than 23 million oysters worth more than $6.7 million in 2011 – up 38% from 2010.

The aquaculture industry growth in Virginia can be attributed in part to ground-breaking research by VIMS and ESL which have become recognized for their research on the ecology of all shellfish – clams, oysters, and scallops. VIMS has introduced such innovations as: oysters grown in protective containers (cages, racks, and floats) which reduces predators; farmed oysters that are moved into saltier waters just prior to harvest, nearly eliminating the presence of bacteria that can make humans sick; and faster growing oysters.

Education and Outreach

VIMS maintains web sites of free resources for teachers: Bridge[19] is "an ocean of teacher-approved marine education resources," and "ChesSIE"[20] (Chesapeake Science on the Internet for Educators) provides science information about bay area animals, plants, habitats, and water as well as professional development opportunities in the watershed area.

University of Maryland-Eastern Shore

The University of Maryland Eastern Shore (UMES) is a historically-black university located in Princess Anne, 10 miles from the bay and 20 miles from the ocean. The university has top-rated research and education programs in marine and related disciplines, particularly

[18]The "Virginia Shellfish Aquaculture Situation and Outlook Report" is available from the VIMS website, www.vims.edu.

[19]http://web.vims.edu/bridge, sponsored by NOAA Sea Grant program and the National Marine Educators Association.

[20]http://www.bayeducation.net, a project of the Mid-Atlantic Marine Education Association.

fisheries science. UMES offers bachelors, masters, and PhD degrees in Marine, Estuarine, and Environmental Sciences (MEES).[21]

While there has been a recent increase in the number of students nationwide choosing marine science as careers, the percentage of minorities doing so is below expectations. The NOAA Educational Partnership program supports the UMES-led Living Marine Resources Cooperative Science Center (LMRCSC) consortium to increase the number and diversity of students involved in NOAA core science areas. The consortium includes six other universities located on the water around the country[22], which are linked via video-teleconferencing for distance-learning, enabling them to share classes and seminars by renowned scientists and foster research collaborations among the schools. The consortium was founded in 2001 when NOAA awarded UMES and its partners their first grant; support is currently extended through 2016.[23]

UMES has a water quality lab on campus and, in 2005, built a $3 million Paul S. Sarbanes Coastal Ecology Center located 30 minutes from the UMES main campus on 8 acres across from Assateague Island. This center is under the administrative authority of the UMES School of Agricultural and Natural Sciences, but also serves as a field lab for LMRCSC. It is focused on fish microbiology, water quality, and the ecology of water organisms.

LMRCSC research, overall, is focused on the four broad areas of fish populations, economics, habitats, and aquaculture. The consortium conducts an annual proposal solicitation with guidance on the priority research topics for the year for the purpose of encouraging collaborative research among the students, faculty, and NOAA scientists.

Program Outputs and Benefits

Since 2001, the LMRCSC consortium has produced significant output measures of its performance, as shown on Table 2. The data reflect

[21]Areas of specialization for the MEES academic program are: fisheries science, oceanography, ecology, environmental chemistry, environmental science, and environmental molecular biology/ biotechnology.

[22]The partner institutions are: Delaware State University, Hampton University, University of Maryland, Savannah State University, University of Miami, and Oregon State University.

[23]In 2006, NOAA awarded the consortium a second 5-year grant and, at the beginning of FY2012, awarded approximately $15 million, extending support through 2016.

more than 350 graduates, 80 research projects, 150 interns, 500 presentations, nine government and university scientists, and 1,085 trainees. The consortium works to support NOAA's mission to conserve, protect and manage fish stocks. Its research has resulted in information on more than twenty species, including, for example, the mortality of yellowtail flounder; the genetic structure of monkfish; and the socioeconomic indicators of billfish. The ongoing research is also providing information needed to restore and enhance fish habitats.

Table 2. LMRCSC Output Measures

Education	LMRCSC institutions graduated 352 students (268 bachelors, 73 masters, and 11 PhD), with 55 students participating in open ocean fisheries research through winter cruises
Research	The LMRCSC consortium **s**upported more than 80 research projects developed in collaboration with NOAA scientists
Internships	The consortium has provided internships for some 150 students at NOAA labs or at the University of Maryland Institute of Marine and Environmental Technology
Presentations	LMRCSC research resulted in more than 500 presentations at meetings of scientific and professional societies, and 185 peer-reviewed articles and book chapters
Employment	These outputs have resulted in at least 3 NOAA hires, 3 university faculty members, and 3 post-doctoral researchers
Outreach	The consortium has provided other training and support for an additional 1,085 graduate, undergraduate and K-12 students

Establishing the consortium has allowed the UMES faculty to leverage more than $11 million in grant funding from other agencies to establish related programs. The new programs have enabled UMES to further develop capacity in marine and fisheries science and recruit more graduate students. Through one of these programs, the university was able to add a Professional Science Masters (PSM) degree in Quantitative Fisheries and Resource Economics.

Salisbury University

As of September 2012, 677 university presidents had signed the American College and University Presidents' Climate Commitment (ACUPCC), a group of academic institutions pledging to work towards climate neutrality. The commitment is the first of its kind to target climate

neutrality, not just a reduction. The signers include Salisbury University and the eleven other institutions comprising the University System of Maryland.

Salisbury University (SU) is the largest institution of higher education on the Eastern Shore. Located in the city of Salisbury, Maryland, the campus occupies 155 acres, and includes 56 buildings with more than 1.6 million square feet of space. Salisbury signed on to the ACUPCC commitment in 2007, and that commitment states:

> "We believe colleges and universities must exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions, and by providing the knowledge and the educated graduates to achieve climate neutrality."

Almost 470 of the institutions signing the Commitment have completed Climate Action Plans which outline how and when they will achieve climate neutrality, or zero net greenhouse gas (GHG) emissions. Salisbury University developed its plan in 2010 through a workgroup of some twenty students, faculty, and staff. The focus of the SU Plan is to reduce emissions through: efficiencies of operation/equipment; increased use of renewable energy; and promoting behavioral changes. For most of the ACUPCC signers, including Salisbury, the target date for achieving neutrality is 2050.

In order to provide a baseline to track its progress toward neutrality,[24] the university developed a campus-wide GHG inventory or "carbon footprint" according to ACUPCC standards, published in early 2009. The University System of Maryland was the second university system in the country to require its campuses to conduct carbon inventories,[25] and SU has been the only institution in the Maryland system to conduct its inventory using its own students exclusively. Students in SU's Perdue School of Business conducted the inventory, collecting data from a number of sources including, for example, commuter data from a

[24]For tracking this progress, the university actually identified FY2005 as its baseline year (rather than the 2008 data), since statewide energy reduction requirements use 2005 as the baseline year. Therefore, a retrospective carbon footprint inventory was developed for 2005 by estimating data based on population and other changes. Going forward, the university intends to conduct carbon emission inventories every other year.

[25]California was first.

survey of 1,142 respondents out of the overall campus population of approximately 9,000.[26]

Education and Curriculum

SU has three undergraduate degree programs related to the environment, climate change, and sustainability: (1) an Environmental Studies major or minor; (2) a Department of Biological Sciences dual major in biology and environmental/ marine science (in cooperation with UMES); and (3) a Geography and Geosciences major, with tracks in environmental land use planning and Earth & atmospheric science. Although SU does not currently offer a graduate program in environmental studies, it offers an MS in Applied Biology which provides training in biotech lab research and environmental sciences. Sustainability is continually being integrated into the academic programs at the university, and at least 87 courses from 19 disciplines now include a focus on the environment.

In July 2012, SU elevated its fast-growing interdisciplinary Environmental Studies program to become the Department of Environmental Studies. In this academic area, the students learn from distinguished faculty such as award-winning Chesapeake Bay writer Tom Horton, and Jay Martin who started Community-Sponsored Agriculture on the Eastern Shore. The students intern at state and federal agencies such as the U.S. Environmental Protection Agency (EPA); during the past three years, five environmental studies majors have been awarded prestigious $50,000 EPA Greater Research Opportunity Fellowships. The students work toward career paths in: (1) land/resource management, (2) pollution control/abatement, (3) environmental advocacy, (4) eco-tourism/ environmental education, (5) sustainable business, or (6) graduate school or law school, including environmental law.

SU also provides the students opportunities to learn about the environment and sustainability by living in a "Green Floor Living-Learning Community" in one of the dormitories. This option is open to first-year students who take certain courses, perform green service projects, and develop environmentally-oriented activities on campus. As extra-curricular activities, students can cultivate the campus garden or kayak on 100,000 acres of local rivers and wetlands, among other activities. In addition, the university has a number of university-sponsored

[26]The 2008 GHG inventory, filed with ACUPCC, documents the student survey work toward the inventory. See http://rs.acupcc.org/ghg/645/.

clubs focused on the environment such as the Environmental Student Association, Bio Environs Club, and others.

Research and Community Service

A wide variety of environmental research is pursued on the Salisbury campus. Environmental Studies faculty members have received grant funding from NSF, The Nature Conservancy, and other sources to study forest growth locally and in the Amazon, and this has led to more than 20 published articles. The SU Biological Sciences Department is performing ongoing research in its Bacterial Source Tracking Laboratory and conducting research on biofuels. The Geography/Geosciences Department is doing research on smart growth, and the Sociology Department is researching local sustainable agriculture. Based on conference agendas and other sources,[27] a number of research topics are pursued at SU that closely relate to the Eastern Shore marine environment.[28]

The Salisbury University-based Eastern Shore Regional GIS Cooperative (ESRGC) is a joint effort between the university and two regional planning and development councils covering six Eastern Shore counties.[29] The Maryland Department of the Environment recently hired ESRGC researchers to pinpoint 420,000 septic systems statewide in order to identify failing systems which critically impact the bay.[30]

University of Maryland Center for Environmental Science

The University of Maryland Center for Environmental Science (UMCES) is the University System of Maryland's environmental research institution. UMCES operates five programs, four of them being major

[27]See, for example, SU's annual Student Research Conference (which showcases and celebrates more than 200 student accomplishments), the 2011 National Conference on Undergraduate Research (held in Ithaca, New York), and the 2011 SU faculty grant proposals.

[28]A sampling includes: "The Chesapeake Bay and Puget Sound: A Bi-Coastal Survey of Environmental Issues and Perceptions"; "The Maryland Watershed Implementation Plan: What's Being Neglected in the Chesapeake Bay Clean-Up Efforts"; and "A Geographic Analysis of Storm Water Run-off as a Problem."

[29]These are the Tri-County Council for the Lower Eastern Shore of Maryland, and the Mid-Shore Regional Council.

[30]Current ESRGC projects involve a flood vulnerability analysis and critical area boundary mapping for the participating local and regional entities.

research facilities related to the environment in the Chesapeake Bay and Eastern Shore area: the Horn Point Laboratory (HPL) on the Eastern Shore; Chesapeake Biological Laboratory (CBL) at Solomon's Island on the western shore of the bay; Institute of Marine and Environmental Technology (IMET) in Baltimore; and the Appalachian Laboratory in western Maryland, focused on the bay's watershed rivers and streams. UMCES also administers the Maryland Sea Grant College program out of College Park, Maryland, which is a university-based cooperative research and education extension program.

In general, the UCMES sites are focused on ecosystem-based environmental management – integrating marine, aquatic, and terrestrial habitats – and ecosystem restoration, which involves holistically restoring sustainability to areas stressed by development and climate change. Every year more than 100 graduate students conduct research and studies at UMCES as part of the University of Maryland's MEES program, mentioned earlier.[31] The UMCES faculty and students frequently use scuba diving as a research tool. They also use the research vessels, and the flagship of that fleet is the 81-foot R/V *Rachel Carson*.

The Center administration of UMCES is headquartered at the Horn Point Laboratory on more than 800 acres by the Choptank River – the former estate of Francis V. DuPont – near the city of Cambridge on Maryland's Eastern Shore. HPL began operation in 1974 after Hurricane Agnes rainfall decreased the bay's water salinity levels in 1972, drastically diminishing shellfish populations. HPL focuses on environmentally-sustainable strategies for restoring the bay, its watershed, and the mid-Atlantic coastal ocean, and the HPL scientists have made significant research findings related to the bay's dead zones and acid levels.

Oyster Aquaculture

HPL has one of the largest oyster hatcheries on the East Coast, the Aquaculture and Restoration Ecology Lab. This $25 million 65,000 square foot aquaculture facility, with its sophisticated instrumentation, is designed to produce disease-free oyster larvae and "spat" (baby oysters produced by allowing oyster larvae to settle on old oyster shells in tanks). The spat is used in research, educational projects, the private aquaculture industry, and restoration activities throughout the Maryland portion of the bay. In this way, HPL serves a similar purpose for oysters as a state

[31]Lab instruction takes place at the UMCES sites, and the degrees are awarded by the University of Maryland.

agricultural experiment station does for crops. The spat, or seed oysters, are planted in the bay, producing clumps of oysters that grow and can later be harvested.

Unique features of the aquaculture facility include experimental controls for climate change research; a quarantine facility for the safe study of non-indigenous species; and a narrow water channel for research on submerged vegetation and seagrass. The quarantine lab and ¼-acre outdoor ponds are supplied with up to 350 gallons per minute of Choptank River water.

By the Fall 2012, HPL has produced a record number of oysters to aid in restoring the bay. This is the fifth year in a row that production has exceeded half a billion, as the hatchery has already produced more than 880 million spat in 2012. Over the past decade, the HPL hatchery has deployed more than 4.5 billion young oysters to the bay.

Oceanography

HPL scientists are also very active in interdisciplinary oceanography and its monitoring instruments, and they have developed several new technologies for accomplishing their research activities:

- The *physical* oceanographers are concerned with the motion of the ocean – waves, erosion, and interaction with climate variability – as well as systems and technologies for environmental observation. UMCES helps run a NOAA-funded public-private partnership to test new sensor platforms.[32]
- HPL's *chemical* oceanographers have expertise in water columns and sediment, and they are developing a new technology – an integrated water column profiler – which can observe simultaneously water properties such as turbulence, particles, and nutrient uptake.
- The HPL *biological* oceanography group is concerned with food web dynamics and specializes in shellfish, aquatic plants, and floating plants and animals – including jellyfish and unicellular organisms.

HPL's overall strength is in collaborative *biogeochemical* studies, including, for example, the modeling and ecology of seagrass beds.

[32]The UMCES/CBL site serves as the headquarters for the Alliance for Coastal Technologies (ACT), a NOAA-funded partnership of universities, companies, and state programs which together serve as a testbed for quantitatively evaluating new sensor platforms. In early 2013, a 16-foot long underwater research vehicle will be delivered to UMCES which will provide even more data collection capabilities.

Education, Outreach, and Extension

UMCES reaches more than 12,000 school age students and 50 teachers annually, helping school districts comply with state environmental education requirements. HPL's Environmental Science Education Center is for K-12 education and teacher training focused on STEM subjects. HPL offers a variety of programs for school age students. For example, the "Biologist for a Day" program brings groups of middle and high school students for a day of hands-on learning at the hatchery. Eastern Shore middle school students have helped to hatch and raise baby diamondback terrapins (the state reptile) and then release them into HPL-monitored wetlands. For even younger children, HPL offers brief weekday tours so they can see baby oysters spawn.

UMCES and HPL extension activities are coordinated through the University of Maryland Extension and Sea Grant programs. They involve technical support via training, publications, and site visits for a variety of stakeholders – from home owners to industry. For example, HPL is evaluating the effectiveness of aquatic plants (a $2 million industry in the state) for their value in keeping algae out of the tens of thousands of stormwater ponds in residential developments. HPL extension, in turn, is sharing the research results so the ponds can be better managed.

HPL conducts extensive public outreach. In addition to twice-weekly walking tours during summer months, the lab also holds an annual open house in the Fall with numerous activities and exhibits. The open house begins with a "Spat Dash" race to benefit environmental education programs and raises thousands of dollars for summer student scholarships.

Commonalities Among the University Programs

Several unique aspects of each Eastern Shore university environmental program were highlighted above. While they represent different institutions and states, the programs also have much in common. The following list suggests some of the more generic aspects of the educational missions of these university programs. Most of these institutions:

- Host visiting scientists on contracts and grants from other universities in the spring and summer months, and maintain facilities to accommodate them (*e.g.*, dormitories and dining halls). They even maintain boats to transport them to and from data monitoring locations.

- Receive supplemental funding from the National Science Foundation's Research Experience for Undergraduates program and other programs to provide paid summer fellowships, grants, and internships. These types of programs allow undergraduates to conduct research with mentors, and they may be paid monthly stipends, and lodging and travel expenses.

- Offer courses at the undergraduate and graduate levels taught by the resident faculty and principal investigators. The courses may even be taught toward academic degrees granted by other universities. The resident faculty members also supervise the research of rotating graduate researchers, and may serve on policy advisory boards needing specialized expertise.

- Provide teacher training in STEM areas for local high school and middle school teachers. This may be delivered in the form of lectures, group discussions, outdoor excursions, lesson plans, videos of scientist interviews, and other media.

- Offer paid summer internships for local high school students during the summer months. Some of these programs are competitive and merit-based, and the hope is that the hands-on research will encourage the students to pursue eventual majors and careers in environmental studies.

- Produce publications, data, conference presentations, patents, and intellectual capital resulting from the research that is likely accessible for second-level applications or licensing.

- Host multiple school student field trips and tour groups representing various professional societies (*e.g.*, Virginia Master Naturalists).

- Conduct monthly evening seminars to educate the public on research findings and environmental projects on the Eastern Shore. Topics include, for example, the bay's dead zones, the impact of climate change on the Eastern Shore, and the overall ecology of the region. They also maintain speakers' bureaus for local civic organizations seeking speakers with expertise in environmental subjects.

- Provide extensive research and academic facilities such as classroom buildings, teaching laboratories, wet laboratories, conference centers, libraries, high-speed Internet, GIS, laboratory equipment, image analysis capabilities, centralized data portals and database systems, video equipment, and museums and exhibit/display areas.

- Maintain research fleets with small vessels for local project work and shallow-water habitats, and larger vessels for offshore work and open ocean navigation.

- Support resident staff providing specialized technical services to the onsite and visiting researchers, such as assistance with computers, graphics, equipment, mechanics, chemical analyses, and even water transportation.

See the Appendices for additional background on several of the university programs.

Rationale for Promoting a Science and Technology Sector

Clearly, there is a variety of university-based education and research programs on the Eastern Shore with a similar variety of facilities and expertise in environmental fields. Due to the fragile nature of the environmental conditions of the region, and environmental connections to the regional economy, each of the programs provides unique opportunities for education, research, internships, employment, and community involvement. The outputs, impacts, and research findings of the programs indicate they are fulfilling their missions, making exceptional research contributions, and providing a service to their stakeholders regionally, nationally, and internationally. Furthermore, the researchers involved in complementary research efforts seem to be cooperating well toward their common goals.

Given these findings, it's interesting to note that a 130-page Eastern Shore Career Guide describes 123 occupations listed as appropriate for Maryland's Lower Shore and Upper Shore[33] but the guidebook does not list any positions related to marine science and technology, for example. This is a notable omission, particularly given that it lists "fishers and related fishing workers" as occupational groups with the fastest nationwide growth rates (from 2004 to 2014).[34]

[33]In this guidebook, "Lower Shore" includes Somerset, Wicomico, and Worcester counties; "Upper Shore" includes Caroline, Dorchester, Kent, Queen Anne's, and Talbot counties.

[34]At the time it was printed, the *Career Guide* projected that there were 30,955 openings on the Eastern Shore for 121 of the 123 occupations (data on projected number of biologists and chemists was listed as "not available.")

Occupations based on science and information rather than manual labor make up the "knowledge industry sector."[35] This sector – which includes marine science, sustainable agriculture, and environmental studies among others – is growing faster than the overall economy and it supports higher salaries.[36] Knowledge-based economies tend to feature regional innovation systems clustered around science and technology facilities. Innovation clusters are comprised of tech firms, university spinoffs, entrepreneurs and their start-ups, and the technical support organizations that serve them – usually a variety of for-profits and non-profit centers that can capitalize on the region's scientific resources.

An internationally-recognized example not far from the Eastern Shore is the biomedical corridor in the Baltimore area extending from Johns Hopkins University down to the National Institutes of Health in Bethesda, Maryland.

Is there a sufficient science and technology base on the Eastern Shore on which to build a science and technology-based economy? There is a concentration of research and education on environmental issues and an existing cadre of world-class scientists doing basic and applied research and producing outputs like scientific and technical information, scholarly publications, technology applications, patents, *etc*. Furthermore, local human resources are being developed through the educational programs and internships to create an available pool of human capital – although it has been said that the Eastern Shore suffers from brain drain, according to a member of the Greater Salisbury Committee,[37] so there may be a need for incentives and programs encouraging them to stay.

[35]The *Career Guide* contains three occupational clusters oriented toward scientific and technical fields: biologists, chemists, and engineers. It lists these occupations related to the biology cluster: foresters, oceanographers, pathologists, range managers, and soil scientists. Related occupations for chemists are listed as: agricultural scientist, chemical engineer, chemical technologist, and food technologist.

[36]There is an extensive body of literature on technology-based economic development and regional innovation clusters. See, for example, www.clustermapping.us, a project under development at Harvard University and supported by the U.S. Department of Commerce, to be expanded in the Spring of 2013.

[37]Rafael Correa, President of MaTech, Inc., a former 8(a) company; presentation at the Federal Laboratory Consortium's Eastern Shore Economic Development Meeting, March 12, 2008.

"Collaboration between business and academia helps fuel research necessary for American innovation and helps prepare a workforce that meets the needs of industry. Both are critical components to future economic prosperity and job growth," as stated by the chairman House Subcommittee on Research and Science Education chairman at an August 2012 Congressional hearing.[38] What is needed on the Eastern Shore is an active focus on bringing together the public and private actors so that the networking and university-industry partnerships are not just clustered around Williamsburg, Charlottesville, Blacksburg, and College Park.

As an example, William and Mary's Virginia Institute of Marine Science has a VIMS-Industry Partnership Committee to advise the VIMS director on the development of long-term partnerships with industry and steps to improve collaborative research and technology transfer. In addition to representatives from William and Mary and VIMS, the committee includes industry participants from a few dozen companies, county economic development directors, representatives of NASA and the Office of Naval Research, and representatives from the Hampton Roads Research Partnership. This industry partnership has focused, for example, on marine sensors, the deployment of observation platforms in the bay, autonomous underwater vehicles, modeling and simulation of storm surges, and the Chesapeake Bay algae project which is researching the conversion of algae into fuels. Furthermore, the partners have collaborated on Small Business Innovation Research projects and federal, state, and international contracts and grants.

The above example is based on the mainland, but there are networks located on the Eastern Shore. The "Skipjack Network" website, mentioned earlier, was created to showcase enterprises that can help strengthen and diversify the economy of Maryland's Eastern Shore. This is an outreach activity provided by the University of Maryland-Eastern Shore, and it has received support from various sources like USDA's Rural Business-Cooperative Service, the U.S. Economic Development Administration, and Maryland Cooperative Extension. Skipjack is a website[39] that serves as a portal to local economic development directors and private business developers and intermediaries.

[38] August 1, 2012 hearing on Business-Research University Partnerships held by the U.S. House of Representatives Committee on Science, Space and Technology (Research and Science Education Subcommittee).

[39] http://skipjacknews.net/

Just as Maryland has its biomedical cluster, the Eastern Shore can become branded as a regional cluster of science and technology based on the environment. A commitment is necessary from all sectors – government, universities, and industry – to leverage the region's strengths. The following list of ten stakeholder groups notes some roles for each:

1. The university players: University faculty, researchers and administrators, technology transfer program staff, and community college faculty[40] can market their technologies and foster spinoffs and entrepreneurship through incubators, research parks, and business advice.

2. High-profile industry and growing technology companies: The existing base of recognized and well-known Wallops Island support contractors can sponsor networking events and bring visibility to the region's science and technology assets.

3. World-class federal laboratories: A NOAA laboratory on the Eastern Shore in Oxford, Maryland – an 18,000-square feet research facility on the water – houses the most complete expertise that exists worldwide on marine genomics, marine toxins, and harmful algae. Among the lab's commercialization applications, for example, is an aquaculture shrimp vaccine. The Smithsonian Institution will also soon be launching a research site in Edgewater, Maryland, for studying the coastal ecosystem. By law, federal scientific labs must promote tech transfer, and can enter into cooperative research and development agreements with partners for this purpose.[41] Some also offer technical assistance to small businesses. In addition to the NOAA Oxford Laboratory and Smithsonian, these mandates also apply to federally-funded research and development facilities at Wallops Island (NASA, NOAA, and Navy).

4. Professional societies and intermediaries: These players can organize conference sessions targeted toward Eastern Shore students and workers. As an example, the Washington Academy of Sciences in the Washington DC area recently teamed with Salisbury University and the

[40]For example, the Eastern Shore Community College (ESCC) started out as the University of Virginia Eastern Shore Branch on Wallops Island. In 1971, the UVA branch campus became an independent college within the state's system of community colleges, and moved from Wallops Island to Melfa, Virginia, in 1974. ESCC currently has an enrollment of more than 1,000 students.

[41]Stevenson-Wydler Technology Innovation Act of 1980 and subsequent related legislation.

Marine Technology Society to co-sponsor a career-related event for students.[42]

5. Technology councils: The Lower Eastern Shore Regional Technology Council is based in Salisbury, Maryland. The two counties of Virginia's Eastern Shore come under the purview of a regional technology council on the mainland known as Technology Hampton Roads. These types of groups provide a comfortable platform through which the public and private sectors can interact, but they must be conveniently-located on the Eastern Shore to be viable contributors.

6. Elected officials and economic developers: This group of stakeholders brings leadership and expertise in strategizing for technology-based economic development.

7. K-12 educators in STEM (science, technology, engineering and math) and locally-based **workforce organizations**: Teachers on the Eastern Shore, who are already benefitting from the locally-based academic and research programs, serve as mentors and advisors for the young interns and future workers.

8. Foundations and non-profits: The Chesapeake Bay Foundation is exemplary here, with a long history of environmental activism and educational programs in the region. The Foundation's legislative efforts have led to requirements for environmental education at the high school level to prepare students for green jobs and improving environmental awareness; also, the Foundation's vice president for education serves as director for the No Child Left Inside Coalition, a national coalition of more than 2,000 business and education groups.

9. Entrepreneurs: The UMES Sarbanes Coastal Ecology Center serves as a business incubation facility for entrepreneurs partnering with the university's Rural Development Center through the Worcester County Department of Economic Development. These entrepreneurs are potential users of university technologies and serve as role models for others.

10. Financial institutions and investors:[43] They provide needed capital for new ventures.

[42]Capital Science 2012 Program: http://www.washacadsci.org/capsci12/abstracts.pdf.

[43]Such as Angel investors or venture capital -- to the extent that these communities are available within the region.

This region – with its unique environment and socio-economics – deserves an organizational champion to harness the attention of all these groups that have a stake in the region's future. The region will benefit from a targeted coordinated effort to develop an environmentally-oriented cluster, persistently over time. Regular and ongoing outreach is how relationships and collaborations develop. Such an approach, along with a strategy for environmental "branding," will result in positive economic impact. Toward this end, the Eastern Shore stakeholders are advised to study the best practices of other environmental clusters around the country, as well as international models. The possibilities are definitely not saturated at this point.

Appendix A: University of Virginia – Supplementary Information

UVA's Department of Environmental Sciences in Charlottesville, Virginia, serves as the administrative headquarters for the VCR/LTER project. NSF has supported this effort since the 1980s, as shown on Table 3. It is one of 26 such sites coordinated by the U.S. LTER Network encompassing more than 1,800 researchers. The data developed at VCR are integrated with data from other sites and programs -- including socio-economic data. The VCR/LTER studies have contributed to, for example, interdisciplinary breakthroughs involving social scientists in network analysis and ecology.[44] Data produced by the LTER program feeds into the U.S. Global Change Research Program which integrates research from 13 agencies.[45] A related global network, the International LTER program, is contributing to the United Nations program on assessing global change.

Many partners are on-site and have a stake in the research at the UVA field site. NOAA installed a Climate Reference Network station at this facility, providing adjunct data to the LTER meteorological data. The Nature Conservancy purchases related LiDAR[46] data for the Eastern

[44]For example, a collaboration with Dr. Stephen Swallow, a University of Rhode Island economist, has produced ground-breaking work on the tradeoffs involved in environmental conservation. A sample of this body of work is a presentation to the 2010 Soil & Water Conservation Society conference, "Selling Ecosystem Services as Public Goods to Consumer-Beneficiaries: An Auction Experiment on Restoration of Seagrass and Bird Habitat in Virginia Coastal Reserve."

[45]USGCRP began as a presidential initiative in 1989, and was mandated by Congress in 1990. From 2002-2008, it was known as the U.S. Climate Change Science Program.

[46]LiDAR = Light Detection and Ranging, an optical remote sensing technology.

Shore. Additional federal partners include the U.S. Geological Survey and the Naval Research Laboratory. Both federal and state agencies charged with managing coastal resources and/or agricultural fertilization practices benefit from data on the relationship between land use, water quality, and contaminants.[47]

Appendix B: University of Maryland-Eastern Shore - Supplementary Information

UMES has the advantage of being located in close proximity to Delaware State University (DSU) on the Delmarva Peninsula and Hampton University (HU) located near the mouth of the Chesapeake Bay, both historically-black universities and known for their programs in this area. For example, HU has a number of programs promoting the participation of minority students in marine sciences, including Multicultural-students At Sea Together (known as "MAST") and others. The DSU Aquaculture Research and Demonstration Facility has numerous freshwater ponds and large wet lab. UMES also collaborates with nearby sites of the University of Maryland's Center for Environmental Science; the LMRCSC partner is the joint USM Institute of Marine and Environmental Technology located on the Inner Harbor by Baltimore.

Appendix C: Salisbury University – Supplementary Information

The students inventorying the Salisbury University GHG emissions, found that the university emitted almost 28,000 metric tons of equivalent carbon dioxide (CO2) emissions during FY2008, as detailed on Table 4.[48]

Campus Milestones: ACUPCC participants commit to initiating at least two "tangible actions" toward carbon neutrality. Salisbury University's first commitment is focused on energy efficiency and conservation. The university established a policy that new campus construction and major renovations will be built to at least the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Silver standard or equivalent certification. SU also plans for new construction to use 20-30% renewable energy, with the renewable energy

[47]These include the Water Conservation Districts on the Eastern Shore and the Virginia Department of Environmental Quality, among others.

[48]This is roughly equivalent to the annual emissions from 4,600 cars or sequestered by 7,600 acres of Maryland's Eastern Shore forest, according to the university's Climate Action Plan.

being generated on-site. The university has made significant progress in this regard. In 2008, the SU Teacher Education and Technology Center became the Eastern Shore's first LEED-certified new construction, earning Silver status. Since then, five more university buildings earned LEED certification, with two of them earning Gold certification. Since 2010, three buildings have been renovated with geothermal heating and cooling systems, which save 30-70% on monthly utility bills. One of the buildings features a roof-mounted solar water heater supplying hot water.

Table 4. SU Greenhouse Gas Inventory (2008) *does not total due to rounding

Source	Metric tons of equivalent CO2 emitted	Percentages
Electricity	15,525	55.6%
Oil & gas heat	3,551	12.7%
Ground transportation	5,753	20.7%
Air transportation	2,224	8.0%
Refrigerants, chemicals	708	2.5%
Solid waste	166	.0001%
Agriculture	8	N/A
Total	**27,935**	**~ 100%***

As its second commitment, SU has adopted an energy-efficient appliance purchasing policy. The washers and dryers in all the SU residence halls are now Energy Star-rated high-efficiency laundry units from Mac-Gray Intelligent Laundry Systems. SU was the first university in the country to install such units campus-wide. The washers use 12.2 gallons/wash, a savings of three gallons compared to previous machines, resulting in an annual savings of more than 100,000 gallons of water.

The campus vehicles and computers are also contributing energy efficiencies. The Motor Pool has replaced some of its older higher-mileage vehicles with more environment-friendly hybrid cars. A ride-sharing program is reducing the number of student, faculty and staff cars travelling to campus or home for weekends. The university's Information Technology office is using "server virtualization" software that reduces the number of physical server boxes that are necessary, saving both electricity and heating and cooling costs.

Even before signing ACUPCC and developing its Climate Action Plan, Salisbury University had a highly visible university-wide "Sustainability Initiative."[49] The university established a partnership with Pepco Energy Services to put into place campus-wide energy conservation measures projecting more than $5.3 million in savings by 2021. For example, lighting, plumbing and HVAC fixtures have been replaced with energy-efficient models.[50]

SU has been implementing a recycling program since about 1990, and every year exceeds the state standard which requires that it recycle at least 20% of its trash.[51] Since Spring semester 2012, the university has been composting food waste to minimize the volume sent to local landfills. The composting program has already processed nearly 70 tons of food waste which represents a decrease of nearly 60% in landfill use. The waste is compressed into fertilizer pellets sold to area farmers and also used in the campus greenhouses.

Campus Culture: SU has a tree-friendly campus, which is a national arboretum and home to student-planted wildlife and rain and vegetable gardens. This has garnered the university some recognition. It earned the 2009 Maryland Department of Natural Resources' (DNR) "People Loving and Nurturing Trees" (PLANT) Green award, the highest sustainability award given by the DNR Forest Service and Forestry Council. SU also became the first university to be honored with the WMDT News-Mountaire Environmental Star award. In 2010, 2011, and 2012, The Princeton Review named SU one of the nation's most environmentally-responsible colleges based on a survey and "green rating" scores of hundreds of colleges nationwide.[52]

[49]Salisbury University touts this definition of sustainability "… meet the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987).

[50]It is estimated the Pepco partnership will save an amount of electricity equal to powering 1,600 homes, and reduce emissions equal to removing 1,571 cars from the road or planting 2,145 acres of trees.

[51]The university's Climate Action Plan says SU "boasts a recycling program that consistently achieves a recycling percent higher than the required 20 percent mandated by the [1988] Maryland Recycling Act," but does not cite a percentage. The university website states "SU always far exceeds this standard."

[52]SU received a rating of 86 (on a scale of 60-99) in 2012, and was featured in the *Guide to 322 Green Colleges*.

An extensive web site, "Sustainability @ SU,"[53] consolidates an array of Salisbury University initiatives not covered here. Through its initiatives, the university intends to serve as a model for the surrounding regional community. Additional activities are in the planning stages, and will become visible to the region's residents in the near future.[54]

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Bio

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